“Strengthening Urban Resilience: Unleashing the Power of Green Infrastructure in European Cities”

Ing. Arch. Jenan HUSSEIN. MSc.

Supervisors: Doc. Peter KUMBLE. Ph.D.

Dipl. arch. Henry. W.A. HANSON IV.

Department of Landscape and Urban Planning

Czech University of Life Science

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Declaration

I hereby declare that I have prepared this dissertation independently and have cited all sources of relevant information. The dissertation has not been published elsewhere.

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PhD Thesis

Thesis supervisor: Doc. Peter KUMBLE. Ph.D.

Dipl. arch. Henry. W.A. HANSON IV.

Thesis reviewers:

Department of Landscape and Urban Planning

Czech University of Life Science

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Jenan Hussein

Thesis

This thesis is submitted in fulfillment of the requirements for the PhD degree at the Czech University of Life Sciences Prague, Department of Landscape and Urban Planning.

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"This thesis acknowledgement is a tribute to all the people who made my academic journey worthwhile."

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Even Henry you are not here, I know you will be so proud of what we have done… we all miss you with us, but you know I am in good hands with Peter.

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I would like to express my sincere thanks to the academic staff who provided their invaluable expertise and guidance. The colleagues I extend my deepest gratitude to all who have walked with me on this challenging but fulfilling journey. It was very rich of challenges, knowledge, ups and downs and success in the end to be in this level.

"I would also like to thank the whole department team professors and all stuff , whose endless kind support made this research possible."

"Special thanks go to my family, whose constant encouragement fueled my perseverance during the completion of this dissertation. Especially my little daughter whom I want her to always be proud of me as I am proud of her"
"I would like to acknowledge the significant contributions made by my research participants; I express my heartfelt gratitude to my friends who have been my pillars of strength."

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Abstract

More than ten years back, the notion of urban resilience was a term that was used interchangeably with climate change. However, extant literature pertaining to resilience nonetheless revealed varied definitions within social sciences, natural sciences, engineering, and psychology. There was a need to adopt a highly integrated approach, in terms of defining urban resilience as the capability of cities to foresee, restrict, absorb, and recover from stresses and shocks, while enhancing necessary fundamental response structures and function, while incorporating varied facets of sustainability, urbanization, green infrastructure, and development.

Resilience responds to stresses and shocks that emerged from rapid technological, environmental, demographic, and social changes, which could be the result of a natural phenomenon or socioeconomic crisis. Such stresses and shocks could impact one or several urban systems, which include energy grids, urban transportation, and potential spill-over impacts on the city-region territory. Nonetheless, this kind of interdependence and interaction of urban systems could be harnessed to gain benefits of their co-benefits, and complementarity, while realizing synergies in the wider context of sustainable development.

This thesis aimed to investigate how green infrastructure within European cities could strengthen urban resilience. A review methodology has been adopted for this thesis wherein papers similar to the topic of this thesis were reviewed and analyzed in detail to derive and discuss findings, while arriving at a logical conclusion. The findings derived from this paper indicated that while studies pertaining to practice of green infrastructure were most effective when it was merged with grey infrastructure. GI including green roofs and urban forests enhance resilience by overcoming the impact from events that were caused by climate change such as floods and heatwaves. However, there were challenges as well in terms of incorporating GI within territorial plans for tackling climate change adaptation. The

findings thus derived through this research not only added to the extant literature, but it also had major ramifications to society and industry on the whole.

Contents

CHAPTER – 1

Introduction

1.1 Introduction

There are several inter-connected published discussions centered around the concept of urban resilience that discuss this as an approach to characterizing the multifaceted issue of global and local challenges (Ali Adil, 2019). As a concept, urban resilience is comparatively new, and has only recently been defined as the degree to which cities are capable of facilitating changes prior to reorganizing around a novel set of procedures and structures (The World Bank, 2015). Modern challenges warrant the need for sustainable and innovative solutions for facilitating the creation of highly adaptive and resilient regions and cities, that may be capable of maintaining an equilibrium between environmental protection, economic competitiveness, and social well-being. Such solutions can be extracted through spatial planning, community engagement, urban design, and technological innovation to make sure that urbanization is handled for sustaining the feasibility and enhancing the quality of life for people in terms of socio-political and global economic crises and climate change. As a matter of fact, the capability to react to and emerge from sudden shocks and disruptions over a long-term period could be deemed as an indicator of resilience (Shukla, 2023).

Given the many challenges that urban communities have been confronted with, cities across Europe are trying to enhance their resilience while transitioning to an adaptive governance, collaborative decision-making, and behavioural change interests of sustainability. Resilience is mainly perceived as complimentary extension of urban sustainability, fueling urban policy towards a highly intgrated, multi-disciplinary and transparent planning system, which involves community stakeholders as key to the process of planning; planners as creative, innovative, and holistic actors who work within multi-functional and multi-disciplinary frameworks (Matteo Bizzotto, Ayan Huseynova, Victoria Vital Ariel Dekovic, Marion Guénard, Evgenia Mitroliou, Pourya Salehi, n.d.). The significance of diverse viewpoints is clearly visible in terms of managing and analyzing intricate systems, and in recognizing that non-expert and local knowledge is of much value for urban management.

However, there would be several ways in which urban communities might regard the concept of resilience. Some communities might perceive it as maintaining the status quo whereas others would consider it as an opportunity to structure a new environment or enhance the quality of life. Across several cities in Europe such as Copenhagen in Denmark, Vienna in Austria, Amsterdam in the Netherlands, Prague in the Czech Republic and more, conventional urban planning has frequently focused on tackling design responses to intricate social challenges that concentrate on renewal of neighbourhoods (Metzger et al., 2021). This has led to particular prescriptions of design that might handle the initial issues such as urbanization, growth of population, environmental degradation etc., but however they are not able to respond to the rapidly changing social structures, cultural and environmental awareness, or demands for public spaces. Such novel and intricate demands would consist of collaborative approaches to restoration, conservation, and augmentation of ecosystem services, such as biodiversity, waste management, flood control, and air quality(Metzger et al., 2021). Furthermore, there is increasing awareness that the future of civil society is intricately associated with valuing and maintaining ecosystem services with the intention to retain social and environmental resilience (Anbumozhi & Kojima, 2019).

Urban green policy is being extensively utilized as an instrument to improve urban resilience and sustainability that supports ecosystem and biodiversity services (Vargas-Hernández & Zdunek-Wielgołaska, 2021a). The concept of green infrastructure has great significance as it can integrate nature and incorporate it within urban living, allowing cities to lower their ecological urban footprint through improved execution of private and public green infrastructure, with the use of organic materials and/or green procedures or products that are nature inspired. This might upgrade urban services while boosting urban biodiversity (Vargas-Hernández & Zdunek-Wielgołaska, 2021a). Unused buildings and vacant sites might offer urban communities and cities a scope for higher level of resilience. It does so by allowing them to enhance planning efforts on the basis of revitalization projects and innovative creative design. Increased awareness about the need to incorporate resilience in mainstream planning and design would thus be of significance, enhancing the capacity of a community for adapting their social capital, and local planning policies for specific urban neighbourhoods (Mukherjee & Takara, 2018).

The recent emergence of projects that are community-led can be attributed much to the changes in perceptions and physical procedures. This is facilitated when there is a shift in perceptions, developments in technology, decentralized models of governance, and participatory planning procedures. Collaboration are those that stimulate procedures that have been conceptualized and fueled by people and, enabled by broader numbers of stakeholders, and deriving from current social capital networks, and in close collaboration with management practitioners, academic research, and innovative design groups (Bautista-Puig et al., 2022). Planning that is led by citizens comprises a basic shift in the paradigm of planning wherein the focus is on enabling communities to create a notion for their wishes and needs in the future, while trying to work with planning stakeholders at an egalitarian level. This would imply becoming more open to actors beyond the conventional domains, thus referring to the inclusion of cultural, and other knowledge forms.

At the same time, green spaces such as wildlife corridors, national parks, parks, and urban forests of diverse sizes, have several roles to play within cities and their adjoining areas. Such green areas are known to exist at varying scales, which range from small to large scale - neighbourhoods to cities, and then overall urban regions. As a term, Green Infrastructure (GI) is quite wide that takes under its ambit natural as well as artificial green spaces, offering social as well as ecological functions within urban regions (Reynolds et al., 2022). It was (Sandstro¨m, 2002), who was instrumental in initially introducing the term GI for widening the objective of green spaces to encompass aspects other than recreation, taking into account purposes such as preservation of biodiversity, cultural identity, urban structure, environmental quality and utilizing natural solutions to engineering and technical challenges. GI has been further defined by (Parker & Zingoni de Baro, 2019) as an interlinked network of multifunctional ecological systems, that are inclusive of semi-natural, natural, and artificial components within, around, and between urban regions, irrespective of its spatial scale. GI was formally defined by the European Union as a network of semi-natural and natural areas, in tandem with other environmental traits, that have been strategically planned, designed, and managed to offer an extensive array of ecosystem services from an urban and rural context (Europeon commision, 2023). Such ecosystem services would comprise not only of green and blue spaces (water), but would also be inclusive of other physical attributes within marine and terrestrial regions like agricultural fields, hedges, walls and green-roofs, eco-bridges, and fish ladders too. The Environmental Protection Agency (EPA) of the United States have defined GI as a term that is highly flexible which is inclusive of several products, practices, and technologies that use natural systems or imitates natural procedures to improve environmental quality on the whole and offer utility services (Green, 2019). Though the fundamental focus of the concept of GI is stormwater runoff management using methods that comprise of vegetation and soil, it acknowledges many economic and environmental advantages like air and water purification, lowering demand of energy, mitigation of urban heat island, aesthetic enhancements, urban heat islands, carbon sequestration, and benefits pertaining to natural resources.

On the other hand, urban resilience has been defined as the capability of an urban system and each of its constituent socio-technical and socio-ecological networks across spatial and temporal scales. This is for the purpose of sustaining or promptly returning to expected functions when confronted with a disturbance, to adjust with changes, and to promptly convert systems that restrict present or future capacity for adaptation (Meerow et al., 2016). Therefore, a city that is resilient would be one that foresees, plans, and initiates action for responding to unanticipated crises.

This PhD dissertation aims to systematically review how urban resilience can be strengthened by unleashing the power of green infrastructure across European cities.

1.2 Definitions

1.2.1 Urban Resilience

In recent times, the notion of resilience has gained much popularity within policy and academic discourses, with several explanations for such popularity (Sahni & Aulakh, 2021). Possibly the theory of resilience offers deeper insights into intricate socio-ecological systems and its sustainable management, particularly with regard to climate change (Cinner & Barnes, 2019). Considering that socio-ecological resilience theory comprehends systems as continuously changing in non-linear manners, the approach would be highly pertinent for tackling with future climatic uncertainties. Resilience as a term is also known to have societal connotations that are positive, which has led some to suggest that it is preferred to similar, but highly charged notions such as vulnerability. Specifically, resilience has turned out to be a lucrative viewpoint in terms of cities, frequently theorized as highly intricate and adaptive systems (Kong et al., 2022).

The continuous expansion of large cities and the increase in urban resilience are the challenges that society is confronted with today. The notion of urban resilience has emerged as a response to threats to urban survival and sustainable development. In comparison with studies conducted in the past on urban disasters, urban risk, and urban vulnerability, urban resilience would refer to the level of risk that a city will be able to endure and their pace of recovery following a disaster. It is an extensive performance of enhancing ability in terms of resistance to urban risk, lowering urban vulnerability, and lowering urban loss post a disaster. In contrast, urban resilience tends to be highly global and strategic (Zheng et al., 2018).

As a concept, urban resilience has been defined by (Meerow et al., 2016), as the capability of an urban system and each of its constituent socio-technical and socio-ecological networks across spatial and temporal scales for maintaining or rapidly reverting back to expected functions when confronted with a disturbance, to adapt to change, and to promptly convert systems that restrict present or future capacity for adaptation. As per this definition, urban resilience is dynamic and provides several pathways to resilience (transition, transformation, and persistence). It acknowledges the significance of temporal scale and advocates general adaptability instead of particular adaptiveness.

1.2.2 Green Infrastructure

For several ecologists, green infrastructure (GI) induces a multi-scalar network of ecological components offering several benefits and functions. The roots to this landscape concept can be traced back to 19^{th} century landscape design and planning in the United States (US), like the Frederick Olmsted park systems (Eisenman, 2013), and other traditions for spatial planning within the United Kingdom (UK) and Europe (Grădinaru & Hersperger, 2019). A landscape notion of GI would continue to guide initiatives in planning to offer high quality green spaces in an equitable manner, handle risks to environment, and enhance urban public health. The Environmental Protection Agency (EPA) in the US in 2007 officially defined GI as an array of stormwater control practices that were utilized to comply with Clean Water Act (CWA) regulations (Pollalis, 2019). Nonetheless, considering that the EPA does not have any formal regulatory authority over land cover/land use, applying the notion of GI is restricted to technologies for control, frequently termed as 'best management practices'. Such hybrid measures for stormwater control are engineered facilities that operate across a 'gray-green' continuum (Bell et al., 2019), and have extensive applications within the US (McPhillips & Matsler, 2018), and the world over (Mell & Clement, 2020).

It has been argued by (Bag, 2016), that a single accurate meaning of GI would be challenging owing to the fact that the concept continues to evolve and has built response to diverse needs. Therefore, GI could be considered as a boundary concept, that can be defined as terms that act as notions across varied disciplines or viewpoints, referring to the same phenomenon, object, quality or process of these, but hold vastly varied meanings across various viewpoints or disciplines.

As per the European commision (2023), GI has been defined as a network of semi-natural and natural areas that has been strategically planned along with other environmental features, structured and managed such as to provide an extensive array of ecosystem services, while also improving biodiversity. Such services would also encompass water purification, enhancing air quality, offering recreational spaces, and facilitating climate change mitigation and adaptation. This network of blue (water) and green (land) spaces enhances the environmental quality, the connectivity and condition of natural areas, and enhances peoples' quality of life and health as well. The development of GI can also lend support to green economy while creating ample opportunities for employment.

1.3 Significance of the Dissertation

The concept of GI has been largely applied within urban contexts with the purpose of enhancing the overall structure of a city and to ensure that advantages from natural capital are provided within urban systems that mostly comprise of built spaces. It is possible to extend support to extensive levels biodiversity through urban green and blue spaces, while offering various ecosystem services. These would comprise of regulating, provisioning, and cultural services that are intrinsic to the overall well-being of urban populations, specifically in terms of human health advantages, both psychological and physical (Felappi et al., 2020; Spano et al., 2020). Urban green spaces are known to offer novel ecosystems and habitats for species (Andrade et al., 2021), food security, and agricultural connectivity (Yacamán Ochoa et al., 2020), facilitates air and water purification, moderate local climates, sequester carbon di-oxide, lower erosion of soil, ease noise pollution, augment the value of real estate, enhance aesthetics of landscape and neighbourhoods, while improving psychological and physical well-being of people (Bratman et al., 2019). An extensive array of major economic, environmental, health and social well-being advantages were summarized through a study carried out by (Parker & Zingoni de Baro, 2019). Specifically, cultural and regulating services within urban landscapes were largely significant for well-being of people, with growth in the climate change phenomenon, increasing density of population, and growing risk of global pandemics. Adapting GI at diverse scales could augment the adaptability of urban regions to environmental modifications and also facilitate provisioning of ecosystem services through green spaces (Guide, 2021). Furthermore, GI is known to make huge contributions to the green economy by having an instrumental role in adaptation to climate change and migration within urban regions, and also to the circular economy by offering bio-products, which is also intrinsic in generating new job opportunities.

Literature pertinent to the context has revealed that the importance of urban GI connectivity is to a large extent projected through its promotion of biodiversity within the site, the movement of organisms, and functions of ecosystems (Ramyar, 2017a). To realize sustainability within cities, research and application of GI should concentrate on the enhancement of GI connectivity on the whole (Mattijssen et al., 2017). Notwithstanding, a gap in knowledge exists with regards to connectivity modeling of GI networks and its performance for optimization in real world practice. Such a deficiency could hamper effective intervention in planning and management of urban GI to enhance urban resilience (Bagstad et al., 2013). With regards to representation of connectivity, indices of landscape and GIS-based methods that can only derive GI network elements, that is, nodes and corridors separately for analysis are common. It is clear that such methods make it unlikely to intuitively and extensively comprehend the structure and function of a GI network and create obstacles for extensive suggestions to enhance GI connectivity. Owing to the intricacies within GI networks, an integrated approach that comprises of multidisciplinary knowledge and multidomain technology is required for quantitatively simulating the connectivity of GI networks while identifying conservation priorities, making reasonable and multifaceted suggestions for strategic GI network, and planning for habitat conservation (Garmendia et al., 2016).

In addition, the threat of climate change and the recent COVID-19 pandemic have drawn attention to the significance of GI within and around cities, thus triggering an urgent call for highly sustainable and functional planning and designs in urban regions. There have been several studies (O'Brien et al., 2017; Staddon et al., 2018) that were conducted in the recent past which indicated the variety of ecosystem functions and services that are necessary for urban sustainability and human well-being, which is of much significance to challenges to health and climate. The significance of this review would like in the fact that it would stress upon the importance of the current GI for enduring stress that emerge from climate change, such as those pertaining to growth in climate variability and extreme temperature and precipitation events, which are contributory factors for mental and physical health of people residing in urban regions. In such instances, a review of GI in terms of building resilient cities would have a key role to play in offering urban regions with a capacity for resilience which will be intrinsic for urban sustainability. The significance of this review would also lie in the fact that the findings from this review would emphasize on the need for widening and enhancing GI, specifically in European cities that are highly vulnerable on the basis of participatory and integrative procedures.

Given the fact that since several cities across Europe are trying to enhance their urban environments as a medium to tackle climate change mitigation and adaptation, while at the same time enhancing the quality of life for their citizens through GI and nature-based solutions (NBS). NBS as an integral aspect of GI, refers to solutions supported and inspired through nature. By using natural features and nature, and procedures as a response to challenges, they are an addition or replacement to purely technical solutions, adding additional economic, ecological, and social values through their multifunctional attributes (European Commision, 2023). In view of these factors, the findings derived through this dissertation would be instrumental in helping policymakers and planners to derive new insights into the phenomenon and embrace GI from a holistic perspective.

Furthermore, the natural capital or the natural fabric on which our society hinges is largely eroded by urbanization, unsustainable agro-ecosystems and continued expansion and consolidation of what is known as ‘grey infrastructure’, referring to portions of landscape that do not provide any concessions towards, or would be actively hostile to biodiversity. The present regulations within EU make contributions towards ensuring that environmental outcomes of infrastructure development and spatial planning at the EU level are lowered but this has been evidenced to be inadequate to prevent loss of biodiversity and to restrict the incremental fragmentation and degradation of ecosystems, thus justifying the significance of this dissertation. With massive growth in global population and increasing suburban and urban density, there is frequently scant scope for green spaces. Thus, additional incorporating varied kinds of green spaces within the built environment, turns out to be a priority. Thus, exemplifying the significance of this dissertation.

In addition, climate change has the potential to augment the risk of natural disasters such as forest fires and floods. Though intensification of land management and grey infrastructure have revealed the restrictions and negative impacts in tackling such risks, GI would be instrumental in lowering susceptibility, augment natural system resilience, while restoring natural capital within societies while also lowering the possible impacts of natural disasters. Therefore, the significance of this research is evident in the fact that it will examine how GI within European cities would be helpful in reinforcing urban resilience. This will help policymakers and planners to examine strategies for improving GI across cities in Europe.

1.4 Goal of the Dissertation

The purpose of this dissertation is to explore how green infrastructure can be used to facilitate the development of resilience within EU cities.

To achieve this, a review of previous literature will synthesize, analyze, and deliberate the findings from past studies, and present a summary on how resilient cities can be developed by incorporating green infrastructure into their planning and design process/requirements. By summarizing previous findings, this dissertation will aim to make contributions to resilience within European cities, while also providing inputs on how urban planning could likely tackle future challenges. Thus, this dissertation will stress the need to anticipate future requirements, while outlining long-term goals for the future to tackle such challenges.

1.5 Research Questions

1. To what extent does the historical background and institutional framework of Eastern European countries and specifically the Czech Republic influence the implementation and effectiveness of environmental policies, considering the higher regulations set by the European Union?
2. How does the distinction between city Borders and Ecosystem Edges influence the planning strategies for urban development and the application of Blue-Green Infrastructure (BGI) as a strategic solution for climate change adaptation in cities, with a focus on Prague (Czech Republic).

3. How does the social and cultural factor, including the role of users, influence the application and acceptance of Blue-Green Infrastructure (BGI) in urban areas, and how can user involvement in planning contribute to creating a better living environment in cities?
4. How do the robustness and applicability of Blue-Green Infrastructure (BGI) planning methods and technologies vary across different urban contexts, and how can the integration of social, technical, and resource considerations lead to sustainable development outcomes in cities?

1.6 Methodology

A systematic review was the method adopted to conduct this research. This systematic review ascribes to an approach that has been previously utilized by several authors (Parker & Simpson, 2018; Peters et al., 2015). A detailed literature review was carried out, wherein papers that were highly pertinent to the phenomenon being investigated were found through diverse academic databases. The primary keywords used to identify the papers were ‘urban resilience’, and ‘green infrastructure’.

Further, the use of Landscape Functional Units (LaFU) method is also adopted. The technique for evaluating GI within European cities comprised of two key phases;

- Phase I: Planning the GI system, which refers to the identification and analysis of current semi-natural and natural areas and planning the GI system on this basis.
- Phase II: Assessing the GI system which refers to the segregation of the planned GI system into LaFU, and assessing such units for identification of strengths, potential, and threats within the functioning of the GI system.

The method proposed above is founded on the multifunctional and structural approach within GI planning. It intends to link the two vital facets of GI planning viz multifunctionality and connectivity.

1.6.1 Methodology Phases in LaFU

Phase I: Planning the GI System

Phase Ia: Identifying and analyzing semi-natural and natural types of land cover, its spatial connectivity and distribution. This would comprise of areas that encompass diverse types of nature protection, and areas that are unprotected, mainly areas that have greenery of possibly high significance for the GI system.

Phase Ib: Conducting the synthesis of the analysis of semi-natural and natural components and mapping the GI system on its basis.

Phase Ic: Deciding the foremost functions of individual components of the GI system, like regulations on climate, retention and conservation of water, while also ensuring appropriate development of the area in connection with the city and the provision of pertinent ecosystem related services. At the same time, the current and possible advantages of the planned GI system for local communities need to be indicated, which is significant to promote the citizens as well as authorities to initiate steps to safeguard, reinforce and develop the proposed GI system (Niedźwiecka-Filipiak et al., 2022).

Phase II: Assessing the GI System

This phase would comprise of an analysis that will be executed in five steps wherein the first step would be to segregate the area into landscape functional units, the next would be its evaluation. The second and third steps would comprise of designing units that are significant for continuity and communication of GI. The fourth step would be to determine threats from the expansion of built-up areas, and the last step refers to defining the strengthening and protective measures for the GI system.

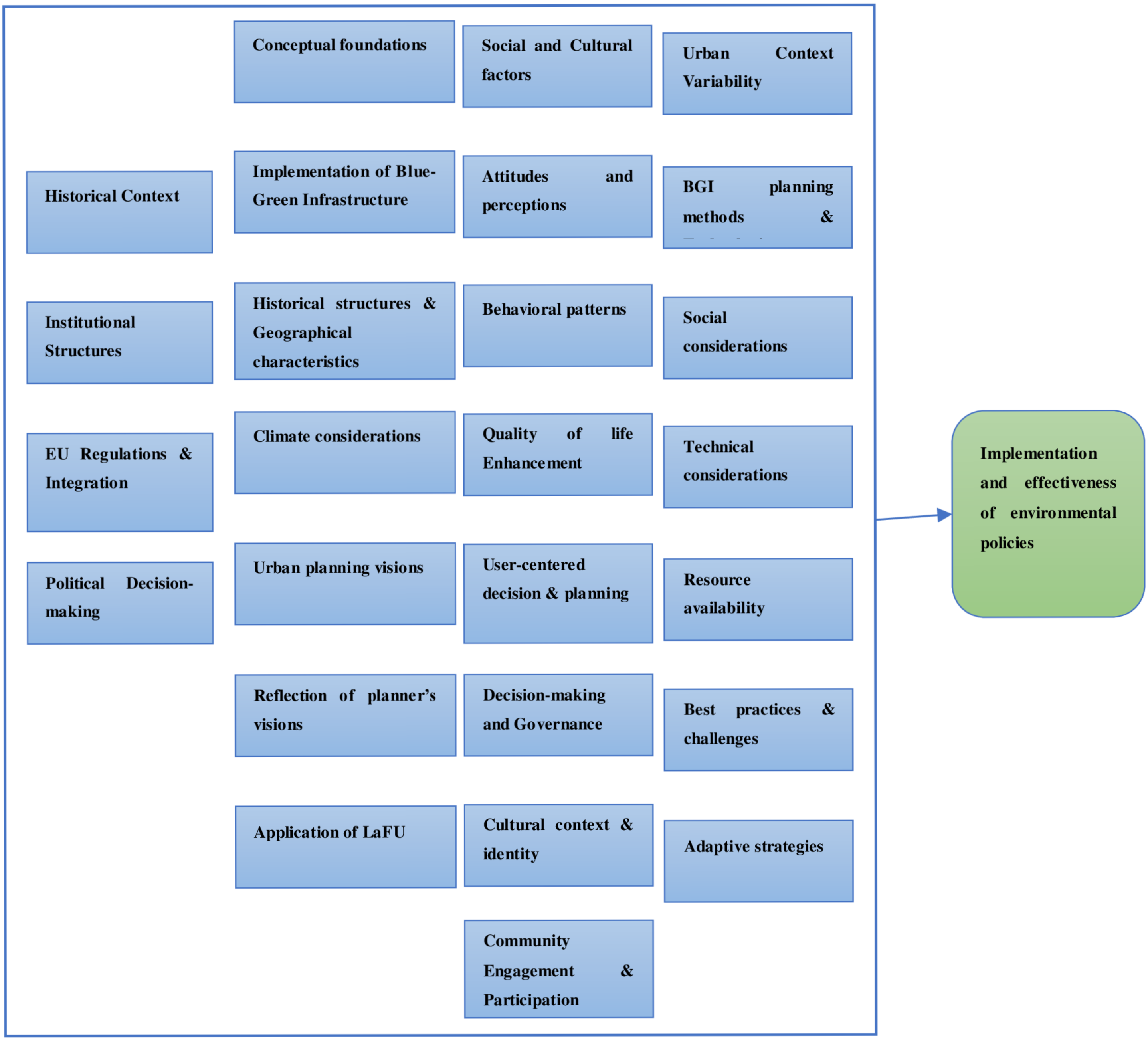
CHAPTER- 2

Conceptual framework

2.1 Conceptual framework:

This chapter presents the conceptual framework for this research thesis, wherein the framework essentially investigates the interaction between environment sustainability, urban development, and strategies for resilience. It comprises of understanding the diverse types of green infrastructure like parks, green roofs, and urban forest, and the multifaceted role it plays in improving the resilience of the city to environmental, social, and economic challenges. Through this research, the idea is to examine the mechanisms through which green infrastructure would contribute to urban resilience by circumventing the impact from climate change, lowering urban heat island effects, improving biodiversity, nurturing social cohesion, and encouraging sustainable urban development practices. In addition, it also involves analyzing the effectiveness of various policy interventions, planning strategies, and governance mechanisms in incorporating green infrastructure within urban landscapes to develop resilient cities that have the capability to adapt to challenges in the future.

Figure 1: Conceptual Framework (Author)



Historical Context: Explore Czech Republic historical background, including its periods of political change, economic development, and environmental challenges. Investigate how historical events, such as the transition from communism to democracy and market economy, have influenced the country's environmental policies. This work will consider factors such as industrialization, urbanization, and the legacy of environmental degradation during different historical phases.

Institutional Structures: Analyze the organizational setup and institutional framework responsible for environmental governance in Czechia. This includes government agencies, ministries, regulatory bodies, and their roles in formulating and implementing environmental policies. This review will investigate the distribution of powers, decision-making processes, and coordination mechanisms among different institutions.

EU Regulations and Integration: Examine the role of the European Union in shaping Czechia's environmental policies. Investigate how EU regulations and directives related to environmental protection have been adopted and integrated into Czech law and Will explore the dynamics between EU-level policies and national implementation, considering challenges and opportunities posed by EU membership.

Political Decision-Making: Delve into the political dynamics that influence the formulation and execution of environmental policies. It will do so by analyzing how political ideologies, party platforms, and electoral cycles impact the prioritization of environmental issues. Consider the role of interest groups, civil society, and public opinion in shaping political discourse.

Conceptual Foundations: Establish a clear understanding of the concepts of "city Borders" and "Ecosystem Edges." Define their significance in urban planning and ecological contexts. Explain how these concepts relate to the spatial configuration and ecological boundaries within urban environments.

Blue-Green Infrastructure (BGI): Define and contextualize BGI as a strategic approach to urban planning that integrates natural and man-made water systems, such as rivers, wetlands, parks, and green spaces, to manage water, enhance biodiversity, and adapt to climate change. Describe its benefits for climate resilience and urban livability.

Historical Structures and Geographical Characteristics: Investigate the historical development and geographical features of Prague. Analyze how its distinct historical contexts, urban forms, and geographical conditions (such as topography, water bodies, and land use patterns) have influenced the establishment of city Borders and Ecosystem Edges.

Climate Considerations: Examine the climate challenges faced by each city, including temperature variations, precipitation patterns, and flooding risks. Explore how these climatic factors influence the need for BGI as a climate adaptation strategy and how city Borders and Ecosystem Edges intersect with these considerations.

Urban Planning Visions: Study the long-term urban planning visions of Prague. Analyze their metropolitan development plans, strategic documents, and policies related to BGI and climate adaptation. Identify the role of city Borders and Ecosystem Edges in guiding the spatial distribution, design, and implementation of BGI components.

Reflection of Planners' Visions: Investigate how the concepts of Edges and Borders influence the visions and strategies of urban planners in Prague. Analyze how planners perceive these concepts in relation to BGI and climate adaptation, and how their perspectives shape the development of spatial interventions.

Application of LaFU (Landscape Functions and Values): Discuss the application of the LaFU approach, which emphasizes understanding the functions and values of landscapes in urban planning. Explore how LaFU principles can inform the incorporation of BGI within the urban fabric, considering ecological, social, and economic aspects.

Social and Cultural Factors: Define and categorize the key social and cultural factors that influence the implementation and acceptance of BGI. These may include public attitudes, perceptions, behaviors, social norms, cultural values, community engagement, and socio-economic backgrounds.

Attitudes and Perceptions: Investigate how residents perceive BGI in terms of its benefits, drawbacks, and relevance to their daily lives. Explore public attitudes toward nature, water, green spaces, and urban aesthetics, and how these attitudes influence the willingness to embrace BGI.

Behavioral Patterns: Examine how people's behaviors and interactions with the urban environment are impacted by the presence of BGI. Study how BGI influences outdoor activities, recreational choices, physical activities, and patterns of social interaction within communities.

Quality of Life Enhancement: Explore how the integration of BGI can contribute to enhancing the overall quality of life in cities. Investigate the impact of BGI on air and water quality, temperature regulation, mental well-being, biodiversity, and the creation of attractive public spaces.

User-Centered Design and Planning: Highlight the importance of involving users in the planning and design of BGI projects. Explore different participatory methods, such as workshops, surveys, focus groups, and community engagement, to gather insights into user preferences, needs, and aspirations regarding BGI features.

Decision-Making and Governance: Analyze how user perspectives are integrated into the decision-making process for BGI projects. Examine the role of local governments, urban planners, designers, and community stakeholders in incorporating user input and how this involvement can lead to more successful BGI implementation.

Cultural Context and Identity: Consider the influence of cultural values, traditions, and identities on the adoption of BGI. Explore how cultural practices, beliefs, and heritage affect people's perceptions of BGI elements and their willingness to engage with them.

Community Engagement and Participation: Study successful case studies where active community engagement has led to the successful implementation of BGI projects. Examine the strategies used to foster community ownership, collaboration, and sustained involvement in BGI planning and maintenance.

Urban Context Variability: Define and categorize the different types of urban contexts, considering factors such as geographic location, climate, population density, socio-economic conditions, existing infrastructure, and governance structures.

BGI Planning Methods and Technologies: Define the range of BGI planning methods and technologies available for urban development. These may include green roofs, permeable pavements, rain gardens, wetlands, urban forests, and more. Discuss their intended functions, benefits, and challenges.

Social Considerations: Investigate how social factors, including community engagement, public perception, cultural values, and social cohesion, influence the robustness and applicability of BGI planning methods. Analyze how different urban contexts impact the acceptance and adoption of BGI among diverse populations.

Technical Considerations: Examine the technical capabilities and limitations associated with implementing BGI planning methods and technologies. Consider factors such as engineering feasibility, maintenance requirements, scalability, and integration with existing urban infrastructure.

Resource Availability: Explore how the availability of resources, such as funding, skilled labor, materials, and land, affects the implementation and success of

BGI projects. Investigate how resource disparities across different urban contexts impact the feasibility of BGI solutions.

Best Practices and Challenges: Conduct a comparative analysis of BGI planning practices across diverse urban contexts. Identify successful case studies and challenges encountered in different scenarios. Highlight the factors that contribute to the effectiveness or limitations of BGI implementation.

Adaptive Strategies: Discuss strategies for adapting BGI planning methods and technologies to suit the specific characteristics of different urban contexts. Explore how flexible approaches can be employed to address unique challenges while maximizing benefits.

CHAPTER-3

Incorporating Green Infrastructure in Territorial Planning

3.1 Background

Green Infrastructure (GI) is deemed as an advantage for territorial development as it offers several functions in the same spatial domain. The inherent principle of GI would be in the fact that the same land area would offer several environmental, cultural, social, and economic advantages as well, given that its ecosystems would be in a robust and healthy condition (Ade & Rehm, 2020). Nonetheless, European ecosystems of value are experiencing degradation owing to fragmentation of land, urban expansion, and the development of infrastructures for energy and transport. This impacts species and habitats, while also reducing functional and spatial logic of the environment as such. Ecosystems that are degraded tend to have low richness in terms of species and would not be in a position to provide similar services as compared to ecosystems that are healthy (Cortina-Segarra et al., 2021). This is the reason why in 2011 the European Union (EU) embraced their strategy for biodiversity, which intended to ensure that by the year 2020, ecosystems and services are sustained and improved with the establishment of green infrastructure and restoring around 15 per cent of the degraded ecosystems (Hattori, 2015). It also warrants the need for member states to map and evaluate the current situation of their ecosystems and services at a national level. In response to the commitment made in terms of the biodiversity strategy, in 2013, the European Commission presented the GI strategy for EU to ensure protection, restoration, creation, and improvement of GI emerge as a key aspect of spatial planning and territorial development whenever it provided a superior alternative, or was complementary, to standard grey choices (Maes et al., 2020).

GI is inclusive of ecological networks, which constitutes natural vegetation areas, other open spaces, or areas with known ecological values, and links that interlink such areas to one another. GI solutions are of particular significance within urban environments wherein around 70 per cent of the population in the EU is known to reside (Staccione et al., 2022). Within cities, GI elements such as green roofs and walls, urban woodlands and garden allotments deliver health-related advantages such as improved reduction in Urban Heat Index (UHI), improvmetn to surface water quality, and contributions to cleaner air. GI also presents opportunities to link rural and urban regions and offers appealing places to live and work. In addition, the restoration of land within cities could prove to be cost-effective and a way that is economically feasible to bring in increased sustainability, and resilience (Baffoe et al., 2021). Regional and local authorities who are usually responsible for decisions pertaining to land-use, are known to have a significant role to play in evaluating environmental impacts and safeguarding, improving natural capital, and conserving (Ruzow Holland, 2022). Integrating GI into associated plans and strategies could be instrumental in overcoming landscape fragmentation and to restore ecological connectivity. It can also improve the resilience of an ecosystems, and thus ensure the consistent provision of ecosystem services while offering healthy environments and recreational spaces for people to enjoy (Di Marino et al., 2019). From this setting, GI can also be perceived as a provider of nature-based solutions that are vital to address societal challenges like unsustainable urbanization and associated human health issues. However, it has been reported that one key barrier in terms of deploying GI would be an inadequate understanding among stakeholders about the way natural ecosystems operate, which frequently leads to underused potential for development of GI (Kabisch, Frantzeskaki, et al., 2016). Improved utilization of incorporated spatial planning procedures, enhanced capacity of decision-makers and better institutional cooperation are significant components to tackle such challenges.

Territorial planning has been recognized to play a key role in tackling climate change mitigation and also adapting to its unavoidable impacts (Ray Biswas & Rahman, 2023). This perception is derived from the understanding that territorial configuration of cities and towns, and the manner in which land is being utilized and developed have substantial impacts on climate change (Jia et al., 2022), and would be key to enacting adaptive responses to such changes. Significantly, modern empirical research has revealed that institutions for planning are vital drivers of adaptation to climate change. As per a recent review regarding the significance that legislation has upon climate change adaptation has identified land-use planning as a highly effective tool to lower exposure and sensitivity to extreme weather events in several instances (McDonald & McCormack, 2021). Irrespective of the role of planning in tackling climate change adaptation, it is not universally agreed upon. For instance, (Boyd et al., 2022) are of the opinion that planning could positively contribute to adaptation and mitigation of climate change. They have indicated that previously planning systems have delivered policy that has been unfavorable to climate change. The results were inclusive of building codes not adhering to energy efficiency, dependence on fossil fuels, suburban sprawl, obsession with automobiles, and failure to take environmental externalities into account. Given these factors, it becomes imperative to investigate the need for incorporating GI into territorial planning.

3.2 Role of Green Infrastructure in Territorial Planning

Over the years GI has gained much attention as a vital element in territorial planning. It refers to a network of semi-natural and natural features, that are strategically designed and managed to offer an array of ecosystem services, improve biodiversity, and contribute to the well-being of rural and urban areas on the whole. The integration of GI within territorial planning has been identified as a sustainable strategy to tackle social, environmental, and economic challenges. According to Tirla *et al* (2014), GI has a key role to play in improving the provision of ecosystem services like water and air purification, climate regulation, and recreational opportunities. The authors also stress upon the significance of GI in promoting urban resilience by mitigating the effects of climate change and improve adaptive capacity of cities. This view is additionally supported by Fu, Hopton and Wang (2021),who have argued that incorporating green spaces in territorial planning enhances the ability of a region to withstand environmental stressors.

A key advantage of GI refers to the contribution it makes towards conserving biodiversity. It has been highlighted by Farinha-Marques *et al.*(2011),that GI networks would be beneficial in offering habitats for diverse species, enabling their movement and improving genetic diversity. Furthermore, (Nilon et al., 2017) have deliberated the role played by GI in urban biodiversity and highlight the significance of planning for connectivity within green spaces for supporting wildlife movement. In addition, the link between GI and human health has been well-recognized. There are several studies that have indicated that access to green spaces had a positive impact on mental and physical well-being. According to Shanahan *et al* (2014), exposure to greenery tends to lower stress while improving cognitive function, resulting in enhanced mental health on the whole. Moreover, a study carried out by Kabisch, van den Bosch and Lafortezza (2017), stressed upon the fact that GI that is well-designed could promote physical activity and social interactions, which contribute to healthier lifestyles. GI also has the scope to tackle social inequalities and nurture inclusivity. The concept of 'just GI' was discussed by Wolch, Byrne and Newell (2014), who stressed that accessibility and equitable distribution of green spaces could encourage social cohesion while lowering disparities in access to nature. In addition, (Schirpke et al., 2020) are in favor of participatory territorial planning procedures that comprise of local communities within design and management of GI, to ensure that it met the varied needs of people.

Other than the social and ecological role of GI in territorial planning, GI has the potential to provide economic advantages as well. It has been argued by Hanna and Comín (2021), that investments in GI could result in increased property values and attract businesses, thus making a sizable contribution to development of the local economy. In addition, evidence has been presented by Costanza *et al.,* (2014), regarding ecosystem services offered by GI tends to provide significant economic value, which underlines its scope to lend support to economic growth which is sustainable. However, though the advantages of GI in territorial planning have been largely recognized, there are challenges when it comes to its implementation in an effective manner. It has been posited by Pauleit *et al.,* (2020), that governance structures that are fragmented and insufficient funding could hamper the establishment of unified green infrastructure networks. Furthermore, the need for incorporating conventional ecological knowledge along with scientific expertise for successful GI planning was highlighted by Colding and Barthel (2019). There are many case studies that demonstrated successful incorporation of GI into territorial planning. For example, the 'Superkilen' park project in Copenhagen, Denmark as indicated by Fleming (2023), projected how the necessities of various communities could be met on the basis of innovative design in green spaces. In the same vein, the approach adopted by the city of Singapore to integrate greenery within their urban fabric, as elucidated by Han (2017), offers valuable insights into effective GI execution in areas that were densely populated.

The literature here underlines the vital role played by GI in territorial planning. It presents a multifaceted approach to tackle social, environmental, and economic challenges while encouraging ecosystem services, conservation of biodiversity, well-being of humans, and social equity. Nonetheless, challenges pertaining to governance, funding, and interdisciplinary collaboration need to be circumvented to wholly understand the scope of GI in shaping resilient and sustainable territories.

3.3 Methodology

This chapter adopts a *systematic review* as the principal methodology. A systematic review refers to a methodology that produces an overview of outcomes from primary research, pertaining to a particular research question. It tends to vary from conventional literature review in the manner that it recognizes, chooses, synthesizes, and assess only evidence that is of high quality, based on a rigorous, explicit, and specific procedure (Van Rooyen et al., 2018). The notion of a systematic review is to establish what the best evidence is with regards to a particular question and utilizing it for informing practice and policy. Thus, it is in line with the transition to an evidence-based approach for decision-making for policy.

3.4 Findings

Based on the findings derived through a study conducted by Sturiale and Scuderi (2019), it was indicated that GI are identified as best practices within local governance when merged with conventional 'grey' infrastructure to realize sustainability and resilience. Furthermore, GI have been identified for their value in terms of adapting to the emergent and irreversible impacts from climate change. Moreover, certain local governments have embraced GI as a measure for adapting to climate change, especially in case strategies lead to several other advantages. Certainly, adaptation to climate change is perceived as having economic, social, and ecological advantages. Similarly, it was reported by Li *et al.,* (2020), that GI and their incorporation within territorial planning emerged as one of the most apt and impactful ways to enhance microclimate and confront the effects of climate change. GI forms comprise of green walls, green roofs, bioswales, urban forest, urban agriculture, rain gardens, peri-urban agriculture, collective green, local products market, river parks, areas of constructed wetlands, nature conservation areas, and alternative energy farms.

(Sussams et al., 2015) in their study revealed that provision that GI has been extensively identified as having a major role in catering to the challenge of climate change adaptation. Incorporating GI within ecosystem-based territorial planning renders the design of GI assets as a vital tool for planning for developing highly sustainable urban environments, that are resistant to future challenges and adapting to needs of the future. GI is well establishing within strategies for climate adaptation, however, they added that it was of importance that such strategic tools are promoted through particular incorporated territorial and urban planning such as planning and sustainability in decision-making, long-term investments, GI models for climate change adaptation, and for optimal multiple advantages. Based on the findings derived through the research carried out by Bush *et al.,*(2021), it was reported that the escalating impacts from climate change was reshaping the urban landscape on the whole, warranting innovation in approaches that can be adopted. Territorial plans that incorporate GI have turned out to be a promising strategy to improve urban resilience against climate related challenges.

The studies that were reviewed continuously stressed the several benefits of incorporating GI into territorial plans for climate adaptation. At the outset, GI tends to act as a natural buffer against urban heat islands, with green spaces and vegetation mitigating fluctuations in temperature and improving microclimates in urban areas. This finding was at par with the studies carried out by Xue *et al.,* (2019) and (A. Coutts et al., 2010), who showed the cooling impacts of GI on urban regions. Secondly, inclusion of GI helps to manage stormwater and lower risks from floods. Green roofs, permeable surfaces, and constructed wetlands in GI systems extensively contribute to effective stormwater drainage and retention, as is evidenced through research executed by Quagliolo *et al.,* (2022) and (Khodadad et al., 2023). Thirdly, GI tends to promote ecosystem and biodiversity services in urban environments. Urban green spaces offer habitats for diverse species, which contribute to urban wildlife conservation and improving resilience within urban ecosystems. Third, GI encourages ecosystem services and biodiversity within urban environments. Habitats are provided through urban green spaces which accommodate several species, thus contributing to conservation of urban wildlife and improving the resilience of urban ecosystems (Langemeyer & Gómez-Baggethun, 2018).

At the same time, it has been posited that many challenges have been found at the time of incorporating GI within territorial plans for climate adaptation. One of the foremost challenges was identified as restricted available space within urban regions. This was particularly true in cases of cities that were densely populated. This finding has found support through findings derived from studies carried out by Ge, Wang and Song (2023), which highlighted the competition amongst green space preservation and urban development. Furthermore, government structures that are fragmented have also proved to be a challenge, which hampers coordinated territorial planning and execution. This challenge has been covered through the study carried out by Bulkeley, Broto and Edwards (2014), which emphasized the significance of cross-sectoral collaboration between urban policymakers, planners, and other stakeholders. Further, financial restrictions have been identified to be a major restriction in implementing GI projects for territorial planning. The costs linked to designing, executing, and sustaining GI systems have been deliberated through studies carried out by Breuste *et al.,* (2015) and Schwarz et al., (2015), which underscored the necessity for innovative mechanisms in financing.

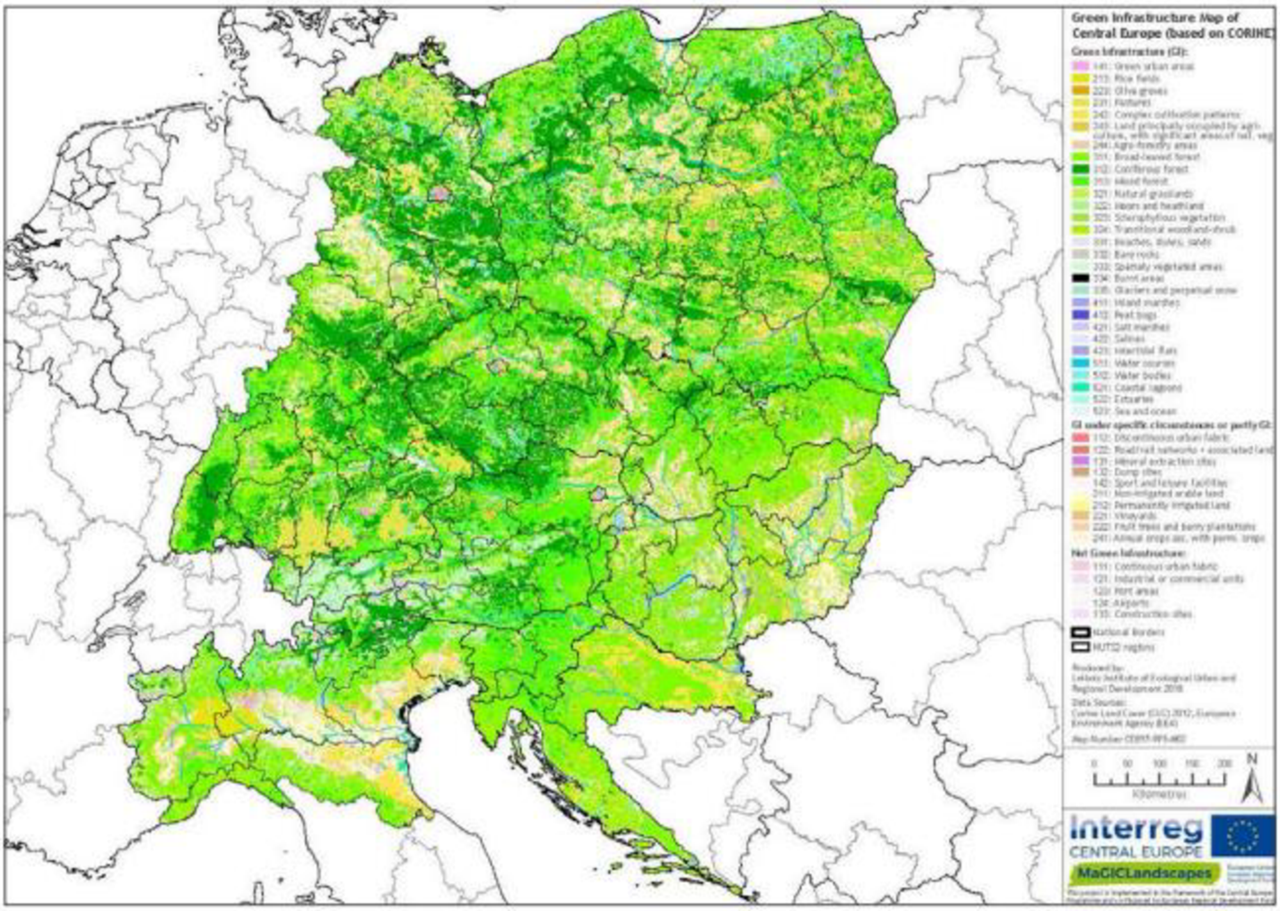
On the basis of this systematic review, it was possible to identify several successful case studies that highlighted the incorporation of GI in territorial plans. The 'Cloudburst Management Plan'(Arnbjerg-Nielsen et al., 2013) of Copenhagen, and Melbourne's 'Green Infrastructure Strategy'(Sturiale & Scuderi, 2019), indicated effective urban cooling and flood management through green infrastructure. Similarly, the 'ABC Waters Program (Feng, 2021)' of Singapore, showcased innovative approaches in managing stormwater with the help of green infrastructure. In addition, the 'Toronto Green Streets' initiative (Sekulova et al., 2021), revealed the transformation of urban streets into green corridors, improving urban aesthetics and stormwater management.

From the systematic review thus executed on recent academic literature underlines the importance of green infrastructure into territorial plans for climate change adaptation. Green infrastructure provides benefits that are multifunctional in nature, which are also inclusive of stormwater management, urban cooling, and conservation of biodiversity. Though challenges like fragmented governance, limitations of space, and financial restrictions continue to exist, successful case studies and evolving best practices offer valuable inputs for urban planners and policymakers to maneuver bottlenecks of such kind and achieve the potential of green infrastructure for resilient urban development.

3.5 Geographical Delimitations of Green Infrastructure

Recognizing Green Infrastructure (GI) as a key element within rural and urban environments has witnessed a substantial growth in recent times. With the threat of climate change, rapid urbanization, and environmental degradation looming large, the need to identify and map GI within territories has assumed much significance. GI comprising of a network of semi-natural and natural regions, acts as a vital tool for encouraging ecological sustainability, improving resilience, and enhancing the quality of life for inhabitants on the whole (Liquete et al., 2015). From an urbanization context, the expansion of cities is frequently at the expense of green spaces (Puplampu & Boafo, 2021). Concrete cities soon replace lush greenery, and natural ecosystems are replaced with built environments. Such kind of an urban transformation is known to have severe consequences for the well-being of communities, and the environment on the whole (Colding et al., 2020). Nonetheless, recognizing the importance of GI presents a ray of hope. Through a systematic identification and mapping of GI within a territory, policymakers, as well as planners acquire insights into the distribution of such vital natural assets (Ramyar et al., 2020). This knowledge tends to act as the base for decision-making that is largely informed, and devising strategies that could result in a highly livable and sustainable future.

Figure 2: Map of Green Infrastructure for Central Europe Source: (Interreg, 2020)

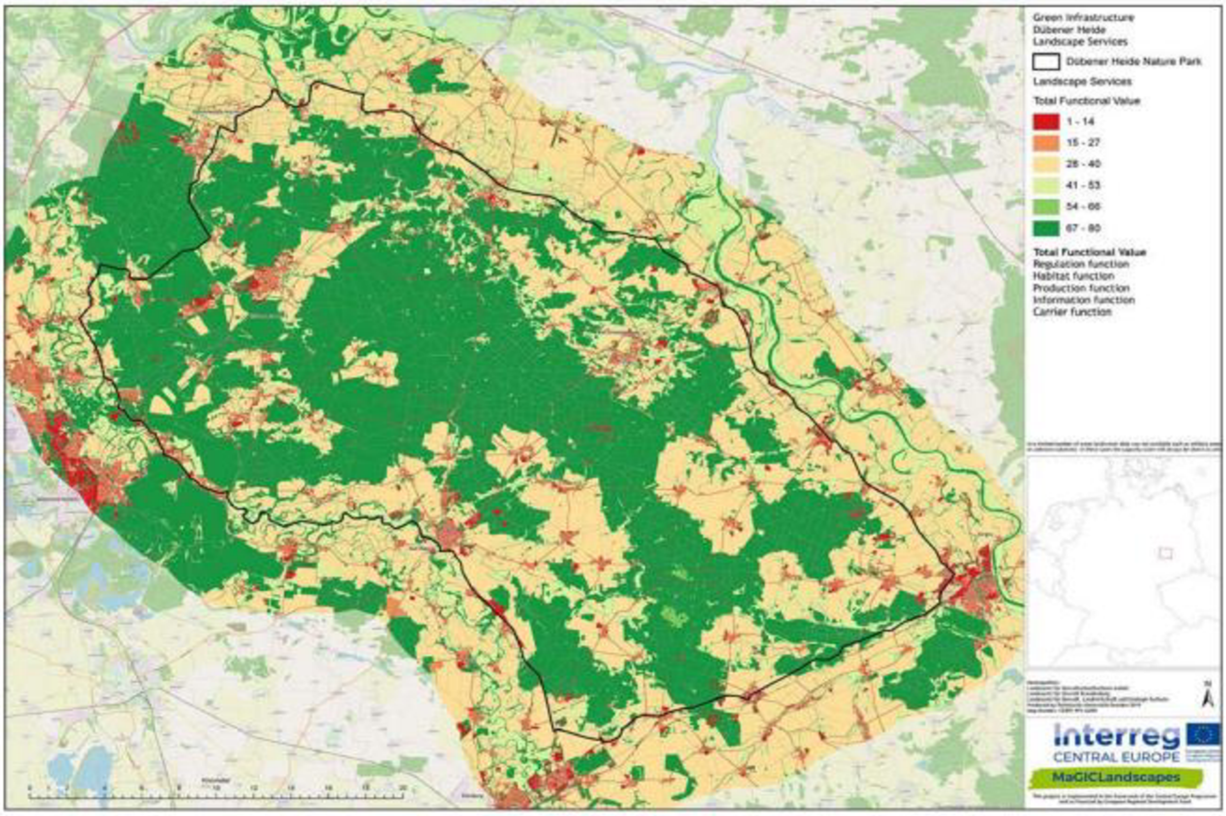


From an ecological point of view, the significance of mapping GI would lie in its capability to unravel the complex web of interlinked ecosystems. By gaining an in-depth understanding about the locations of forests, water bodies, wetlands, and other green spaces, authorities would be in a position to protect hotspots of biodiversity and conserve habitats that are essential for the survival of diverse species (Lepczyk et al., 2017). In addition, mapping has been proven to be helpful to recognize wildlife corridors that allow movement and genetic exchange between habitats that are fragmented.

Such type of a connectivity, as is indicated through recent research (Janiszek & Krzysztofik, 2023) (Zellmer & Goto, 2022), not just extends its support to ecosystem resilience but it is also instrumental in contributing to necessary services that they offer, like water purification, pollination, and carbon sequestration. The importance of mapping green infrastructure goes beyond ecological considerations. It is innately associated with social well-being and quality of life. Having access to green spaces have been exhibited to make a positive impact on physical and mental health, thus acting as a contributory factor to stress reduction and enhanced psychological states (Browning et al., 2022). Such advantages are not distributed across communities in an equal manner, which frequently results in disparities in access to nature and its interlinked benefits. With GI mapping, policymakers and urban planners will be able to identify areas that lack green spaces, enabling them to initiate targeted interventions that enable equitable access to such vital resources. An approach of this kind would be at par with the notion of environmental justice, intending to build healthier and inclusive communities for all (James et al., 2015).

From an economic perspective, mapping GI enables multifaceted benefits. Green spaces are known to increase the value of properties within urban regions, thus creating desirable neighborhoods which tend to attract residents and businesses as well (Garcia, 2019). Furthermore, the existence of GI has been associated with lowered costs of healthcare, as access to nature tends to promote physical activity while contributing to enhanced well-being on the whole (Butt et al., 2018). With a quantification of economic benefits from GI, policymakers and urban planners will be able to make a compelling case to drive investments towards expansion and preservation of green spaces.

Figure 3: Green Infrastructure Functionality Map (Interreg, 2020)



The significance of identifying and mapping green infrastructure in a territory is something that cannot be undermined. It acts as a vital step in terms of tackling the challenges presented through urbanization and climate change while nurturing resilience of the ecology, improving social well-being and unlocking economic opportunities. Given its significance, this chapter focuses on exploring the importance of identifying and mapping green infrastructure within a territory. At the same time, it will also delve into the geographical delimitations of green infrastructure.

3.6 Techniques and Tools for Mapping Green Infrastructure

Loss of biodiversity and climate changes are the foremost two challenges of current times (UNESCO, 2018). At every level, there has been a decline in biodiversity across the world and at rates that are unprecedented, mainly owing to changes in land and sea use, climate change, direct exploitation of organisms, invasive alien species, pollution, and these will be on a downward spiral in case no concrete action is initiated (Newbold et al., 2015). In order to sustain their functions, ecosystems are losing their resilience, which will eventually endanger our water and food security, deteriorate our health, and threaten our socio-economic well-being (McGill et al., 2015). As per estimates, it has been projected that around 68 per cent of the world's growing population would be residing in urban regions by 2050, which will eventually augment the pressure for developing grey infrastructure for mobility, housing and economic use. In tandem with other human initiatives, urbanization would continue to have severe repercussions for providing benefits of ecosystem to people and biodiversity. Increase in demand for new residential spaces is a key driver of policy within urban land use planning and management, road constructions also project a global threat to biodiversity (Meijer et al., 2018). Regardless of the diverse initiatives dedicated towards conservation of nature and widening protected areas, there is failure in terms of meeting Aichi targets, as set by the United Nations Convention on Biological Diversity (Tittensor et al., 2014).

Schemes towards nature conservation have conventionally concentrated on preserving species and safeguard wilderness but recently it has witnessed an evolution into a holistic approach that is more oriented towards nature and people (Mace, 2014), where management of landscape is done with the objective to support humanity and biodiversity over a long-term period (Kremen & Merenlender, 2018). This new model considers the vital interactions between nature and people while evaluating economic, social, and ecological systems on the whole. Such a novel framing demonstrates the reliance on ecosystems while stressing that people are part of nature, not apart from it (Georgina Mace, 2016). Considering that degradation of land is one amongst the leading threats to biodiversity and natural habitats, the significance of our natural capital in terms of decision-making needs to be better stressed upon to enhance sustainability within landscape management (Piers Blaikie & Harold Brookfield, 2015). Such kind of recognition has given rise to the notion of GI for helping conserve a functional network of ecosystem based on land-use planning. GI elucidates an interlinked network of semi-natural and natural areas designed and managed to deliver an extensive array of social, economic, and ecological advantages (European Environment Agency, 2014b).

GI pertains to a network of semi-natural and natural aspects that offer necessary ecosystem services within peri-urban and urban areas. With continuous growth in urbanization, incorporation of GI within urban planning has proved to be vital for encouraging sustainability, resilience, and well-being of urban people on the whole (Semeraro et al., 2017). In order to effectively integrate GI within urban planning, precise and in-depth mapping is necessary. This makes it imperative to examine the tools and techniques that are used for mapping GI.

Geospatial technologies like Geographic Information Systems (GIS) and remote sensing, form the crux in GI mapping. GIS enables the incorporation of varied spatial data sources, facilitating planners to identify appropriate locations for GI components, evaluate connectivity, and prioritize the efforts at conservation (Thekkan et al., 2022). Remote sensing technologies on the other hand, comprise of satellite imagery and LiDAR (Light Detection and Ranging), offering high-resolution data for detecting cover changes in vegetation, land use transformations, and urban expansion (Bartesaghi-Koc et al., 2019). Apart from physical delineation, mapping of GI would comprise of quantification of the ecosystem services provided by such green components (Ayanu et al., 2012). With the help of ecosystem mapping, it is possible to assess the contribution made by GI, like wetlands, parks, and urban forests, to services such as water regulation, air purification, and recreational opportunities. Similarly, approaches such as InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) present frameworks for quantification of such services, allowing a cost-benefit analysis to be carried out on GI projects.

In addition, effective mapping of GI would also take under its ambit the cultural and social dimensions by considering the needs and preferences of communities. Participatory mapping tends to engage local residents for identification of areas with recreational or cultural importance. Incorporating such insights with physical GI features improves the involvement of community and the cultural pertinence of green infrastructure initiatives (Abualhagag & Valánszki, 2020). Further, technological developments present innovative techniques for GI mapping. Drones (Unmanned Aerial Vehicles), offer an efficient and flexible way to capture images with high resolution for analyzing vegetation and assessing land cover (Budiharto et al., 2021). Moreover, data that is crowdsourced and mobile applications enable people to make contributions towards GI mapping, nurturing community engagement and urban planning that is collaborative. In order to smoothen the intricate procedure of GI mapping and decision-making, incorporated decision support systems are fast gaining prominence. Such platforms are known to blend spatial data, analytical tools, and inputs of stakeholders to aid planners in identification of optimal GI configurations, taking the social, ecological, and economic factors into account.

3.7 Case Studies of Successful Mapping of Green Infrastructure

3.7.1 Vancouver, Canada: Green Infrastructure Network Mapping

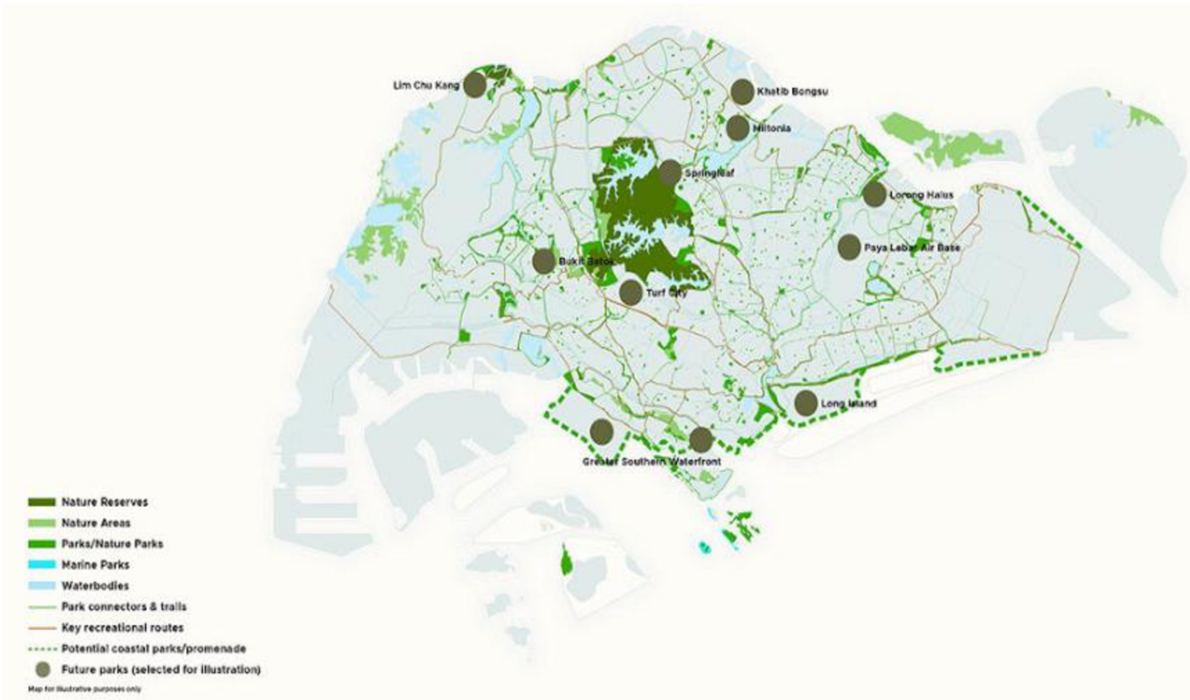
The city of Vancouver undertook an ambitious project for mapping their green infrastructure network with the help of advanced geospatial technologies. The purpose of this initiative was to develop an extensive inventory of urban green spaces, which comprised of street trees, parks, and wetlands. The project used a blend of high-resolution satellite imagery, LiDAR data, and ground-level surveys to precisely capture the level and distribution of green assets (Taya Lynn Triffo, 2022). One amongst the unique features of the approach adopted by the city of Vancouver referred to its incorporation of citizen science. Community members were actively involved in the process of data collection, verification, and mapping. This was instrumental in not just enhancing the precision of the map, but it also nurtured a feeling of ownership and pride amongst residents for their local green spaces. The resulting green infrastructure map turned out to be a valuable instrument for urban planners, which helped them to arrive at informed decisions pertaining to efforts towards conservation, infrastructure development, and land-use planning (Taya Lynn Triffo, 2022).

Figure 4: Existing and Proposed Greenways in Vancouver (City of Vancouver, 2022)

3.7.2 Singapore: Geospatial Technologies for Urban Green Mapping

The city of Singapore is densely populated and restricted with limited land resources, realized the significance of mapping their green infrastructure to improve urban livability. The city implemented a Green Plan 2030, with the help of cutting-edge geospatial technologies that comprised of LiDAR, and also multispectral imagery, for creating an extensive map of green spaces, water bodies, and vegetation cover (Sini, 2020). The major components of Singapore's mapping approach comprised of real-time data updates and accessible digital platforms. The data was consistently updated for reflecting changes within the urban landscape, and the map was made available to the public through user-friendly applications. Such an approach not only allowed the engagement of citizens but also supported urban planning decisions that accorded priority to sustainable development and green spaces (Sini, 2020).

Figure 5: Green and Blue Mapping of Singapore Source: (Urban Redevelopment Authority, 2024)

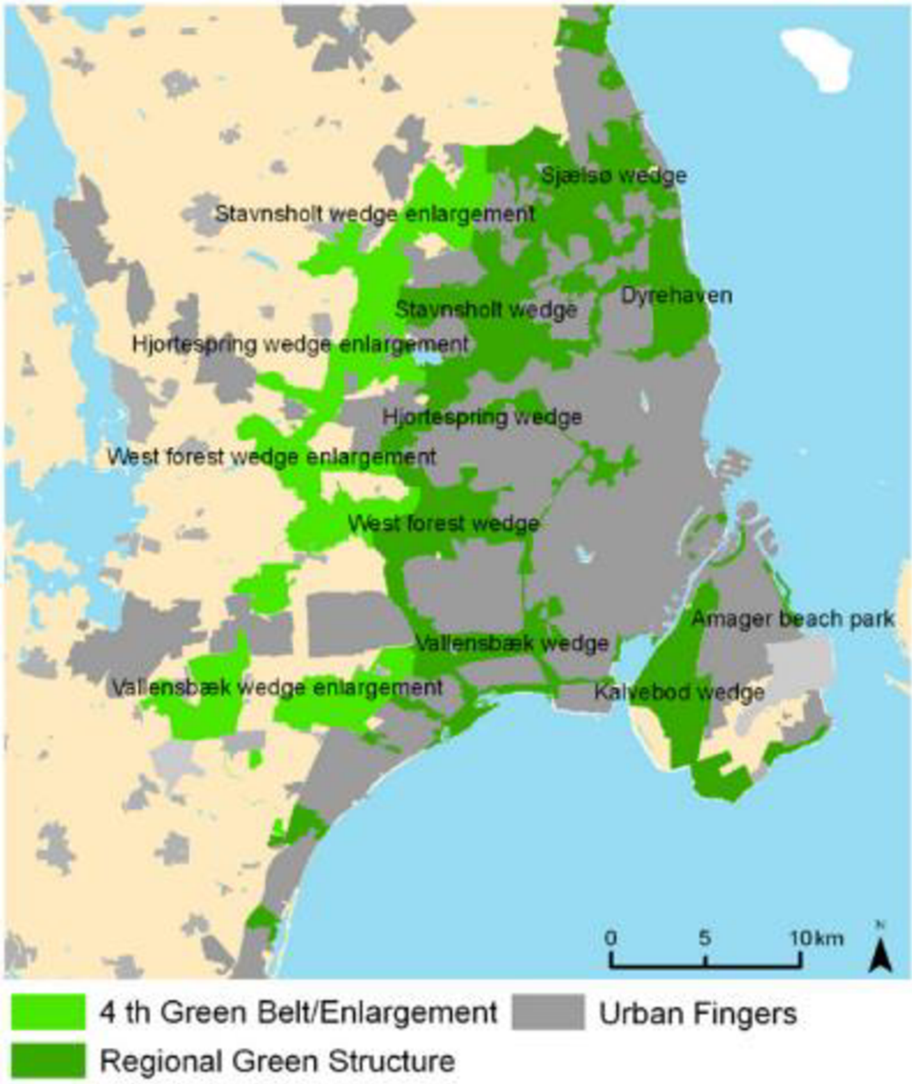


The concept of CIAG adopted by Singapore is based in the government principle of space optimization, as per which it has recommended land productivity maximization (Ministry of National Development, 2015). It is presently being executed at an exhaustive level on the basis of novel typologies of towns that have been defined by public housing with an increased population density acquired with new standards for high-rises, and novel environment-friendly living solutions gained from skyrise greenery. Similarly, it has been posited by Tan, Wang and Sia (2013), that on the basis of novel experiments in the domain of green architecture, the city with scarce land has come to be termed as vertical garden city, which offers a valuable lesson to the world that planning could include more than one function on the same land-coverage.

3.7.3 Copenhagen, Denmark: Participatory Green Infrastructure Mapping

As a city, Copenhagen in Denmark is known for its commitment to livability and sustainability. They initiated an approach for mapping their green infrastructure. It was recognized that community engagement and local knowledge was essential to capture their green assets from a holistic perspective (Rusche et al., 2019). In order to realize this, Copenhagen introduced a mobile application that enabled residents to report green spaces, recommend regions where green development could be facilitated, and share information regarding their preferred natural areas. The approach adopted by the city of Copenhagen, the participatory approach, was instrumental in not just enriching the dataset but it also empowered citizens to proactively make contributions to the conservation and improvement of their environment (Rusche et al., 2019). This technique led to the creation of a highly exhaustive and precise map of green infrastructure, reflecting both the emotional links and physical assets that citizens shared with these spaces. As a matter of fact, the UGI isolation map of Copenhagen reveals robust links with the 'fingers', that are settlement extensions alongside the key corridors of transport. Nonetheless, for every central region with fingers, there was found to be a similar picture of isolation as in the city centre.

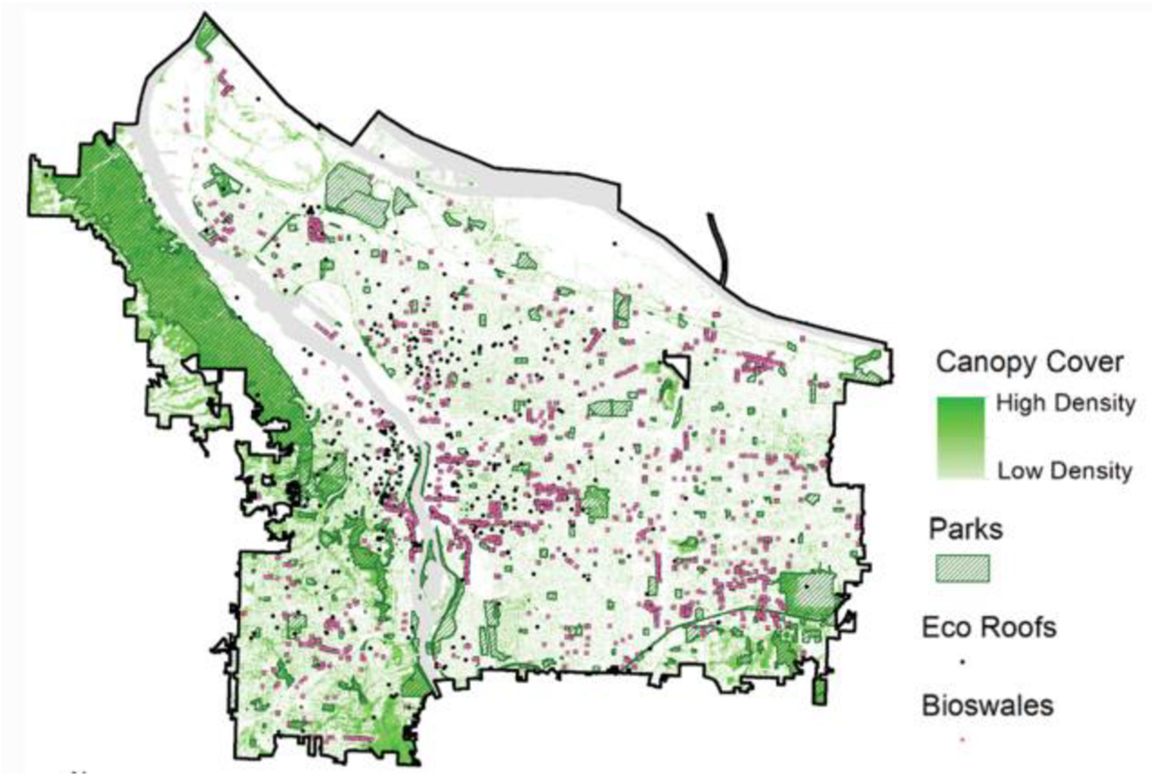
Figure 6: Green Structure of Copenhagen Source: (Caspersen & Olafsson, 2010)



3.7.4 Portland, United States: Urban Greenprint for Equitable Green Infrastructure

The city of Portland, in Oregon adopted a rather holistic approach towards green infrastructure mapping by incorporating economic, ecological, and social data. The project on urban greenprint intended to prioritize the development of green infrastructure while ensuring accessibility and equity across varied communities (Ahmad et al., 2018).The project overlaid habitat quality, connectivity, and social vulnerability data to develop a spatially explicit map that guided initiatives towards conservation and identified areas for expansion of green infrastructure.

Figure 7: Distribution of Diverse GI Elements in Portland Source: (Shandas & Hellman, 2022)

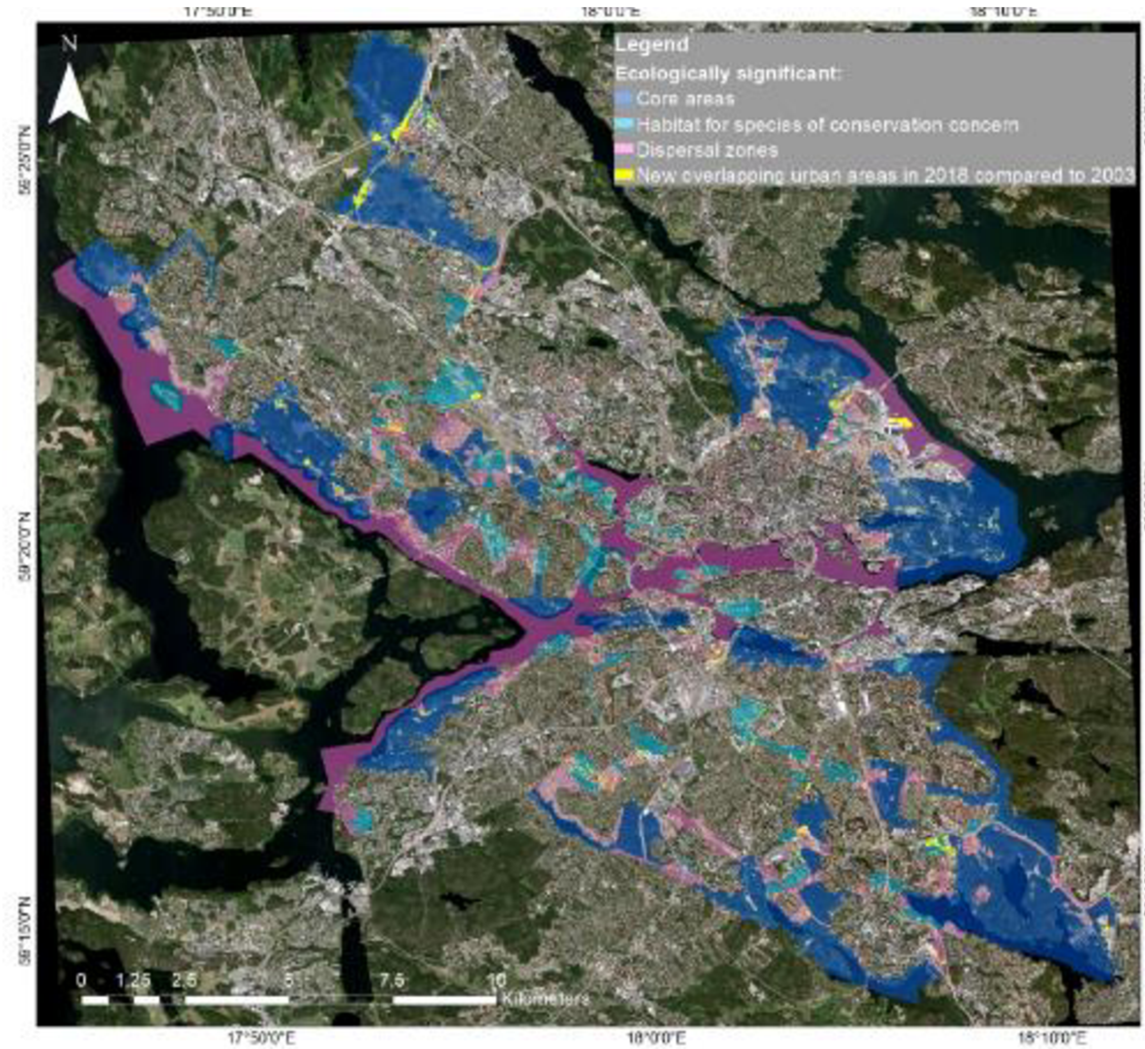


By tackling concerns on social equity, the urban greenprint project illustrated that impactful green infrastructure mapping must not exclusively concentrate on ecological factors but also take under its ambit the dissemination of advantages and access over various socio-economic groups. The map acted as a strategic tool for policymakers and planners to arrive at decisions that were well-informed and promoted both environmental sustainability and social inclusivity (Ahmad et al., 2018).

3.7.5 Stockholm, Sweden: Green Infrastructure Mapping

In recent times, Stockholm has emerged as a ground-breaking example of effective green infrastructure mapping. The commitment of the city to environmental sustainability resulted in the implementation of an extensive mapping project focused on identification, preservation, and improvement of its green spaces (Xiu et al., 2016). By harnessing advanced geospatial technologies and engagement from the community, Stockholm has managed to create a harmonious blend of urban development and natural landscapes. The GI mapping project within Stockholm comprised of the collaboration and coordination of several stakeholders which included environmental organizations, governmental bodies, and residents as well. With the help of satellite imagery, ecological surveys, and GIS data, the project was able to successfully map forests, existing parks, wetlands, and other green spaces around the city (Wikström, 2020). Such kind of mapping not only helped in evaluating the present state of GI but also guided decisions pertaining to future urban planning and development.

Figure 8: Green Infrastructure Mapping Stockholm (Furberg et al., 2020)



One of the remarkable outcomes from this endeavor refers to green corridor optimization that links various parts of the city. Such corridors not just provided recreational spaces for citizens, but also acted as key habitats for wildlife, encouraging biodiversity in an urban region (Wikström, 2020). Furthermore, the mapping project was instrumental in identifying regions that were prone to flooding, enabling targeted green solutions like rain gardens and permeable surfaces to be incorporated, thus overcoming possible risks. Success in Stockholm's GI mapping could be credited to their wholesome approach, which merged data-driven insights with active involvement of people from the community. The outcome is a highly resilient and sustainable landscape, where the incorporation of nature into urban planning has improved the quality of life for their residents, while protecting the environment for generations in future.

3.8 Provision of Ecosystem Services, Biodiversity, and Ecological Connectivity in Territorial Planning

Ecosystem services (ES) that are termed as advantages that individuals acquire through the ecosystem, have an integral role to play for people around the world (Costanza et al., 1997). Research pertaining to ecosystem services has widened its impact on territorial planning and landscape ecology, turning out to be a necessary focus of the movement on sustainability. Such an incorporation offers the scope to improve usefulness, usability, legitimacy, and effectiveness of ES in territorial planning with the creation of ES that is basic to the well-being of humans. ES has been exhaustively known to be largely significant, therefore, there is a need to apply it in a practical manner and become a potent instrument for environmental and land-use planning to aid decision-makers (Lerouge et al., 2017),(Woodruff & BenDor, 2016). Proper polices are vital for incorporating ES in territorial planning (Grêt-Regamey et al., 2017). It has been indicated through studies carried out in the real world that ES has been revealed to enable the process of decision-making that caters to various needs (Cortinovis & Geneletti, 2018). Knowledge about ES is realized at a conceptual level on the basis of reframing dialogues and increasing the awareness of stakeholders, at a strategic level by extending support to policy and planning, and at a very crucial level by directing particular decisions (McKenzie et al., 2014).

Scientists in 2011 had suggested that ES would have a pedagogic role to play in modern territorial planning (Colding, 2011). The notion of ES can act as a supplement to current instruments pertaining to policy and those that concentrate exclusively on a particular sectoral interest or task (Hauck et al., 2013), incorporate ecosystem services within their territorial planning and decision making. ES is known to have the scope for reinforcing urban nature and considering the advantages from planning (Hansen et al., 2015), improve the quality of life and resilience within cities, while recognizing an increasing array of socio-cultural impacts and economic costs (Gómez-Baggethun & Barton, 2013). Developing ES approaches would play a key role in contributing to environmental effect mitigation and enhance urban resilience. Planners are well-aware of this and so are keen to incorporate it within their plans (Mascarenhas et al., 2014). As far as comparative models are concerned, ES has emerged as a robust instrument for planning, that can enable achievement of sustainable development goals and an enhanced understanding about trade-offs.

Similarly, incorporating information on biodiversity and principles of conservation within territorial planning, will enable decision-makers to lower the adverse impacts arising from development, on biodiversity such as streamflow modification, forest fragmentation, and introduction of invasive species. Biodiversity as a term would refer to the variety of life on earth at every level, from species to ecosystems, and will also take under its ambit the ecological, evolutionary and cultural procedures that tend to sustain life (Allred et al., 2021). Intricacies within natural processes and systems which sustain biodiversity would not willingly incorporate within the conventional framework of territorial planning, that would frequently comprise of parcel scale decision-making, with scant attention being accorded to biodiversity resources shared with neighbouring communities or the wider ecological setting. Such kind of a mismatch could lead to developmental patterns that are rather sprawling that utilize territories in an inefficient manner and tends to disproportionately impact biodiversity.

At the same time, ecological connectivity pertains to the level to which a territory enables or hampers movement within resource patches (Perrin et al., 2022), or the ease with which individuals will be able to move around within the territory. However, it would also comprise of the flow or movement of abiotic factors like water and nutrients. Ecological connectivity is a significant condition for sustaining the unhindered movement of species and enabling the flow of natural procedures that sustain life within earth (Collard et al., 2020). Though loss of habitat continues to be basic threat to biodiversity, ecological connectivity warrants the need to maintain it within and among habitats in terrestrial and aquatic systems that enable dispersal, migration, re-colonization, prevention of in-breeding, and sustaining several other ecological procedures. In addition, with species being compelled to alter their distribution by climate change, as a response to the changing conditions of the environment within their conventional range, sustaining ecological connectivity could act as the lynchpin for the persistence of several wildlife populations.

Given these factors, this chapter will delve into providing ecosystem services, biodiversity, and ecological connectivity within territorial planning.

3.9 Zoning of Territorial Planning Instruments to Consider Ecosystem Services, Biodiversity, and Ecological Connectivity.

Territorial planning is a basic tool used for managing land use and development for realizing diverse economic, social and environmental objectives. Of late, there has been an increasing recognition about the necessity for incorporating ecosystem services, biodiversity conservation, and ecological connectivity within zoning and territorial planning instruments (McShane et al., 2011). Such a transition projects an understanding about the key role that natural ecosystems have to play in lending support to human well-being and the pressing need to tackle loss of biodiversity and fragmentation of habitat. Ecosystem services are the advantages that humans stand to gain from nature, and this includes air, clean water, food, recreational and cultural opportunities (Ronchi, 2021). Incorporating ES within territorial planning could result in increasingly resilient and sustainable communities. Through the zoning of green spaces for particular ecosystems services, planners would be in a position to ensure that vital resources are safeguarded and are existent to cater to present and future requirements. For instance, it is possible to zone wetlands for purification of water and flood control, while forests can be marked for carbon sequestration and timber production. One effective approach would refer to execute assessments on ES at the municipal or regional level (Helfenstein & Kienast, 2014). Such type of assessments could be instrumental in recognizing regions with high ecological significance and these can then be prioritized for protection or sustainable use. With the integration of such assessments within decisions on zoning, planners can ensure that development would be compatible with the provision of ES, while reducing the adverse impacts on natural systems (Pomara & Lee, 2021).

On the other hand, biodiversity is necessary for stability in the ecosystem and resilience as well. In order to conserve biodiversity, it is imperative that territorial planning comprises of zoning that safeguards and improves natural habitats. This can be realized with the establishment of protected areas, zones for habitat restoration, and wildlife corridors (Nilon et al., 2017). Zoning for biodiversity conservation would ensure that vital habitats like forests, wetlands, and grasslands are protected from incompatible land uses such as industrial initiatives or urban development. In addition, zoning would also be instrumental in tackling the requirements of endangered and threatened species with the designation of particular areas as refuges or habitats for such species. This type of a proactive approach towards zoning would facilitate in preventing additional declines in biodiversity and support the recovery of endangered wildlife populations.

Ecological connectivity pertains to the capability of species to move and interact over landscapes (Tabor et al., 2019). It is imperative for sustaining genetic diversity, facilitating species to adapt to changing environmental situations, and supporting functions of ecosystems like seed dispersal and pollination. Zoning has an intrinsic role to play in ensuring ecological connectivity on the basis of designating wildlife corridors and green infrastructure networks (Tabor et al., 2019). The process of zoning for ecological connectivity frequently comprises of recognizing key areas where it is imperative to have wildlife movement, and later creating zones that enable such movement. For example, zoning might designate a wildlife corridor that links two protected areas or even set up greenways aside rivers which lend support to riparian ecosystems and migration of aquatic species (Jiang et al., 2022). Such decisions in zoning are instrumental in overcoming the detrimental impacts of habitat fragmentation which enable species to thrive in a connected environment.

Though the integration of ecosystem services, biodiversity conservation, and ecological connectivity within zoning is vital for sustainable land use, it certainly presents some challenges (Birkhofer et al., 2015). A challenge here would refer to the necessity for interdisciplinary collaboration between planners, economists, and ecologists, and other experts to execute extensive evaluation and arrive at informed decisions pertaining to zoning (Vizzarri et al., 2015). Furthermore, it is necessary to have public engagement for ensuring that zoning projects community values and necessities while also taking environmental conservation under its ambit. In addition, zoning for ecosystem services, biodiversity, and ecological connectivity warrants the need for a long-term perspective. The advantages that can be derived from this kind of zoning might not be visible immediately, rather they will be active contributors to the long-term resilience and health of communities and ecosystems (Van der Biest et al., 2020).

Incorporating ecosystem services, biodiversity conservation, and ecological connectivity within zoning and territorial planning tools would be crucial for realizing sustainable land use and environmental protection. Zoning for ecosystem services ensures that the advantages presented through nature are conserved and are accessible to society. Zoning for biodiversity conservation tends to protect vital species and habitats, while zoning for ecological connectivity facilitates the movement of wildlife and helps in sustaining genetic diversity. By tackling these facets in territorial planning, communities are in a better position to balance development with the conservation of necessary natural resources. Such efforts will be instrumental in contributing to the well-being of society on the whole and the long-term health of the planet.

3.10 Findings: Examples of Successful Zoning for Green Infrastructure in Territorial Plans

3.10.1 Vojvodina, Serbia

A classic example of this has been observed in Vojvodina, Serbia in central Europe. According to Bajić *et al* (2022), the principle of connectivity takes under its ambit an array of ecosystems services within the hybrid notion of green infrastructure, that can be perceived from the perspective of territorial cohesion. A multifunctional importance can be observed in the components of GI, which is projected not only in its ecological but also their visual, cultural, and social importance at a local level. Additional research pertaining to the dimensions of territorial cohesion, from the setting of application of GI within territorial planning at varying scales, need to focus on cross-sectoral research (agriculture, forestry, water management etc). A cohesive visual and environmental evaluation of semi-natural and natural components and determining its scope for the creation of GI would be a necessary practical and methodological initiative that could offer guidelines for designing GI components. Through an application of a research approach which is transdisciplinary in nature, wherein population from local areas also actively take part, it would be essential to examine the visual and environmental qualifications that GI dots need to have.

Following an enhancement on the basis of landscape design, they can turn out to be lucrative recreational multifunctional green spaces that demonstrate the eco-visual territorial cohesion of the urban-rural continuum.

3.10.2 Portland, Oregon, United States

The region of Portland in Oregon has been frequently indicated as a model for demonstrating successful zoning in terms of GI. The code for zoning in the city of Portland, tends to prioritize environmental sustainability while promoting the integration of permeable pavements, green roofs, and native vegetation within urban developments. Moreover, the city of Portland is known to adopt an innovative tool for zoning which is known as 'ecoroofs', which provide bonuses for density to developers who are known to add green roofs within their projects. Such an approach has resulted in a major increment in green roofs around the city, offer several advantages, which was inclusive of stormwater management, and lowered urban heat island effects (Ismail et al., 2012).

3.10.3 Freiburg, Germany

The city of Freiburg in Germany is famous for their practices towards sustainable development, and zoning for GI has a vital role to play in driving its success. The zoning regulations adopted by the city accord high priority to mixed land use, streets that are pedestrian friendly, and green spaces. Remarkably, the Vauban district of Freiburg has executed stringent codes for zoning that encourages sustainable transportation, automobile-free living, and green building design. Such an approach has converted the district of Vauban into a paradigm for sustainable urban living (Mössner, 2015).

3.10.4 Singapore

Singapore, as a state is heavily populated, and has adopted GI zoning within their plans to tackle the present urban challenges. The Planning Act and Development Control Regulation of the city warrant the integration of water bodies and green spaces within novel developments. Such type of an approach has led to an impressive network of green corridors, parks, and waterways that lower the risk of floods, improves biodiversity, and enhance the resilience of the city to climate change (Sia et al., 2023).

3.10.5 Melbourne, Australia

The scheme for planning in Melbourne, Australia illustrates GI zoning. The zoning codes within the city promote green streetscapes, mature tree retention, while mandating the inclusion of public open spaces in new developments. The commitment of the city of Melbourne to GI has resulted in the creation of the 'Green Wedge', a network of secured agricultural land and natural resources that encompass the city. This measure is vital in protecting biodiversity while sustaining the green lungs of the city (Willams, 2001).

3.10.6 Vienna, Austria

The concept of GI has been incorporated by the city of Vienna, within their territorial plans and received much success. The zoning codes of the city stress upon public parks, green corridors, and urban agriculture. Such zoning practices have made a major contribution to the reputation of the city of Vienna as one among the greenest cities across Europe. The extensive network of green spaces within the city of Vienna, which is inclusive of the famed Prater Park, has not only enhanced the quality of life of the people of the city, but it has also improved the ecological resilience of the city (Haase et al., 2017).

3.10.7 Copenhagen, Denmark

The city of Copenhagen, in Denmark has been appreciated owing to their progressive approach to GI zoning. The zoning regulations of the city are framed such that it encourages permeable surfaces, green roofs, and extensive bicycle infrastructure. The blend of GI and an urban layout that is cycling-friendly has converted Copenhagen into a leader in terms of sustainable urban development. It is frequently projected as an excellent model for cities across Europe to lower carbon emissions and improve urban sustainability (Cucca, 2012).

3.10.8 Barcelona, Spain

Barcelona in Spain has made substantial in-roads in terms of incorporating GI within territorial planning. As per the zoning codes of Barcelona, the creation of green connectors has been emphasized, which connects natural areas and parks to create a consistent network. Remarkably, the city's initiative 'Superblocks' was developed with the intention to reclaim streets for pedestrians, and green spaces through a planned restriction of vehicular traffic (Grădinaru & Hersperger, 2019). Such kind of an innovation in the strategy for zoning improves both urban experience and the environmental quality as well, thereby illustrating the scope for implementing GI within European cities that are highly populated (Slätmo et al., 2019).

3.10.9 Amsterdam, Netherlands

The city of Amsterdam has always garnered much praise for their urban planning which is way advanced than its contemporaries. As per the zoning regulations that currently exist within the city, priority has been accorded to green walls, green roofs, and incorporating features pertaining to water within urban design. Moreover, the commitment of Amsterdam to sustainable building practices and green transportation has resulted in a highly sustainable and healthier urban environment (Mazur-Belzyt, 2019). The initiatives driven by the city of Amsterdam have effectively indicated that zoning can prove to be a robust instrument in facilitating the development of cities that are not only resilient but greener as well.

The examples presented above of cities around the world act as stellar models that reveal effective zoning for GI within territorial plans. The experiences that these cities have gained highlight the significance of community engagement, political will, and tools for flexible zoning towards encouraging urban development that is sustainable in nature. Nonetheless, there would be challenges that emerge from coordination between agencies, cost of land, and long-term maintenance which must not be ignored. By gaining lessons from such examples, and taking into account the inherent associated challenges, planners from urban regions will be in a position to build strategies for zoning that prioritize GI, nurturing highly livable and sustainable cities across Europe. Zoning, that is successful in terms of GI in territorial planning would be necessary for facilitating the creation of livable, resilient, and sustainable cities. Through an examination of successful examples from cities across Europe and other developed nations, the key factors that play a contributory role to success in zoning, which is inclusive of community engagement, political will, effective monitoring, and flexible instruments for zoning. Nonetheless, challenges that exist in the form of long-term maintenance, land cost, and coordination amongst agencies should not be overlooked. Deriving learning from these examples and taking the challenges into account, urban planners will be able to develop strategies for zoning that encourage the incorporation of GI within the fabric of cities, eventually offering advantages to the environment and the people as well.

Chapter 4

Public Participation in Designing Green Infrastructure – Systematic Review

4.1 Background

The notion of Green Infrastructure (GI) is not only about strategic planning, but it is all about implementation too. The European Commission states that GI can be defined as, *"networks of high-quality semi-natural and natural areas that have been strategically planned and comprises of other environmental aspects, that are structured and managed such as to deliver an extensive array of ecosystem services while safeguarding diversity in urban and rural settings."* (European commission, 2023). As of now, cities specifically are undergoing major transformations owing to demographic and economic changes and the process of urbanization that includes this kind of change. This results in intricate environmental challenges and problems like pollution, biodiversity loss, excess population, and increased consumption of land. Furthermore, owing to the dense working, housing, and information networks, cities offer a commendable foundation for new governance forms and planning that are helpful in developing solutions to intricate environmental challenges (Young & McPherson, 2013). As a concept for strategic spatial planning, GI would be able to cope with and respond to such societal challenges and changes (Vargas-Hernández & Zdunek-Wielgołaska, 2021b). At the ground level, GI is in a position to tackle social, environmental, and economic issues by providing ecosystem services and the advantages that such services like protection of species, recreation, and quality of place (Kabisch, 2015). These aspects signify the importance of GI within cities and regions.

It is quite common to limit resources for GI planning and management, given that the advantages from GI investments are not easily captured or transferred (C. Mell, 2015). Significantly, it has been emphasized through research that urban green is a pertinent urban amenity in terms of delivering urban quality of life. However, considering that GI is important but there are still setbacks in adoption, it would be imperative to involve public participation in the delivery of GI planning. This can be deemed as a key issue within practice of planning, given that the challenges mentioned above would lead to low integration and consideration of input from stakeholders. Nonetheless, owing to the tremendous social advantages offered by GI, all groups within society need to be able to contribute towards its planning and execution, in order to ensure that they meet its requirements. This indicates the significance of effective and efficient public participation in designing GI, given that the expertise of local stakeholders could progress our understanding and thus the outcome of GI initiatives.

Rowe & Frewer (2004) offer a broad definition of public participation as practice that involves consulting and brings in members from the public while setting up agendas, policy making, and decision-making initiatives of players who are responsible for the development of policy. (Finka et al., 2017) have defined public participation within planning as a procedure where the opinions and standpoints of all concerned stakeholders are incorporated within the process of decision-making. In the case of planning procedures, stakeholders would refer to individuals or organizations that have an actual interest in a specific issue that is being taken into account as they could be directly impacted by the planning decision. There could be many ways through which public participation in GI planning could occur. These would vary on the basis of the involvement level of actors in which stage of the decision-making process they would be taking part in. It has been argued by Rall, Hansen, and Pauleit (2019), the development of participation would hinge on factors like civic society development, public disagreement, and public awareness or access to information. It would also include the necessity for involvement within public discussions. Participation has been characterized by Vaňo, Stahl Olafsson, and Mederly (2021), as a dual-edged sword where on one hand the planners are supposed to be prepared and trained to conduct work and collaborate with people and other stakeholders, whereas on the other hand, players are expected to be skilled and active in decision-making which is inclusive of the process of planning.

Table 1: Objectives of Public Participation (Uittenbroek et al., 2019)

No.	Normative Rationale	
1.	Influencing Decisions	Public participation enables those who are impacted by a decision to influence that decision.
2.	Enhancing Democratic Capacity	Public participation allows participants to build their citizenship skills like (communication, interest articulation, and cooperation) while also offering participants an opportunity to exercise their citizenship actively.
3.	Social Learning	Public participation facilitates deliberations amongst participants thereby resulting in social learning.
4.	Empowering Marginalized Individuals and Groups	Modifies the power distribution in society, thereby empowering individuals and groups that are marginalized.
	Substantive Rationale	
1.	Leveraging Local Knowledge and Information	Public participation improves the decision quality outcomes by presenting decision-makers with socially and environmentally pertinent knowledge and information.
2.	Integrating Value-Based and Experimental Knowledge	Public participation improves the decision quality outcomes by presenting decision-makers with pertinent value-based and experimental knowledge.
3.	Assessing Robustness of Information from Other Sources	The quality of decision outcome is increased through public participation,

		by evaluating the robustness of information derived from other sources.
	Instrumental Rationale	
1.	Producing Legitimacy	The decision-making process will be legitimized with public participation, thereby presenting legitimacy to authority and enabling project execution.
2.	Conflict Resolution	Public participation will be instrumental in identifying conflicts and resolving it prior to arriving at final decisions and thereby allow project execution.

In view of the above aspects, this chapter will attempt to investigate public participation in green infrastructure planning.

4.2 Techniques and Tools for Involving the Public in Green Infrastructure Design

The scope of public participation schemes that have been appropriately implemented is well-known, and innovative techniques and tools have been consistently built to enhance the scope of stakeholder participation within GI design, planning and implementation. The fundamental approach to public participation would be Arnstein's ladder of participation (Arnstein, 1969). Arnstein (1969) has suggested three key types of participation (tokenism, non-participation, and citizen power) within the ladder which is inclusive of eight rungs. This ladder principle has been adopted by several people not just to consider the participation of people but also to ensure stakeholder participation procedures that are highly communicative in general, which have been later revised by changing or extending many rungs to detail the level of involvement. It also takes into account highly investigated and developed approaches to participation employed at present. Particularly when the levels of involvement are high, varied techniques have come up over the period of time, and specifically, techniques that tackled greater involvement levels, like citizen control or public empowerment, were developed (Chamhuri et al., 2015). However, as posited by Luyet et al., (2012), there are five levels of participation such as information, consultation, collaboration, co-decision, and empowerment. Though the level of information has been defined as something that merely elucidates the projects to stakeholders, consultation goes a step ahead and seeks their opinions, which could be taken into account during decision-making (Luyet et al., 2012). Collaboration would be the same as consultation, but it ensures that the suggestions given by stakeholders are taken into consideration. While co-decision would indicate that stakeholders and public bodies work in tandem with one another to arrive at an agreement, empowerment would imply that all power in terms of decision-making is delegated to stakeholders. In this instance, the public body might only play the role of a moderator. Association to the degree of involvement, there would be an array of common methods of public participation that are possibly able to realize some level of involvement (Luyet et al., 2012).

The key question would revolve around which of the stakeholders who have been identified need to be involved at varying levels of participation. The answer to this question would be vital to the choice of the technique of participation and has a major impact on the process of participation on the whole. The execution of an inappropriate level of involvement might lead to conferring an inappropriate power level to a stakeholder and in a participation technique that is unsuitable. But it is unfortunate that there is not a standard approach for choosing the right technique or tool of participation, but a list of factors that needs to be taken into account has been presented by Luyet et al., (2012). The difference between expected and realized degrees of stakeholder participation that are held by project leaders and engaged stakeholders would be defined as the so-called 'Arnstein Gap'(Bailey & Grossardt, 2006). Yet another horizontal layer that can be added within the five-step ladder model would be ‘performative’ participation. This term elucidates stakeholders who are physically active, and interventions led by experts in the public domain with the utilization of materials like community gardening (Reed, 2008).

The variation from the typical, primarily communicative approaches to participation like meetings or roundtables, would be the focus of performative participation on joint designing and execution on the ground. Significantly, performative participation can be possible within every involvement level. Attributes of performative participatory planning would include focus on outcomes, materiality, audience-orientation, and open outcome. It can be specifically applied within GI projects owing to the availability of adequate public space and the tremendous opportunities presented by green areas for stakeholders to engage in active design and act spatial in a do-it-yourself way. Thus, it would be an apt strategy for adaptation to cope with the present challenges in planning, like restricted resources or brownfields being allocated for interim uses in public spaces by extending support to co-production within stakeholders (Chygryn et al., 2020). Performative participation complements the conventional communicative approaches to participation by offering an alternative scope for individuals to take part in the planning process, and the planners for obtaining feedback. Owing to its attributes, it has substantial scope to activate public, particularly groups that can be hard-to-reach, as particular knowledge, including knowledge related to language, is not needed, and several other techniques that favored individuals who were well-educated. Nonetheless, performative participation does have its own restrictions, as its success hinges on stakeholder engagement the openness on the part of local planners (Melnychuk et al., 2021).

4.3 Methodology

In order to carry out this research, a systematic review method was adopted. A systematic review is deemed as a research approach that comprises of a summary of findings that have been derived through previous research executed by various researchers, all under the setting of a particular research question. The uniqueness of a systematic review from a conventional review would lie in the fact that it involves a rigorous process of identification, selection, synthesizing, and high-quality evidence with the help of an explicit and extensive process. The basic goal of a systematic review is to filter through the existing evidence, by carefully choosing data that is most reliable and pertinent for tackling a particular question of research. This technique would be crucial in informing policy and offering practical guidance for decision-making. Essentially, it is at par with the existing trend to approaches that are evidence-based in policymaking, while ensuring that decisions are based on the most appropriate data.

4.4 Findings: Case Studies of Successful Public Participation in Green Infrastructure Planning and Design

An investment in Amersfoort city in the Netherlands comprised of converting a hospital site into a new city park while facilitating an expansion to an adjacent city park. In this instance, the citizens and the municipality came together to act as equal partners within this project of redevelopment (Wilker et al., 2016). In order to offer a structure to the said partnership, a core group was created which was comprised of representatives from every pertinent group of stakeholders. The key aspect within this process was that there was no top-down or bottom-up approach, rather there was an authentic cooperation with authority equally distributed among stakeholders and all stakeholders jointly focused on realizing the objective on the basis of creative deliberations and workshops for providing ideas and create a joint plan. The core group presented updates on ideas and objectives of the project, its needs, and restrictions pertaining to money and time to the citizens using social media platforms, and an array of meetings that enabled public to respond to such ideas and plans for the park. In addition, open space methods and world cafes were utilized at the meetings to share the ideas of participants on sub-themes in small groups (Wilker et al., 2016). Over a period of eight months, a plan for redevelopment and management was designed and structured. Owing to this concept of understanding the shared interests of administration and other stakeholders, the participation methods utilized were mainly an aspect of decision-making process and thus indicated a comparatively high level of stakeholder participation.

Similarly, the case of Liege in Belgium can be considered as another successful example of public participation in GI planning and design. In the Liege, the focus was on revitalizing a park, that comprised of green spaces in the vicinity of an erstwhile military fort. The park was an integral aspect of the city's project, which was a strategic action plan that was created by the city of Liege, which involved an extensive participatory process (Wilker et al., 2016). The park's development contributed to the city's plan of designing and developing green spaces, sports and cultural facilities, and recreational spaces. Workshops and round tables were used for consulting with stakeholders for evaluating the existing scenario, and for designing references and potential situations that would be applicable to the site. Another aspect associated with the degree of consultation was to carry out site visits and initiating opinion surveys, with was done in a paper or online format, enabling the identification of uses, perceptions, practices, and needs and desires of people. In addition, participation techniques like charrette and diverse initiatives have been utilized to consult during the process of planning. To encourage interest in the deliberation on the planning process and to promote the distribution of information, a social media platform was also established (Wilker et al., 2016).

The investment site in Sheffield, United Kingdom (UK) presents another example of open/green space provision, as an integral aspect of the South Yorkshire GI strategy, which aimed to direct limited resources to achieve diverse advantages and tackle existing weaknesses in terms of sustainability. The site for investment was underused and derelict within a deprived city-center community. As an outcome, it was recognized as a core site in Sheffield's 'Breathing Spaces' program to offer GI within the city center. Beginning in 2012, many workshops and meetings were carried out with the local community involving residents and friends of resident groups for discussing land transfer and the sustainability, maintenance, and design of a new park (Wilker et al., 2016).

In the same vein, the city of Stuttgart, in Germany is renowned for the innovative approach it adopts towards green infrastructure design, especially in the context of promoting green roofs. The green roof initiative of the city presents a notable example of public participation within sustainable urban development. The purpose of the initiative was to augment the number of green roofs within the city to tackle the urban heat island effect, enhance the quality of air, and improve biodiversity (Winker et al., 2022). Public participation was vital in terms of ensuring success within this initiative. The government in the city organized information campaigns, public workshops, and incentivized green roof installations through regulatory changes and financial support. Residents were motivated to share their opinions, concerns and ideas pertinent to green roofs, resulting in the development of a robust and extensive strategy that was in tandem with the environmental objectives of the city (Winker et al., 2022). This case of Stuttgart highlighted the significance of government-led initiatives that ensured active involvement of the public within the process of decision-making and offering practical incentives to facilitate GI design.

Another successful example of public participation within GI planning and design can be observed from the case of the Thames Tideway Tunnel project for wastewater management, in London, UK. The objective of this project was to restrict the overflow of sewage into the Thames River during heavy rainfall events, safeguarding aquatic ecosystems and enhancing water quality. Engagement with the public was a vital aspect that led to the success of the project (Loftus & March, 2019). Detailed consultation and communication with local communities were carried out to tackle the concerns and acquire feedback. Online surveys, public meetings, and information sessions were organized to ensure the residents were involved and informed in the entire design, planning, and construction stages. In addition, the Thames Tideway Tunnel project was instrumental in setting up a community liaison working group that presented a direct channel for community feedback.

This case in a classic way illustrates that even GI projects of large scale with substantial technical intricacies could gain advantages from public participation. Involvement of the public was instrumental in developing trust, lowering opposition, and creating a sense of ownership among local communities.

The case studies above emphasized the significance of public participation in green infrastructure design within Europe. It was vital in demonstrating that projects that were successful were those that allowed active involvement of local communities, factor their inputs, and develop partnerships to ensure success in the long-term. The lessons thus learnt from these cases can provide valuable inputs for regions and cities trying to improve their green infrastructure while nurturing community support and sustainability.

Chapter – 5

European Model Cities for Green Infrastructure

5.1 Overview of European and Czech Republic Model Cities for Green Infrastructure

Several cities across Europe are attempting to enhance their urban environments as a medium to tackle change mitigation and adaptation while enhancing the quality of life at the same time for their people through nature-based solutions and green infrastructure (European Commission, 2023). Though the backbone of GI has been located by the European Commission within the Natura 2000 network of protected nature areas (European commission, 2023), the World Green Infrastructure Network highlights the significance and need for GI within cities for sustainable urban development (WGIN, 2021). Nature-based solutions, as an integral aspect of GI, refers to solutions that are supported and inspired by nature. With the use of natural features and nature, and procedures in terms of responding to problems, they are an addition or substitution to solutions that are purely technical, which further takes economic, ecological, and social values under its ambit based on their attributes that are multifunctional (European Commision, 2023).

A GI strategy has been in existence in Europe beginning in 2013 (European Environment Agency, 2014a), and member states were actively participating in many strategic and applied GI projects and initiatives (Beery et al., 2017). The endeavour of the GI strategy in Europe is to establish a balance between planet, people, and profit or sustainability, to put it simply. It is also stated that it does not warrant any legislation that is exclusively designed to drive execution, and rather calls for current policies, legislations, and use of mechanisms for funding (European Environment Agency, 2014a). While it is possible to perceive GI as a new facet of governance and policy, particularly within EU policy, research has been carried out in this domain right from the 1970s onwards, in the domain of landscape ecology, conservation biology, and protection of nature (Garmendia et al., 2016). Based on research, it has been indicated that implementation of GI within European nations was mostly on measures to improve ecological networks, and the green space conservation was more common as compared to restoring and creating new green spaces (Davies & Lafortezza, 2017). This indicated a focus on biodiversity and nature protection.

Within Europe, Urban Green Infrastructure (UGI) has emerged as a promising notion at the time of developing multifunctional green space systems to tackle key problems arising from urbanization like increased social cohesion, encouraging a shift to the green economy, adapting to climate change, and biodiversity conservation (Pauleit et al., 2019). The Green Surge project of the European Commission, intended to additionally progress the development of UGI in European cities with a reinforcement of conceptual foundation of UGI, developing enhanced techniques and instruments for evaluating its state, advantages, and governance, while applying these to develop a stronger base of evidence (Pauleit et al., 2019). A transdisciplinary 'double helix' approach was applied through Green Surge for analyzing the link between urban blue and green spaces, its biodiversity and ecosystem services, and local planning and governance mechanisms (Jagt et al., 2016). The approach was attributed with a research design that was multilevel, comprising a blend of local and European level study. In addition, spatial and quantitative approaches for evaluating the links between biodiversity and green space were merged with action-oriented and qualitative approaches to evaluate the governance and planning of urban green infrastructure. Green Surge offered a distinct opportunity to bring together varied disciplines over a large consortium to further the theoretical framing of urban green infrastructure, enhance its evidence base, and recognize strategies and tools for successful incorporation of urban green infrastructure within cities in Europe. The urban green infrastructure thereby presents significant venues facilitating the creation of synergies and novel associations between environmental, social, and economic sectors (Pauleit et al., 2019b).

At the same time, local governments are in a position to opt from several instruments and tools to execute urban GI. For instance, the city of Belfast in Northern

Ireland has undertaken initiatives to plant around one million trees by 2035, to derive several advantages such as lowering flooding and carbon emissions, enhancing urban cooling and the quality of air, and also lending support to biodiversity, while enhancing mental and physical health of citizens (Council, 2023). The city of Stuttgart in Germany has been installing green-blue infrastructure and ventilation corridors to enhance the quality of air and lower extreme temperatures (Wicht et al., 2017). The Slovakian city of Bratislava has been making investments in facilities for retaining rainwater, tree planning and green roofs (Belčáková et al., 2019). The city of Maribor in Slovenia has structured a strategy to make the shift into a circular economy (Brglez et al., 2023), which is inclusive of regenerating areas that have degraded, with the implementation of natural solutions and blue and green infrastructures. Nature-based solutions have been extensively promoted within the city of Budapest in Hungary with an intention to enhance the environment, quality of life and sustainability within the city. In addition, Budapest has also been known to execute many projects to incorporate more green within the city and address problems associated to issues in climate change (Calliari et al., 2022).

On the other hand, it has been found by Skokanová & Slach (2020), that GI is a concept that is comparatively new in the Czech Republic. The definition of GI can be linked with the Czech Territorial System of Ecological Stability (TSES), which is deemed as a system that is interlinked with natural and also altered semi-natural ecosystems to sustain the natural balance.

5.2 Methodology

In developing this chapter, the methods adopted were to find published peer reviewed papers pertinent to green infrastructure model cities across Europe. Though the concept of GI is quite dated and was first mentioned in the literature during 1994, its implementation has been actively initiated only in recent times. Regardless of the fact that GI as a concept was first introduced in 1994, its extensive implementation was confronted with major delays owing to diverse factors. First and foremost, conventional systems of infrastructure have been in existence for a long time, rendering it challenging to making the transition to newer, greener alternatives (Lindholm, 2017). In addition, the initial costs linked with implementation of green infrastructure have been frequently perceived to be prohibitive in comparison with traditional techniques, which acted as a deterrent to immediate adoption and implementation (Heidari et al., 2022). Furthermore, an absence of education and awareness regarding the advantages of green infrastructure among stakeholders, policymakers, and the general public, slowed down its acceptance and incorporation into mainstream practices. Moreover, bureaucratic procedures and regulatory frameworks have also had a rather hindering impact in terms of the prompt implementation of green infrastructure projects (C. Wang et al., 2020). In addition, inertia with industries that were not open to change, along with economic and political interests, have added to the delays in prioritizing initiatives towards GI. Irrespective of such challenges, increasing recognition of the pressing need for sustainable development and resilience towards climate change has been slowly adding momentum towards the widespread adoption of GI across the world. Therefore, the focus was to identify research papers and case studies of recent publication between the years 2015 and 2022 that highlighted the adoption and implementation of GI throughout the EU and UK. As mentioned above, only studies conducted between the periods of 2015 to 2022 were included in this query, excluding papers or case studies that reported on model GI activities in cities in other parts of the world other than the two regions mentioned above.

5.3 Findings: Best Practices and Success Stories of Model Cities

Olic & Stober, (2019) conducted a case study using Osijek as the case city. The city of Osijek in Croatia has been perceived on the basis of an array of spatial frameworks. The data was collected from the European Union (EU) level using a common database that enabled a comparison between similar spatial phenomena.

Urban atlas and urban audit projects enabled a comparison of data for city core and functional urban area level data that matched the administrative boundaries and were largely appropriate for strategic and management plans. With a view to effectively and efficiently manage city spaces, the categorization needs to be vertically incorporated through spatial levels. As per data, the density of green spaces within the city of Osijek was 23.1 m^2 per inhabitant which could be evaluated as high density. The categories that were used for various levels of the core city of Osijek were robust and do not essentially present inputs on functions of GI. In addition, classification was not vertically incorporated at the district level to offer effective maintenance. Data offered by the green cadastre tool of Osijek GI, facilitated a dynamic review and rich database with information which could make contributions to effective maintenance and management of GI within the city.

Figure 9: Green Cadastre of Osijek (GIS Tool) (Olic & Stober, 2019)

A methodology to map GI within Czech Republic was proposed by Skokanová et al., (2020a), on the basis of diagnosis of three approaches for mapping from a regional level, which was founded on the use and processing of varied data sets. (Skokanová et al., 2020a) compared GI maps based on European data from CORINE Land Cover Database, a Czech national database which was known as the Consolidated Layer of Ecosystems (CLE) and a mix of Czech national and regional data, and manual vectorization. The findings in this case indicated that CORINE based GI map was appropriate for transnational scale however, it was not suited for a regional scale. On the other hand, the CLE based GI map was good for national and regional scale but there was a lack of information on GI within urban areas. An in-depth GI map was good for regional and to certain extent even at a local scale, but its creation would be time consuming. Nonetheless, a careful blend of current regional and national data could offer good results in the development of GI map that could be used for territorial planning.

One of the basic facets of a model green city would refer to their approach to transportation that is sustainable. Cities across Europe have been at the frontier in terms of encouraging specific zones for pedestrians, infrastructure to facilitate cycling, and systems for public transportation (Strulak-Wójcikiewicz & Lemke, 2019). For example, the extensive cycling infrastructure in Copenhagen (EMANUEL, 2019) and the initiative 'Superblocks' undertaken by Barcelona in Spain have been instrumental in substantially lowering air pollution and carbon emissions (Rueda, 2019). The cities mentioned here have encouraged shared and non-motorized modes of transportation, that is supported through diverse studies. Similarly, integrating green spaces in urban landscapes would be another key component within model green cities. Schonbrunn Park in Vienna is major example of urban green areas that improve the quality of life of individuals while extending support to biodiversity (Ring et al., 2021). Studies carried out by Pasanen et al.(2023) and (Marques da Costa & Kállay, 2020), emphasize the physical and mental health advantages that are offered by green spaces within urban environments and the role they play in flora and fauna conservation. Incorporation of sources for renewable energy is a key aspect of model green cities. For example, Reykjavik is known to extensively use ample geothermal energy, lowering their dependence on fossil fuels. The renewable energy report of Europe presented by the European Environment Agency underscores the advancement in the region towards a transition to energy sources that are sustainable. Such a transition has been driven by the policies framed by the European Union (EU) about renewable energy, which stimulates cities to make investments in biomass combustion, wind capture, and PV solar energy.

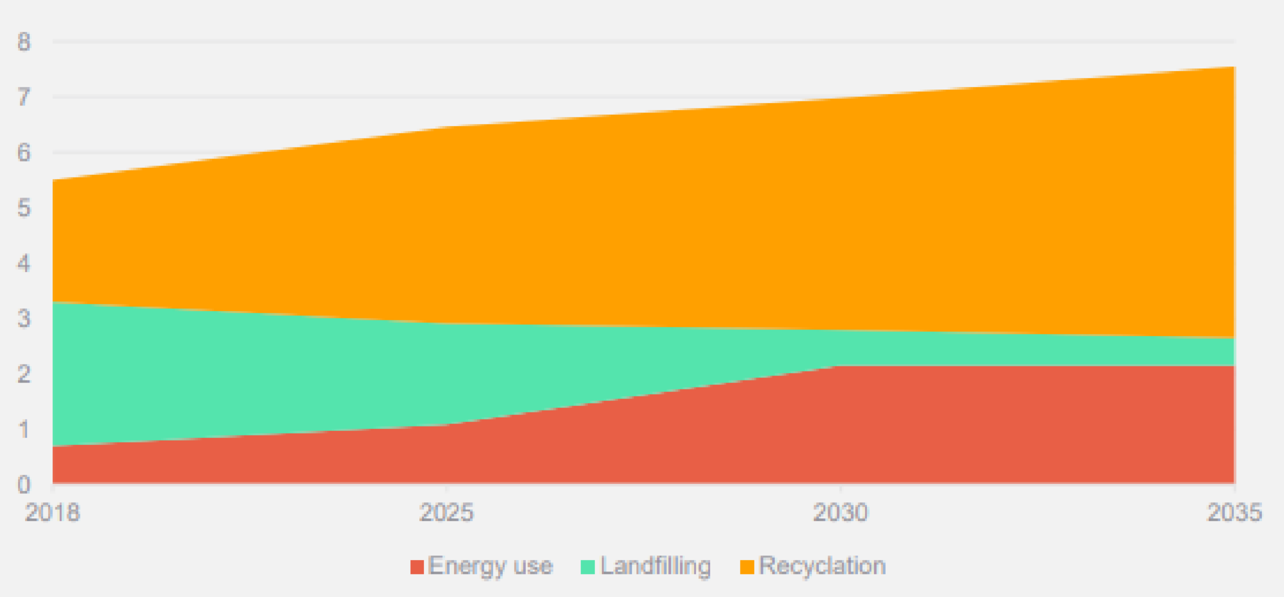
From an economic point of view, model green cities are instrumental in simulating innovation while creating new job opportunities within sectors like urban planning, renewable energy, and sustainable technology (Hadjichambis et al., 2022). Investments within green infrastructure result in long-term savings in costs based on measures towards energy efficiency, and lowered consumption of resources. Also, such cities tend to attract skilled workers and businesses keen to maintain a high quality of life and an environment that is supportive to sustainable practices (Bibri, 2020). Furthermore, the added reputation of being a green city could be instrumental in improving tourism while attracting visitors who are environmentally conscious, boosting local economies based on increased spending and cultural exchange (Straupe & Liepa, 2018). On the whole, model green cities within Europe act as exemplars on how sustainable urban planning could make a positive impact on the economy as well as society, paving the way for a greener and highly prosperous future.

Similarly, effectiveness and efficiency in managing waste with recycling and reuse consistent with circular economy would be crucial to lower the harmful impact on environment. The capital city of Slovenia – Ljubljana, has put in practice a zero-waste program with the intention to substantially lower wastes at landfill sites (Bogusz et al., 2021). Research carried out by Osama & Lamma (2021), highlights the significance of recycling and strategies for waste reduction across cities in Europe, encouraging efficiency of resources and lowering the environmental footprint. Furthermore, it has been observed that model green cities tend to accord high priority for social equity and inclusivity (Perić et al., 2023). Social housing policies across Vienna and the project for revitalizing neighborhoods in Barcelona embody such commitment (Friesenecker et al., 2023). Investigations carried out by Lemaire & Kerr (2017), signifies the role played by urban planning in nurturing communities that are inclusive and tackling social inequalities within green cities. In the same vein, the city of Stockholm in Sweden provides a balanced blend of natural beauty and urban living, which is developed on 14 interlinked islands that are renowned for their efficient green spaces and systems of public transport. Another city in Europe which has been hailed as a paradise for cyclists would be the city of Amsterdam, Netherlands. The city of Amsterdam boasts of having dedicated lanes for bikes, picturesque canals, and eco-friendly policies (Feddes et al., 2020). Cyclists have right of way over motorized transportation modes. The city of Freiburg in Germany is known by its apt monicker 'green city', as it has developed buildings that are energy efficient, extensive use of solar power and sustainable transportation, establishing a precedent for urban planning that is eco-conscious (Fastenrath & Braun, 2018). Similarly, automobiles have been banned in the city center within the capital city of Slovenia. They have also adopted clean energy solutions and nurtured a culture of eco-conscious living. Such model cities embody the scope for urban regions to pave the way in practices that are environmentally responsible and encouraging the world at large to adopt an eco-friendly future that is highly sustainable.

With the continuous expansion of cities, there is an increasing necessity for sustainable urban development which encourages eco-friendly living while lowering the carbon footprint of urban regions. Akin to cities across Europe, cities within the Czech Republic have initiated major steps to emerge as model green cities, embracing approaches that are innovative to address environmental problems while enhancing the quality of life for the residents. One amongst the key elements of green urban planning within the Czech Republic would refer to the incorporation of renewable energy sources. Cities within the region have been making investments in solar energy, biomass energy systems, wind turbines etc., for lowering their dependence on fossil fuels. Such a shift has been underlined by the commitment of Czech Republic to the renewable energy targets of the EU, which intends to lower emissions of greenhouse gases and encourage a greener energy sector. For example, the city of Brno in Czech Republic, has been leading the way in solar energy wherein it has installed solar panels on public edifices, which substantially contributed to an increase in solar energy production (Kalousek, 2021). The Karlovak hospital in Croatia adopted energy efficient practices by retrofitting the hospital with insulation, shifting to natural gas, solar thermal systems etc., which resulted in annual energy savings of 6.5GWh of heat, and an annual cost savings to the tune of €528,000 (PF4EE Expert Support Facility, 2019). Similarly, energy saving initiatives in the Czech Republic led to an annual energy saving of 420 MWh in heat and 2000 MWh in electricity, and annual cost savings of €217,000 (PF4EE Expert Support Facility, 2019). While a project on thermal insulation of a laboratory building in Slovakia also led to an annual energy savings of 115MWh, and annual cost savings of €4,700 (PF4EE Expert Support Facility, 2019). One of the objectives of green cities is to lower the number of private vehicles on the road to encourage cycling and the use of public transportation. The capital city of Czech Republic, Prague, has adopted significant steps to improve their public transportation network, with ample metro and tram lines that offer eco-friendly substitutes as compared to personal vehicles (Fitzová & Matulová, 2020). The city of Prague in 2020 introduced a system that enabled residents to hire electric scooters, which was further instrumental in lowering the environmental impact of short commutes.

One of the keystones of green urban planning would be efficient waste management systems. Cities across the Czech Republic have made investments in extensive programs for recycling and waste-to-energy facilities, which helps in lowering the volume of wastes at landfill sites, and thus increasing the overall resource utilization. This is one aspect that has been pioneered by Brno (Pluskal et al., 2021), with its waste-to-energy plant which generates electricity as well as heat from municipal waste. Encouraging green spaces within urban regions is vital to improve the quality of life on the whole for residents and also to conserve biodiversity.

Figure 10: Waste-to-Energy and Recycling Targets in the Czech Republic in Mill. Tonnes per year (Veolia, 2022).



	2018	2025	2030	2035
Landfilling	2,601	1,823	0,641	0,492
Recyclation	2,196	3,548	4,187	4,906
Energy use	0,694	1,080	2,150	2,150
	Current 2018	Target 2025	Target 2030	Target 2035
Landfilling	45%	28%	9%	7%
Recyclation	38%	55%	60%	65%
Energy use	12%	17%	31%	28%

The city of Pilsen located in the central western region of the Czech Republic has undertaken a thriving initiative focused on the creation of green corridors and urban forests, improving the biodiversity of the city and offering residents with recreational spaces (Jato-Espino et al., 2023). Furthermore, sustainable architectural practices and principles of eco-friendly urban designs are being gradually embraced by the Czech Republic. This would be inclusive of developing buildings that are energy-efficient, using local materials, and green roofs. Features of sustainable urban design can be prominently observed in the city of Olomouc, wherein new buildings are built such that they ascribe to eco-friendly construction benchmarks, lowering the consumption of energy, thereby nurturing an urban environment that is healthy, which is termed as Building Research Establishment Environmental Assessment Method (BREEAM) (Giles-Corti et al., 2022). Similarly, one of the attributes of green cities would be water management which has an intrinsic role to play in green cities. The city of Ceske Budejovice has made massive in-roads in terms of wastewater management, wherein it has been ensured that water is treated and returned back to nature in a manner that is environmentally friendly. Such an approach is known to make significant contribution to lowering water pollution and conserving local aquatic ecosystems (Silva, 2023). Further, sustainable urban development within the Czech Republic would also encompass the conservation of cultural heritage and encouraging eco-tourism. Cities in the Czech Republic such as Cesky Krumlov have incorporated their historical sites within their initiatives for green tourism, attempting to safeguard cultural landmarks while lowering the impact it has on the environment. Prioritizing sustainable transportation by motivating visitors to use public transportation, pedestrian pathways or bicycles to gain access to historical sites. This will lower the emission of carbon and encourage travel options that are eco-friendly. Initiatives towards green infrastructure are executed, which includes the setup of pedestrian-friendly zones, bike lanes, and installing charging stations for electric vehicles (Kalabisová & Plzáková, 2016). Such measures enable environmentally conscious exploration of historical landmarks. Further, initiatives towards management of waste comprise executing extensive systems including strategies for lowering the use of single-use plastics and recycling programmes. Through effective waste management, they lower the environmental impact from tourism on historical sites. Integrating renewable sources of energy like wind turbines and solar panels within the infrastructure of historical sites lowers the reliance of non-renewable energy, while decreasing carbon emissions (Drápela, 2023).

Encouraging the development of sustainable accommodations like eco-friendly lodges and hotels, near historical sites present tourists with lodging options that are environmentally responsible. They also provide guided tours and educational programmes to tourists, stressing the significance of environmental conservation and encouraging responsible behaviour at the time of their visit to historical sites. Moreover, sourcing local goods and services for tourists is encouraged, supporting the local economy and lowering the environmental footprint linked with transportation. Businesses are motivated to embrace practices that are eco-friendly, like using materials that are bio-degradable, and organic products, additionally contributing to the efforts towards sustainable tourism (Drápela, 2023). Based on these extensive strategies, cities like Cesky Krumlov exhibit their commitment towards conserving historical sites, while encouraging tourism practices that are environmentally sustainable.

To conclude, model green cities within Europe and across the Czech Republic have been observed to make substantial strides in their endeavor for sustainability in practice, however there is a long way to go to fully realize these goals. Akin to several other nations, the Czech Republic has been confronted with several challenges in its pursuit of sustainability, especially in their approach towards green cities. Regardless of the initiatives to encourage eco-friendly initiatives, there as substantial drawbacks in the agenda of sustainability of Czech Republic (Vávra et al., 2014). One of the foremost issues pertains to the absence of extensive urban planning which accords priority to sustainability. Though certain cities might have pockets of green infrastructure like bike lanes or parks, these initiatives frequently are devoid of incorporation into a cohesive strategy on sustainability (Jaszczak et al., 2021). In the absence of a holistic approach to urban development, the Czech Republic's green cities continue to be fragmented and are not successful in tackling systemic environmental challenges.

In addition, there is a remarkable lack of strong policies for incentivizing sustainable practices among residents and businesses. Though individual initiatives might exist, there is an absence of regulatory frameworks and financial incentives to motivate the large-scale adoption of eco-friendly behaviours and technologies

(Gürtler et al., 2019). In the absence of such measures, the shift to sustainable urban living continues to be disjointed and slow. In addition, green cities in Czech Republic frequently overlook considerations on social equity. Sustainable development needs not only prioritize the conservation of environment but also tackle social inequalities. Nonetheless, there is a restricted emphasis on ensuring access to green spaces and eco-friendly facilities for all residents, resulting in disparities in environmental quality and well-being (Biernacka & Kronenberg, 2019). To summarize, though the Czech Republic might aspire to develop green cities, its initiatives are hindered by inadequate policies, fragmented planning, and an absence of focus on social equity. To actually advance sustainability, it is imperative that the nation accords due priority to extensive urban planning, formulate robust regulatory frameworks, and ensure inclusivity within their green initiatives.

By incorporating sources for renewable energy, waste management, public transportation enhancements, sustainable architecture, green spaces, conservation of cultural heritage, and water management are facilitating the said regions to drive the change in terms of urban development that is environmentally sustainable. With the world consistently addressing the outcome of urbanization, green cities in Europe and the Czech Republic act as fine examples of the way in which environmental sustainability could be realized within urban spaces.

Chapter – 6

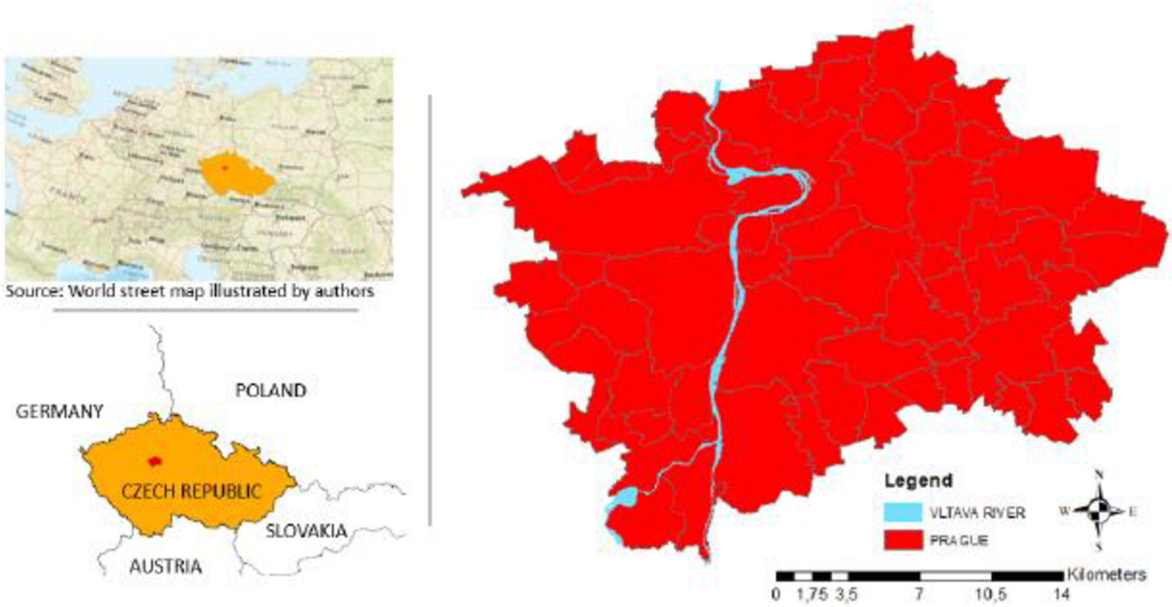
Green Infrastructure in Resilience Development Cities in Europe

6.1 Overview of the General Situation of Green Infrastructure in Prague

Urban green infrastructure (UGI) has been perceived as an essential aspect of cities that offer an array of services to individuals and other lifeforms within urban spaces. It has been stated by Badura et al., (2021), that extensive urbanization has several negative environmental impacts and UGI mitigate many of those factors while sustaining the perceived quality of urban life. This is a fact which is of utmost significance given that within several cities across Europe, more than 70 per cent of the populace are known to reside in urban regions. Migrating from rural regions to urban was a consistent procedure throughout the 19th century. UGI is a significant aspect within municipalities and its ecosystem. Considering that a large number of individuals are known to reside in cities, improvement, restoration, and preservation of biodiversity within urban regions have also assumed significance (Kowarik et al., 2020). GI within an urban context is critical for enhancing and safeguarding the biodiversity within a city ecosystem. (Rastandeh et al., 2017) assessed more than 400 measures pertaining to biodiversity effects on ecosystem services and on its basis has suggested that biodiversity positively impacts services provided by ecosystems. The analysis carried out by Elisha & Felix (2020) has found that loss of biodiversity has adverse impacts on the functions of ecosystems in myriad ways, and the link between biodiversity and the functioning of ecosystem was affirmed by others (Ashford et al., 2021), (Soininen, 2022). While ecosystem services are known to lend support to varied facets pertaining to the quality of human life. Such services have been categorized as regulating, provisioning, support, and cultural services. The irreplaceability of its functions tends to enhance the quality of life within the city and helps in shaping the image of the city.

The borders of the political city district which were developed on the basis of the historic core which straddled the Vltava River in Prague expanded East and West along with stream corridors and across the hillsides which bifurcated the stream valleys with a larger preference for South facing slopes. Substantial areas of steep hillside continue to be developed with less intensity with primarily old vineyards and orchards, several of which have long been discarded, and are in diverse shapes of natural succession. Remaining green areas within the historic tapestry essentially include urban parks, chateau gardens, and cemeteries too, considering that from 1949, certain fundamental changes have occurred within the administrative division. From then on, the borders of several administrative districts and urban districts are autonomous of the boundaries of cadastral territories and some cadastral territories are thus segregated into administrative and self-governing parts within the city. Prague has been segregated into 10 municipal districts, 22 administrative districts, 57 municipal parts, or 112 cadastral areas as is evidenced through figure 10.

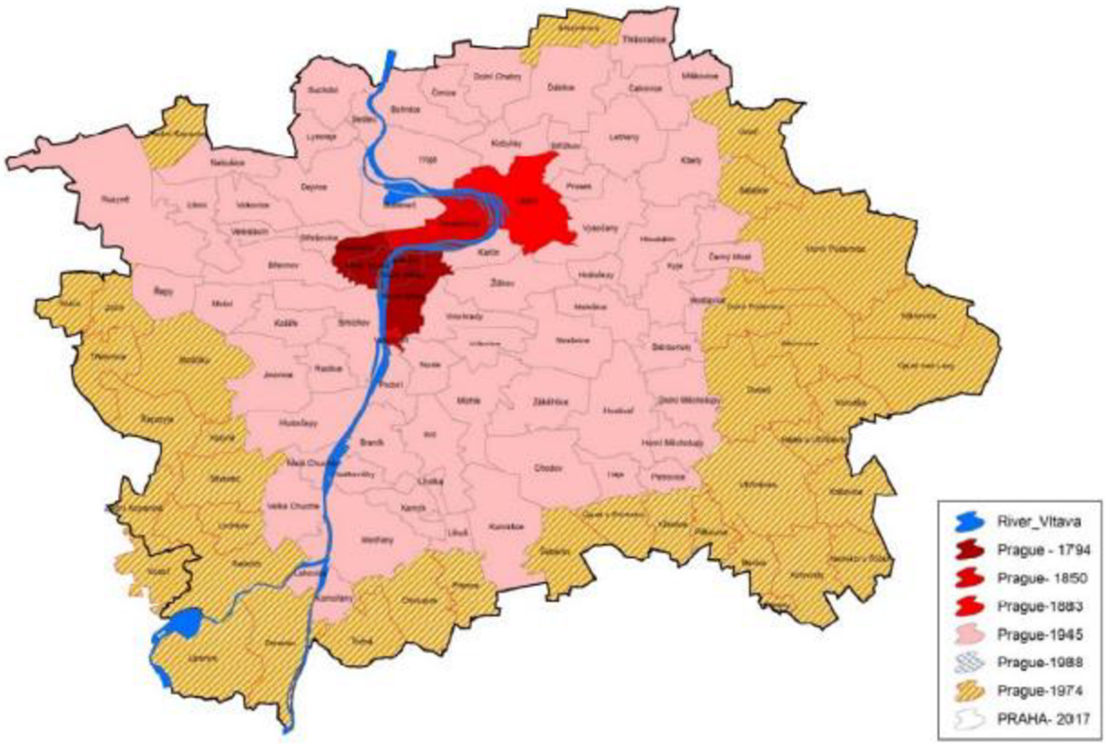
Figure 11: Cadastral Territories in Prague (Author)



The notion of GI has been in existence in city development for many years now and can be found across theoretical considerations, and its meaning, interpretations and also the way in which it is produced in the form of definitions (Wang & Banzhaf, 2018). Cities within Czech Republic have a population density that is comparatively low in comparison to other EU countries. Prague as a capital city has a base population that is considerably lower than other EU capital cities. In particular, cities with the Czech Republic are known to have a relatively low-density level as compared to that of the cities in other nations, that are most densely populated. The density in population touches around 4600 residents for every square kilometer (12000 people who reside in every square mile)(OECD, 2018) in Prague. According to Hussein et al., (2020), the strategy for green infrastructure in the EU, acts as a pivotal step towards the success of the Biodiversity and Conservation Strategy, that was embraced in 2013, which intended to develop a robust policy framework with a view to encourage and enable GI projects that used prevalent legal, policy, and financial tools. The city of Prague has been an integral part of it right from 2013, to initiate major steps to emerge as a city that is sustainable. The strategy of districts in the city of Prague is to adapt against climate changes with the intention to enhance the environment for their inhabitants. A multifaceted approach has been adopted by the city of Prague for adapting to climate change and enhancing the environment for residents. This comprised augmenting urban forests and green spaces to overcome heat island effects, encouraging options for sustainable transportation such as cycling and public transit to lower emissions, executing standards for energy-efficient buildings to lower the consumption of energy, and nurturing community engagement in efforts towards climate resilience. In addition, the city of Prague has also made investments towards water management systems to tackle any risks presented from flooding and improve the conservation of water. Such concerted initiatives exhibit the commitment of the city to develop a resilient and sustainable urban environment for their residents.

Territorial development in the city of Prague commenced from 1784, straddling the Vltava River, while merging four towns in Prague. The last enlargement occurred in the year 1974, and has expanded east and west along stream corridor and over hillsides that bifurcated the stream valleys with a greater preference for South facing slopes. In the process, around 30 municipalities were included, that on the whole made up of 37 cadastral territories. The process of map-making was rendered intricate by modifications in the boundaries within cadastral territories of individual municipalities linked to Prague. Prague has witnessed extensive suburbanization and urbanization of any municipality within the Czech Republic. During the periods between 1985 and 2000, there was an increase in built-up areas from 1.1% of the territory to approximately around 8.1%. Nonetheless, Prague continues to have an extensive share of natural and agricultural lands within its territories (Salama et al., 2020).

Figure 12: Territorial Development in Prague (Author)



In the city of Prague, urban green areas occupy 55.3% and the biodiversity is split into diverse vegetation classes for representing the areas that are most intensely vegetated (shrubby and wooded vegetation) and areas that are impermeable such as water, built areas, exposed soil, and shadow. The classifier that identifies natural breaks splits the array of information into portions of same behaviour (Rocha et al., 2018). The classifier identifying natural breaks segregates data into segments that project similar behaviour. Such an approach enables elements to be grouped on the basis of innate patterns instead of arbitrary thresholds. For example, under the tenets of urban planning, it could classify areas of vegetation density or dynamics of water flow. Through an understanding of natural divisions, it is instrumental in pinpointing areas that have the same type of ecological functions or susceptibilities, facilitating focused interventions like planting initiatives or strategies for flood mitigation. Eventually, such a method of classification helps in optimizing decision-making procedures and resource allocation, nurturing a highly impactful and sustainable management of GI in urban environments. The strategic plan of Prague also outlines the grounds for general drainage and flood management planning for the city and a developmental plan for sewerage system and water supply. The general flood management and drainage plan for the city of Prague was enacted in 2002 by the Prague City Council, and has emerged as a strategic instrument that directs the investment, planning, and operation of measures for managing floods while ensuring drainage of sewage and rainwater. The aim of the sewerage and water supply plan was to ensure wastewater management and an adequate supply of drinking water for the city. The city of Prague also has an integrated a transport system that can be deemed as a grey infrastructure system. This integrated transport system is frequently referred to as a grey infrastructure system owing to its extensive network of bridges, roads, and rail lines, that dominated the landscape in urban areas. This term emphasizes the dependence on conventional, concrete-based structures for transportation. The system of transport within Prague heavily hinges on such grey infrastructure to take the substantial commuter traffic of the city within its ambit, and also extend support to economic activities (Simunek et al., 2021). Irrespective of the initiatives to incorporate sustainable transport modes, like bicycles and trams, the dominance of grey infrastructure continues to persist. However, the notion of developing GI is still an aim, though the city is working towards achieving it. For instance, Prague was also in the process of embracing a platform for green and blue infrastructure for the second time around 2020 by planting millions of trees along the streets to tackle the issue of climate change.

GI within Prague is known to deeply rooted based on the commitment of the city towards urban development and sustainability. This notion gained much attention during the initial period of 2000s, as the city of Prague attempted to thwart the environmental problems linked with rapid urbanization (Badura et al., 2021). In the initial period of 2000s, akin to several other cities, Prague was confronted with major environmental challenges associated with rapid urbanization. A concept that gained much interest during this period was the notion of green roofs (Rebrova et al., 2017). Green roofs comprise covering rooftops with vegetation, that could help in overcoming several environmental issues like heat island effect, air pollution, and stormwater runoff. Prague made an attempt to tackle its environmental challenges by pushing the installation of green roofs across the city. This idea was intended to overcome the challenges the city faced, in an effective manner. However, as far as the success of this initiative was concerned, the application of green roofs within Prague has shown promising results. Green roofs have been revealed to be impactful in lowering heat island effect by offering natural insulation and absorption of solar radiation (Dwivedi & Mohan, 2018). They have also been instrumental in improving the quality of air by filtering pollutants within the air and capturing carbon dioxide (KONÁŠOVÁ, 2019). In addition, green roofs are also helpful in rainwater retention, lowering the stress on the drainage systems of the city in instances of extreme rainfall events (Hejl, 2019). Though it might be challenging to quantify the entire degree of success from green roofs in Prague, its adoption has definitely made a positive contribution to the initiatives on the part of the city to overcome environmental challenges associated with rapid urbanization. Nonetheless, the success on the whole would hinge on diverse aspects like the level of application, practices pertaining to maintenance, and tracking environmental indicators.

6.2 Contribution of Green Infrastructure to Promote Urban Resilience in Prague

For achieving urban resilience, it is essential that government within Prague need to setup a local disaster risk management strategy to mitigate the impacts associated with climate change (Ordóñez et al., 2020). In view of the growing intensity and frequency of climate-related events like heatwaves, floods, and storms, it is imperative that the government initiate steps that are proactive in nature. This would commence with the execution of a detailed assessment of the susceptibility of Prague to such hazards. Through an understanding about particular risks posed by climate change, authorities would be able to better allocate resources, while prioritizing areas that largely require intervention. Remarkably, this procedure needs to include an active engagement with local businesses, communities, and organizations. Their experiences and insights would be of high value in structuring a strategy that is effective as well as inclusive. On the basis of collaboration, the strategy could be customized to cater to the distinct requirements and concerns of varied populations and neighborhoods in the city of Prague. Execution of early warning systems would be another integral aspect of the strategy. Dissemination of information and timely alerts could substantially lower the impact of disasters by facilitating prompt response and evacuation initiatives. Making investments in resilient infrastructure would additionally boost the capability of the city to endure and recuperate from climate-related events. On the whole, setting up a robust strategy for disaster management would highlight the commitment of the Prague government towards the safety and well-being of their residents when confronted with climate change. By initiating proactive steps, the city would be in a position to overcome risks, improve resilience, and develop a highly sustainable future.

The strategy would be inclusive of regular reporting on small-scale hazardous occurrences that do not get recorded in the global catastrophe loss databases (Etinay et al., 2018). Nonetheless, executing the findings derived from the Urban System

Model could be confronted with challenges owing to lack of transparency, shortcomings in urban governance, and restrictions in human and financial resources. Such factors tend to result in biases in terms of socioeconomic evaluation and low performance in urban resilience. The Urban System Model (USM) refers to a framework that has been utilized by researchers, urban planners, and policymakers to comprehend and evaluate the intricate interactions in urban regions (Weinblatt, 1970). The idea is to simulate and forecast diverse facets of urban systems like population dynamics, patterns of land use, economic initiatives, transportation networks, and environmental impacts. Typically, the USM integrates diverse data sources, which are inclusive of demographic data, transportation data, land use day, environmental data, and economic indicators. Computational techniques are used, such as simulation, mathematical modeling, and data analysis to represent the dynamic behaviour of urban systems over a period of time (Bélinga & Haziti, 2023). The USM model facilitates stakeholders to look at various scenarios and policies to assess its possible impacts on the population and the urban environment. For instance, policymakers could utilize the USM to evaluate the impact from executing new transportation infrastructure, zoning regulations, or economic development strategies on aspects such as air quality, traffic congestion, social equity, and land use patterns.

Urban resilience has been extensively deliberated and integrated within policymaking while considering GI within urban areas in the Czech Republic. Subsequently, it is pertinent that investigations be carried out in terms of methods for mapping and measuring techniques for achieving urban resilience and how GI contributes to this in Prague. Research conducted in the past (Karabakan & Mert, 2021) has indicated that adaptive resilience can be mapped to measure the impact of GI, and top-down measures can be commonly utilized to map innate resilience. Adaptive resilience refers to a natural system's capability to endure and recover from disruptions while sustaining functionality and offering advantages. It comprises designing and managing green spaces for anticipating and adapting to changing environmental situations, like climate change and pressures of urbanization (Alshafei

& Faqra, 2023). Such an approach incorporates varied soil types, vegetation, and hydrological features to improve ecosystem services such as biodiversity support, flood mitigation, and carbon sequestration. By nurturing diversity and flexibility, it is ensured through adaptive resilience that green infrastructure continues to be impactful even when confronted with uncertainties, encouraging sustainable development, and improving the well-being of environment and human communities (Pamukcu-Albers et al., 2021). Innate resilience on the other hand pertains to an innate capability for enduring and adapting to environmental stress (Jang, 2021). Such resilience would emerge from natural processes and features like soil composition, biodiversity, and hydrological cycles, that improve functionality and stability. Green infrastructure which comprises wetlands, forests, and green roofs absorbs and mitigates diverse disruptions like pollution and extreme weather events. Based on self-regulation and ecosystem services, it sustains ecosystem health and functionality (Calheiros & Stefanakis, 2021). Such inherent resilience is not only instrumental in sustaining ecological balance, but it also offers benefits over a long-term period such as conservation of biodiversity, climate regulation, and community well-being.

Nonetheless, resilience maps seldom investigate how GI contributes to urban resilience entirely, resilience maps in fact fail to project the capability of systems to evolve or adapt, neither do they project the systemic trait of resilience (Reynolds et al., 2022). Resilience maps frequently ignore the vital role played by GI in improving urban resilience. GI, including green spaces, overcomes environmental risks, provides a buffer against natural disasters, and nurtures community cohesion. Understanding the contribution of GI is necessary for extensive planning of urban resilience and sustainable development (Liu et al., 2020). GI mostly runs on solar energy that is captured through photosynthesis, generally rendering it less polluting and increasingly carbon neutral as compared to human-built 'gray infrastructure', which is more often than not powered through a combustion of fossil fuels. Such qualities of urban GI in Prague could contribute to highly sustainable, carbon-conserving systems. In Prague, urban green infrastructure projects qualities like enhancement of biodiversity, recreational opportunities, and stormwater management. Varied vegetation within the city nurtures habitats for wildlife while overcoming issues of air pollution and heat island effects (Hladíková & Jebavý, 2020). Green spaces that are strategically placed like urban forests and parks, mitigate flooding and enhance water quality by absorbing excess rainwater. In addition, these such areas provide visitors and residents with ample relaxation spaces, social interaction, exercise, while making contributions to mental and physical well-being (Skokanová et al., 2020b). The incorporation of green infrastructure within the urban fabric of Prague improves the resilience of the city to environmental challenges while offering several societal advantages. Carbon-conserving systems refer to approaches that focus on lowering carbon emissions, while maximizing carbon sequestration to overcome climate change. Such systems take under their ambit diverse strategies across sectors like transportation, industry, energy, and agriculture. For instance, sources of renewable energy like wind and solar power, which lower dependence on fossil fuels, thus reducing carbon emissions (Maksymenko et al., 2023). In addition, reforestation and afforestation initiatives help absorb carbon dioxide from the environment. Practices in agriculture like crop rotation and no-till farming could improve soil carbon sequestration. Efficiency in urban planning, encouraging public transportation, and incentivizing low-carbon technologies contribute to lowering carbon footprints (Ramyar, 2017b). Carbon-conserving systems accord priority to environmental responsibility and sustainability, intending to strike a balance between human initiative and the carbon cycle of the earth to conserve the planet for generations in future. Thus, it can be reasoned that urban GI does contribute to urban resilience based on the attributes that lend credence to resilient systems (Darnhofer et al., 2016).

6.3 Methodology

For shaping this chapter, the methodology that was adopted included a thorough search of prominent academic databases such as ScienceDirect, Taylor & Francis, Emerald Insight, and also other relevant academic and scholarly sources. Only relevant papers that were similar to or investigated a similar phenomenon such as GI and urban resilience were considered for this review. The search focused on finding recent papers that investigated and deliberated the contribution made by GI in developing urban resilience in the city of Prague. While finding relevant papers, care was taken to make sure that only research or scholarly work conducted between 2015-2022 were reviewed. At the same time, papers that fell beyond this date range or those that did not investigate the variables in question were excluded from this review.

6.4 Findings – Case Studies of Successful Green Infrastructure Projects in Prague

According to Moravcova et al., (2022), it has been reported that the process of city development involves an interactive procedure.. Including GI initiatives during the spatial planning process serves a critical function if GI is to be incorporated into future growth scenarios. Not only does GI satiate an aesthetic function in towns and villages, but they also substantially impact the quality of life of local citizens (Cole et al., 2017). Essentially these would be areas that offer a place for individuals to meet in a pleasant environment and thereby presents people in Prague with a chance to relax and rejuvenate, as an outcome of the positive impact of green spaces on their sense of well-being (Hussein et al., 2023). At the same time, GI driven green spaces in Prague that would be supported by water features offer the essential shade and more pleasant climate during hot summer months when the city center tends to heat up and expose individuals to extreme temperatures and high thermal stress.

Studies pertaining to thermal comfort analysis continue to be conducted, particularly in cities like Prague, for determining the impact of green infrastructure supported duly with water features on thermal comfort and the psyche and health of people living there (Lehnert et al., 2021) (Wang & Banzhaf, 2018). Furthermore, the role played by green spaces exclusively on public life within communities and its aesthetic functions, blue-green infrastructure has also made a substantial impact in terms of enriching local biodiversity in Prague, which acts as an interactive component with the surrounding nature and thereby offering a refuge for diverse species. Within the city of Prague, the notion of ecosystem services and GI assessment is still a novel topic. Initiatives to evaluate ecosystem services in some manner, or rather multifunctionality of biotopes can be traced back right to the 1970s. The latest contribution towards assessing ecosystem services would be projected on the basis of a methodological framework of the incorporated evaluation of ecosystem services within Prague. As per the framework, t the fundamental processes and rules for assessing the state of ecosystems, ecosystems services, and its economic value is indicated (Krkoška lorencová et al., 2016).

While evaluation of ecosystem services as of now is not a concept that has been largely disseminated across the Czech Republic, there is a tool in territorial planning that has been well-established and to a certain extent fills or achieves one of the principles of GI, that being creating new or protecting existing connectivity and existence of semi-natural and naturally occurring ecosystems. Referred to as the Territorial System of Ecological Stability of the Landscape (TSES) – or USES in Czech language – this is the legally enforceable tool of territorial plans for every municipality (Dennis et al., 2018) for protection and creation of ecological networks. TSES has been defined as an interlinked system of natural and also modified ecological networks which also includes three varied groups of components such as bio-centers, interactive components, and bio-corridors. The concept of Ecological Networks first appeared in several European countries in the early 1980s as a tool to combat habitat fragmentation and the loss of biodiversity as part of EECONET

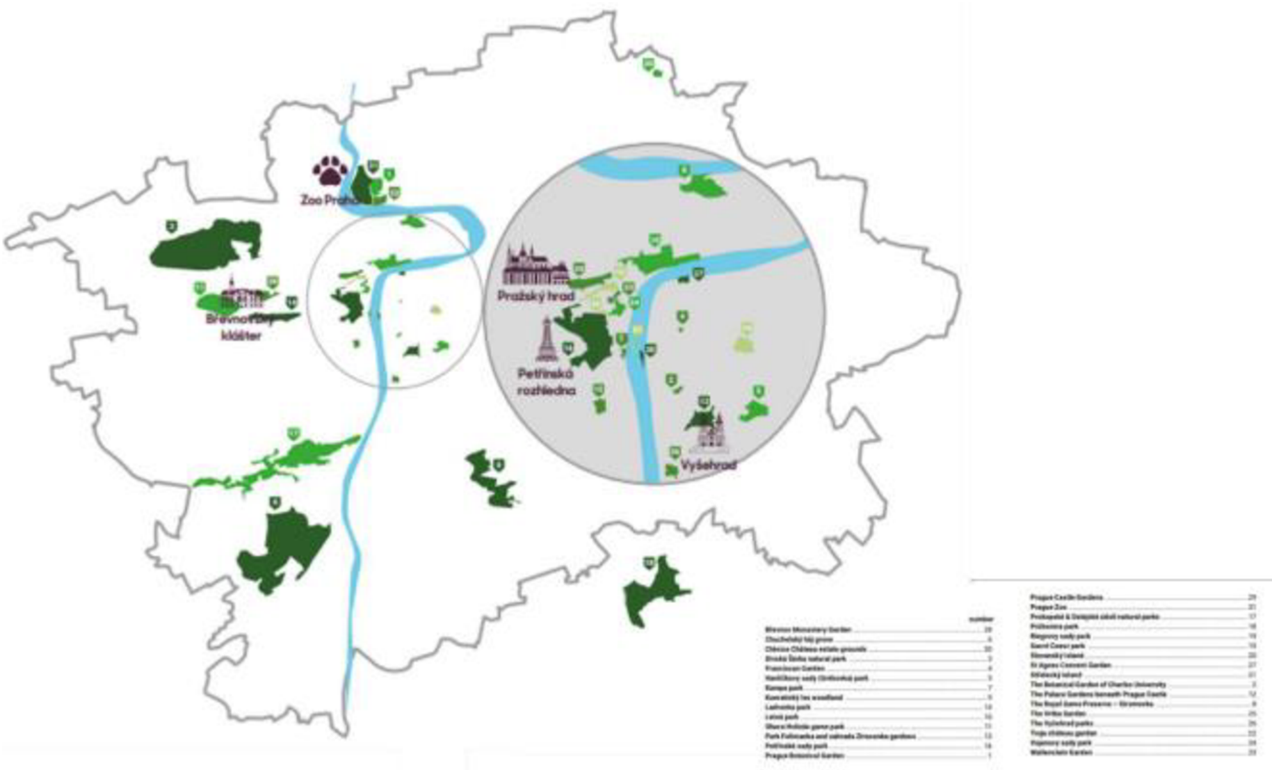
European Ecological Network. Again, the TSES in the Czech Republic, implemented in 1992, is a system is based on the concept of EECONET. It is the only nature conservation tool in the Czech Republic for the creation and protection of ecological networks based upon Czech law. It is used to conserve and enhance the existing natural resources; remedy habitat fragmentation; positively influence the surrounding or less stable parts of the landscape; and is the basis for diverse use in the terrain. TSES plans cover nearly 92% of the Czech Republic. A bio-center refers to a habitat or a system of habitats, which makes sure through its size and status the permanent presence of semi-natural or natural ecosystems and is interlinked with other bio-centers. Bio-corridors are areas which are frequently elongated, that facilitate the movement of terrestrial and flying animals between bio-centers. Interactive Elements are comprised of landscape features that are isolated spatially, providing favorable conditions for the presence of organisms with restricted territorial requirements (Liquete et al., 2015). An Interactive Element could be a solitary tree, trees along a pathway, small pond, an orchard, small meadow or a hedgerow. The TSES ecological network is structured hierarchically, meaning that its parts are distinguished on different spatial levels; they are International (part of EECONET), National, Regional, and local.

At the time of planning, implementing, and managing GI, it is imperative to take spatial scales into account such as local, national, and regional, which is most apt to the procedure or functions that would be taken into account. Note that this is very similar to the structure of TSES. Regional level would also have an intrinsic role to play in the city of Prague considering that GI policies within Czech Republic tend to have an approach that is transnational in nature (Mander et al., 2018). The national level needs to facilitate trans-border and global links, which facilitates strategies to be placed in the context of larger global concerns (connectivity, climate change etc.). The regional level on the other hand needs to offer links across local authorities and other organizations while using an extensive array of data that offers extra understanding and detail for mapping and planning (Rosina et al., 2020). The local level needs to facilitate the involvement of local authorities at the sub-county and county levels, while delivering a proper map for extensive evaluation or planned execution. The information and data flow needs to not only move up and down the scales, but it should also move in a horizontal manner at the local and regional levels.

The city of Prague has made several in-roads for implementing GI and there are many instances that point to successful GI projects within the city. For instance, Stromovka Park that is located at the very center of the city can be deemed as a notable example of success in execution of GI, particularly in an urban environment. The metamorphosis of the park over several years has rendered it as a benchmark for sustainable urban planning and management (Rousek & Hašková, 2017). In the 16th century, the Park was designated as a royal ground for hunting. Substantial transformation of the park in recent times was carried out to tackle the challenges that arose from rampant urbanization in the city of Prague (Strategie Adaptace, 2020). The redevelopment of the park was done on the basis of an integrative approach which took under its ambit diverse social, environmental, and economic facets. One of the foremost components of the project was the integration of sustainable stormwater management methods, like flood walls, permeable gardens, and constructed wetlands, for mitigation of flooding and urban runoff (Haaland & van den Bosch, 2015). Such elements of green infrastructure not only enhanced the city's resilience to floods, but it also improved the quality of water in the adjoining Vltava river.

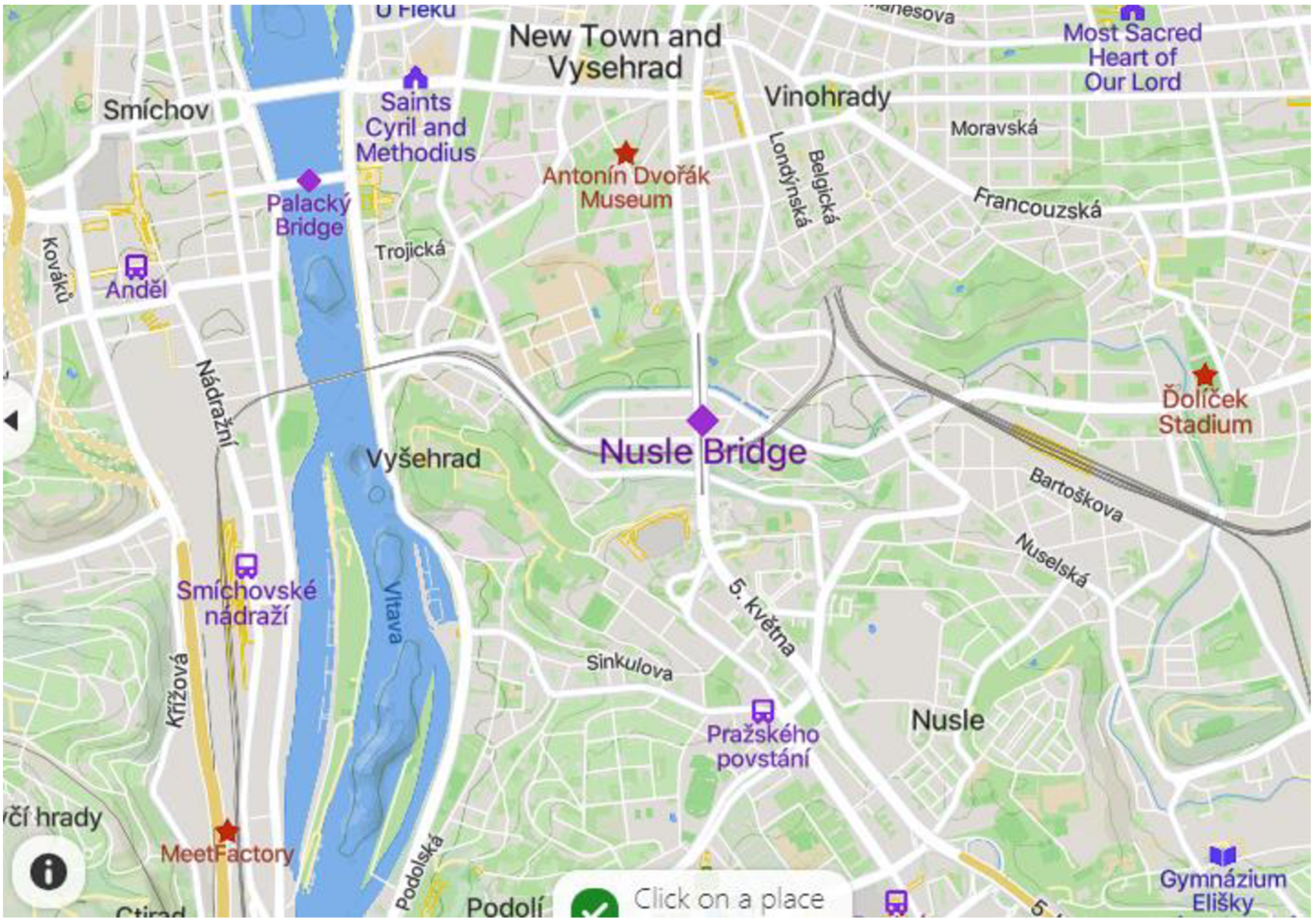
Figure 13: Key Green Spaces within Prague

(Praha ŽP, 2006)



In addition, Stromovka Park provides several opportunities for recreation such as cycling, running, and walking paths, picnic areas, and playgrounds. Such amenities encourage physical activity, nurturing the well-being of the community, and social cohesion (Elands et al., 2018). The varied flora and fauna of the park, which is inclusive of native plantations, have also garnered diverse wildlife, contributing to the biodiversity of an area on the whole (Kabisch, Strohbach, et al., 2016). Thus, Stromovka Park can be considered as a benchmark in terms of effective execution of GI principles, that contributes to urban resilience, community well-being and ecological sustainability within the city of Prague.

Figure 14: Location Map of Nuselsky Bridge ((*Mapcarta*, 2024)



Similarly, Nuselsky Bridge, which is a vital artery for transportation in the city of Prague, has undergone an extensive redevelopment that illustrates the incorporation of the principles of green infrastructure within an urban environment that is highly intricate. The project focused on tackling the issue of congestion, enhancing public transportation, and lowering the environmental footprint linked with the bridge and its surroundings. Several initiatives in sustainable transportation were integrated during the redevelopment process. A feature that is most remarkable would refer to the addition of a dedicated tram line, for improving connectivity within public transport (Hörcher & Tirachini, 2021). This was not only instrumental in lowering situations of congestion of traffic, but it also encouraged the use of public transportation, which contributed to a drop in greenhouse gas emissions. Moreover, Nuselsky's Bridge is known to have an extensive network of pedestrian pathways and lanes for cycling. This encourages options in transportation that are non-motorized in nature, which not only helps in enhancing the quality of air, but it also contributes to the well-being and health of residents (Vrána et al., 2021). Another major aspect of the project was greenery. Vegetation and greenery were planted in a strategic manner along the sides of the bridge and adjoining areas, thus offering shade and improving the overall aesthetics of the urban environment (Ragasová et al., 2019). Such green spaces have an intrinsic role to play in combating urban heat island effect while enhancing the livability within the city on the whole. Such kind of a transformation of the bridge highlights the way in which green infrastructure could be incorporated within urban transportation systems in an effective manner for lowering congestion, enhancing the quality of air and improve the quality of life for the people.

Another GI project in the city of Prague revolved around the Vltava River, which flows through the heart of the city. The River has for a long time been subject to human modification and intervention. Nonetheless, efforts carried oud in recent times have concentrated on restoring it ecologically, stressing upon the significance of GI in revitalizing urban water bodies. The restoration of the River focused on enhancing the ecological health while also offering multiple advantages to the city and its residents. Design techniques that were natural were adopted to create curves for restoring the riparian zones of the river, which allowed for natural filtration of pollutants and improving biodiversity (Morelli et al., 2018). Including green spaces along the banks of the River not only improved the aesthetical aspects but it also encouraged social interaction and recreational initiatives. A significant aspect being that the project tackled the issue of flood risk management by facilitating the river to flow in a rather natural manner during high water events. The integration of floodplains and wetlands alongside permeable surfaces and vegetation, lowered the scope of risk from floods, and protected the city from possible flooding (Csóka et al., 2021). The restoration of the Vltava River acts as a blueprint for rehabilitation of urban rivers, showcasing the several advantages of green infrastructure in terms of ecological restoration, well-being of the community, and reducing the risk of floods.

Chapter 7:

Conclusion

7.1 Summary of Findings

It is evident through the studies of green infrastructure in practice in the previous chapter that GI are acknowledged as best practices when they are combined with grey infrastructure (Alida & Alves, 2020). In addition, it was also found by Adesoji & Pearce (2024) that GI has been largely accepted for the value it offers with regard to adapting to the emergent and irreversible impact from climate change (Sturiale & Scuderi, 2019).. Furthermore, governments in New Zealand, France, Germany, Czech Republic and several other have accepted GI as a step for dealing with the adverse and often irreversible impacts associated with climate change. In addition, the findings also indicated that integrating GI within territorial plans offered several advantages for climate adaptation. Incorporating GI in territorial plans results in several benefits for climate adaptation. At the outset, green infrastructure such as urban forests and green roofs improve resilience by abating the impacts of events induced by climate change such as heatwaves and floods (Bajić et al., 2022). By absorbing excess water and providing shade, GI lowers the urban heat island effect, thereby moderating temperatures and safeguarding health of humans (Marando et al., 2022). Secondly, GI nurtures biodiversity, creating habitat for diverse species, which in turn improves ecosystem services that are vital for climate resilience, like soil stabilization and pollination (Abdulghany & Farahat, 2023). In addition, GI encourages carbon sequestration, facilitating the reduction of greenhouse gases and abating the effects from climate change. Furthermore, incorporating GI into territorial planning also nurtures community engagement and social cohesion with the creation of green spaces for relaxation and recreation, thus enhancing well-being on the whole, and reinforcing community resilience when confronted with climate change challenges (Kim & Song, 2019). On the whole, such advantages emphasize the key role played by GI in improving efforts towards climate change adaptation in territorial plans. Also, including GI was instrumental in managing stormwater and reducing the risks associated with floods. Moreover, the findings also indicated that GI stimulated the expansion of biodiversity and created a zone or location for critical ecosystem services within urban environments. Urban green spaces provided habitats for various species like birds, insects, and small mammals, that were favorable in the protection of wildlife and enhancing resilience with urban ecosystems.

But challenges were also observed while integrating GI within territorial plans for dealing with adapting to climate change. A key challenge that was identified referred to availability of green space within urban areas, particularly for cities like London, Paris, Madrid, that are heavily populated. There were also challenges that emerged from financial restrictions which limit the successful implementation GI projects for territorial planning. Costs associated with the design, implementation, and maintenance of GI systems have been extensively argued and have outlined the need for innovative mechanisms for financing such as municipal bonds, real estate transfer taxes, or municipal bonds in Czech Republic. The findings through this study also indicated that escalation of impacts from climate change was instrumental in reshaping the urban landscape on the whole, which warranted innovation within approaches that could be embraced. Territorial plans that integrated GI have emerged as a vital strategy for enhancing urban resilience against challenges arising from climate change. From the findings of this study, it can be understood that there were many advantages that could be derived with the integration of GI within climate adaptation. It was found that GI played the role of a natural buffer to counteract urban heat island effect, wherein vegetation and green spaces mitigated any fluctuations within temperature and enhancing the microclimate within urban regions. The findings thus derived were at par with findings from other studies which revealed the cooling impacts of GI on urban areas.

As far as successful mapping of GI was concerned, the findings from this research indicated that mapping of GI was undertaken in several cities around the world. For instance, in the city of Vancouver, Canada, an ambitious project was undertaken for mapping their GI network using advanced geospatial technologies.

The idea was to develop an in-depth inventory of urban green spaces that included parks, street trees, and wetlands. LiDAR data and ground level surveys were utilized to accurately capture the distribution and level of green assets. The GI map developed thus turned out to be an instrument of high value for urban planners that enabled them to make informed decisions towards conservation efforts, land-use planning and infrastructure development.

Similarly, Singapore is known to have dense population with restrictions in land resources which made it inevitable to map their GI for enhancing livability. With the implementation of the Green Plan 2030 using latest geospatial technologies including LiDAR and multispectral imagery in order to develop an extensive map of water bodies, green spaces and vegetation cover. The key elements within Singapore's approach to mapping included real-time data updates and accessible digital platforms. It was found that this approach not only facilitated citizen engagement, but it also supported decisions pertaining to urban planning which gave due priority to green spaces and sustainable development. The notion of CIAG which was embraced by Singapore was founded on the principle of optimizing spaces based on which maximization of land productivity was recommended. Based on unique experiments in green architecture, Singapore has now emerged as a vertical garden city that presents valuable lessons on GI mapping.

Another city, Copenhagen in Denmark is known for their commitment to sustainability and livability. Based on their approach to GI mapping, it was found that local knowledge and community engagement was necessary to capture green assets in its entirety. To facilitate this, the city introduced a mobile application which allowed residents to report green spaces and recommend spaces that had the potential for green development, while sharing information pertaining to their natural areas of choice. Copenhagen adopted a participatory approach, which was beneficial not only in improving the dataset, but it also empowered citizens to contribute to the enhancement and conservation process in a proactive manner. This method resulted in the creation of a detailed, accurate map of GI which projected the physical assets and emotional links that citizens had with these spaces. In fact, the UGI isolation map of Copenhagen indicated strong relations with 'fingers' which are extension settlements along main transport corridors.

Recently, the city of Stockholm in Sweden has presented a path-breaking instance of impactful GI mapping. The city's commitment to environmental sustainability led to the execution of a detailed mapping project that concentrated on identifying, conserving, and enhancing its green spaces. Leveraging cutting-edge geospatial technologies and community engagement, the city was successful in creating a harmonious mixture of natural landscapes and urban development. GI mapping within Stockholm included coordination and collaboration from many stakeholders that comprised of government agencies, environmental organizations, and residents too. Using satellite imagery, GIS data, and ecological surveys, their project succeeded in effectively mapping existing parks, wetlands, forests, and other green spaces in the city. Such mapping was helpful in assessing the current scenario of GI, but it also helped in decision-making regarding future planning for urban development. A major result that was observed was optimization of green corridor which connected to many parts of the city. Such corridors not only offered recreational space for residents, but they also emerged as key wildlife habitats, stimulating biodiversity within urban regions. In addition, GI mapping also helped in identifying regions prone to flooding, allowing targeted green solutions like rain gardens and permeable surfaces to be integrated thereby circumventing potential threats. Stockholm's success in GI mapping was found to be an outcome of their holistic approach, which blended data driven insights with proactive involvement of community residents. The result hints at a sustainable landscape that is highly resilient, where the integration of nature within urban planning has enhanced the quality of life for residents, while safeguarding the environment for future generations.

As far as successful zoning for GI within territorial plans were concerned, this review offered several examples. In the city of Vojvodina, in Serbia, the elements of GI indicated a multifunctional significance that is reflected through their cultural, social, visual importance along with the ecological importance locally. A unified environmental and visual assessment of natural and semi-natural elements and identifying the possibility of GI creation would be an essential methodological and practical step that might provide guidelines for structuring the elements of GI. A transdisciplinary research approach that involves local residents would be imperative to investigate the environmental and visual antecedents which GI dots should be having. After an improvement based on landscape design, they could prove to be lucrative recreational multifunctional green spaces that project eco-visual territorial unity within the urban-rural continuum.

Similarly, the city of Freiburg in Germany is known for their sustainable development practices and GI zoning has a key role in ensuring success. Regulations pertaining to zoning that have been embraced by the city give much priority to mixed use of land, pedestrian friendly streets, and green spaces too. A notable aspect being that the district of Vauban within Freiburg has implemented severe zoning codes that stimulate automobile free living, sustainable transportation, and green building design. This approach has been instrumental in transforming Vauban into a model for sustainable urban living. GI zoning within Singapore was integrated within the city's plans to addressing the current urban challenges. The Planning Act and Development Control Regulations of the city necessitate the incorporation of green spaces and water bodies within unique developments. This kind of approach has resulted in an impressive network of parks, green corridors, and waterways that reduce the scope of floods, enhance biodiversity, and improve the city's resilience towards climate change. GI zoning in the city of Melbourne in Australia encouraged green streetscapes, mature retention of trees while necessitating the inclusion of public open spaces in new developments. The city's commitment to GI has led to the development of 'Green Wedge' which is a network of secured natural resources and agricultural land that is included in the city. This step was key to safeguard biodiversity and sustaining green lungs within the city. Whereas zoning codes within Vienna in

Austria lay much emphasis upon green corridors, public parks, and urban agriculture. This type of zoning practice has largely contributed to the city's reputation as being the greenest city within Europe. This vast network of green spaces within Vienna that is also inclusive of Prater Park, was instrumental in not only improving the quality of life of the residents, but it also enhanced ecological resilience of the city.

At the same time, in Copenhagen, Denmark was found to have adopted a progressive approach to GI zoning. The zoning regulations for the city have been framed in such a manner that it stimulates green roofs, permeable surfaces, and massive infrastructure for bicycles. The mixture of GI and an urban layout that promotes cycling has been instrumental in transforming the city of Copenhagen into a leader with regard to sustainable urban development. The city has often been reflected as an excellent model for cities within Europe to reduce their carbon footprint and enhance urban sustainability. Similarly, the findings from this review also indicated that the city of Barcelona has made great progress with as far as integrating GI within territorial planning is concerned. According to Barcelona zoning codes, the creation of green connectors has been stressed upon, which links parks and natural areas for creating a network which is consistent. Notably, the city of Barcelona has also initiated a 'Superblocks' program, with the objective of reclaiming streets for pedestrians, and green spaces through a planned limitation to automotive traffic. This kind of innovation within the zoning strategy enhances urban experience and the quality of the environment on the whole thus projecting the potential for executing GI within European cities with high populations. On the other hand, Amsterdam has been receiving much praise for their urban planning that is highly advanced as compared to their counterparts. The zoning regulations within Amsterdam accord high priority to green roofs, green walls, and integrate features related to water as far as urban design is concerned. In addition, the city of Amsterdam is committed to sustainable practices and green transportation that has led to an environment that is highly sustainable. The steps undertaken by the city have made a positive impact and clearly implied that zoning could be a potential tool in ensuring city development that is not just resilient but green as well.

Furthermore, the examination of successful public participation in GI design has also presented favorable outcomes. In the case of Amersfoort city within the Netherlands, a classic example of public participation was evidenced through a project where a site for a hospital was transformed into a new park for the city while allowing an expansion with an adjoining city part. In this case, the public participation was clearly evident when the residents of the city worked in tandem with the municipality to drive this redevelopment project. To add a structure to such a partnership, a key group was formed that included representatives from all stakeholder groups. The main facet within this process was that it did not have any bottom-up or top-down approach. Instead, an original cooperation was observed where distribution of authority was equal between all concerned, and the stakeholders mutually concentrated on achieving the objective based on creative workshops and discussions for offering a joint plan and creative ideas. The key group provided updates regarding objectives and ideas of the project, its requirements, and limitations arising from funding and time to residents by leveraging the potential of social media platforms. In addition, several meetings that allowed the public to respond to such plans and ideas for the park were also held. World cafes and open space methods were used during meetings to disseminate participants ideas on sub-themes within small groups. World Cafe (WC) is a tool for participatory assessment that is extensively utilized within organizational change procedures or community development, as an additional method for qualitative research. WC is a participatory technique of data collection involving a large number of participants. In situations where there are many participants, it facilitates the verification and exploration of themes (Löhr et al., 2020). Similarly, open space methods facilitate meetings. Over an eight-month period, a redevelopment and management plan were designed and structured. Due to this notion of comprehending the shared interests of the administration and other stakeholders, the techniques of participation that were used were mainly as a facet of the process of decision-making and thereby indicated a relatively high level of participation from stakeholders. Similarly, Leige, Belgium presented another example of successful participation from public in terms of GI design. The idea here was to revitalize a park that included green spaces nearby to a once military fort. Round tables and workshops were conducted for consulting with stakeholders for assessing the situation and for design references. Site visits were also carried out with opinion surveys being conducted. Furthermore, techniques of participation like charrette and other varied initiatives were deployed during the planning process.

Another example of public participation was observed in Sheffield, UK. The idea was to direct restricted resources to realize varied benefits and address current drawbacks with regard to sustainability. A derelict and underused site in a deprived city-center community was chosen for investment. The result from this exercise was that the site came to be acknowledged as 'Breathing Spaces' within Sheffield which aimed to provide GI within the city center. Several meetings and workshops were conducted with the local community which comprised of residents and friends of resident groups for deliberating sustainability and land transfer, designing a new park, and its maintenance. The city of Stuttgart in Germany also presents a fine example of public participation through its innovative approaches to GI design. This was particularly true in the context of green roofs. The idea here was to increase the number of green roofs in the city to address the issue of urban heat island effect, improve air quality, and enhance biodiversity. Public participation was intrinsic to ensure success. Information campaigns, and workshops were arranged by the city government which incentivized green roof installations with regulatory changes and financial support. People were encouraged to share their ideas and thoughts in reference to green roofs, which led to the creation of a strong and widespread strategy which was at par with the city's environmental objectives.

Lastly, the Thames Tideway Tunnel project for managing wastewater in the city of London, UK is also an example of public participation. The purpose was to prevent the flow of sewage into the Thames when the city witnessed heavy rainfall, thereby improving the quality of water and protecting aquatic ecosystems. Public engagement was instrumental in ensuring success within the project. The city carried out extensive consultation and communication with local communities and information sessions were organized to convey the message.

The findings from this review also presented best practices and success stories from model cities. For instance, Osijek, a city in Croatia is known for its array of spatial frameworks. Data collected from EU helped in comparing similar spatial phenomena. Data presented through the green cadastre tool of Osijek GI allowed for a dynamic review and rich database with information that could contribute to impactful maintenance and management of GI in the city.

Similarly, a comparison of GI maps was carried out based data derived through CORINE land cover database of Czech Republic. The findings revealed that CORINE based GI map was suitable for a transnational level, but it was not found to be useful at a regional level. Whereas CLE based GI map was appropriate for regional as well as national levels but there was no information regarding GI within urban areas. Similarly, it was also found that cities across Europe were at the forefront in providing appropriate zones such as cycling zones, parks etc., especially in Spain, Denmark etc. Incorporating green spaces within urban landscapes would be a key element within model green cities such as Schonbrunn Park in Vienna offers a good example of urban green areas that enhanced the quality of life for individuals while supporting biodiversity.

The review also looked into successful cases of GI projects in the city of Prague. In Prague, the idea of GI evaluation and ecosystem services was a unique topic. Initiatives for assessing ecosystem services in some manner, or even multifunctionality of biotope were traced back to 1970s. Contributions that were made recently for assessing ecosystem services were based on a methodological framework of an integrated assessment of ecosystem services within Czech Republic.

While planning, implementing, and managing GI, it is necessary to consider spatial scales like regional, local, and national which would be an appropriate process or function. It was also found that supra-national level had a major role to play in Prague given that GI polices in Czech Republic adopted an approach which was transnational in nature. As far as GI was concerned, Prague has been at the forefront which highlights the many successful GI projects that have been executed within the city. For example, Stromovka Park situated in the central part of the city could be considered as a remarkable example of success in GI implementation, especially within an urban environment. The park's transformation over the past many years has made it as a standard for sustainable urban planning and management. The park which was initially designed as a hunting ground was converted to address the problems that emerged from widespread urbanization. An integrative approach was utilized to transform the park which considered various social, economic, and environmental aspects. A key element of the project was its incorporation of sustainable methods to manage stormwater like permeable gardens, rain gardens, and wetlands for circumventing the problem from urban runoff and flooding. These components of GI not only improved the resilience of the city to floods, but it also enhanced the water quality in Vltava River.

Another notable example of successful GI projects in Prague was Nuselsky's Bridge. This bridge accommodated many cycling lanes and pedestrian pathways. This encouraged options in non-motorized transportation. This was instrumental in air quality improvement, while simultaneously contributing to the health and well-being of residents. The bridge project was also instrumental in improving greenery wherein, vegetation was strategically planted along the sides of the bridge and neighbouring areas, thereby providing shade and enhancing the environment aesthetically. This transformation of the bridge emphasized upon how GI could be integrated in urban transportation systems effectively for reducing congestion, improving air quality, and enhancing the quality of life on the whole. The transformation of the Vltava River presented another example of a successful GI project. This river project concentrated on improving the ecological condition of the river while presenting several benefits to the residents of the city, and the city on the whole. Natural design techniques were embraced to make curves to restore the river's riparian zones, that facilitated natural filtration of pollutants and enhanced biodiversity. Adding green spaces along the riverbanks was effective in not just enhancing the aesthetical facets but it also stimulated social interaction and recreational initiatives. A major aspect here was that the project was effective in addressing the problem of flood risk management by allowing the river to flow naturally in the event of heavy rainfalls, as is indicated in tables 1 and 2.

Table 1: Coding According to Land Use Type in Prague (Source: Author, 2024)

	Code	**Land use type**
1	RPU	park-landscaped areas
2	HY	water courses and areas
3	LRO	Forests
4	LRR	forest parks
5	ND	accompanying vegetation
6	NNK	non-forest stands of trees not associated with shrub
7	NM	wetlands without woody plants
8	NNO	non-forest stands of woody plants not associated with trees and shrubs
9	NZO	non-forest stands of woody plants connected with trees and shrubs
10	NZK	non-forest stands of trees mixed with shrubs
11	NNS	non-forest stands of woody plants not associated with trees
12	NZS	non-forest stands of woody plants connected with

	Code	Land use type
		trees
13	PLP	production field
14	PRZ	agricultural production
15	PLU	field – fallow
16	RAP	natural recreation areas
17	RAZ	recreational and garden settlements
18	RPP	garden park areas
19	RPH	Cemeteries
20	RV	educational recreational areas - ZOO, botanical garden
21	VPN	pedestrian area
22	ZL	meadows, pastures, grass fields
23	ZSZ	Gardens
24	XZ	unused areas with overgrowth of trees
25	ZSV	Vineyards
26	BR	Brownfields

Table 2: LaFU Types (Source: Author, 2024)

Symbol	Type of Unit—Description
A	forests and groups of greenery with a compact area over 25 ha
B	forests and groups of greenery with a compact area over 25 ha with surface waters
C	forests and groups of greenery with a compact area over 25 ha with internal open spaces

Symbol	Type of Unit—Description
D	forests and groups of greenery with an area of about 5–25 ha
E	greenery complexes—with an area of about 0.5–5 ha
F	watercourses in open areas (farmlands)
G	watercourses with greenery
H	surface standing waters with treeless surroundings (in open areas)
I	surface standing waters together with groups of greenery
J	orchard complexes
K	domination of open areas (farmlands)
L	urbanized areas—cities
Z	various types of LaFU with housing complexes and/or economic activity zones

The integration of LaFU analysis and MSPA in this study has presented interesting insights to guide the GBI vision of Prague. We used the results from the LaFU-MSPA intersection analysis and designed a strategic map defined by the distribution of GBI functional typologies in the city. The strategies for enhancing BGI functions were drawn with the reference of existing local and regional policies and also from best practices from other European city-regions. We tabulated the strategies amongst the LaFUs across different regional categories of urban, non-urban and connections. A prominent natural element visible in Prague are the Rivers Vltava and Berounka traversing it north to south (Fig. 22). The diagram also highlights the forest and farm core areas located to the periphery of Prague. While the central districts are largely urbanized with smaller green areas scattered across them, the forest cores exist adjacent to the urban districts. Although the forest cores and connections are not continuous, they approximately form alternate wedges of forest cores and connections around the urban districts, with some forest wedges radially converging into the river zone. Beyond the forest ring, there is a dominant presence of farmlands that are fragmented by streets and roads. The final vision, as presented in Fig. 22, aims to guide for more cohesive strategies for defragmentation and improvement of the quality of Prague's GBI.

Figure 15: MSPA Results with 7 Morphological Pattern Elements (Source: Author)

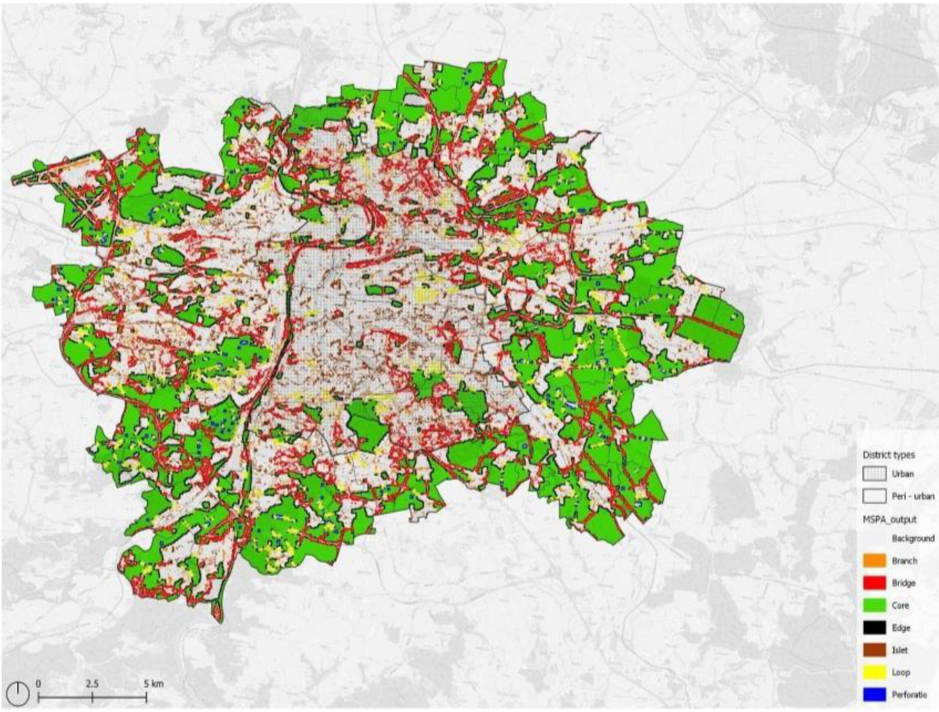


Figure 16: MSPA Cores and Connections Compared to LaFU Obligatory Actions (in Ha) (Source: Author, 2024)

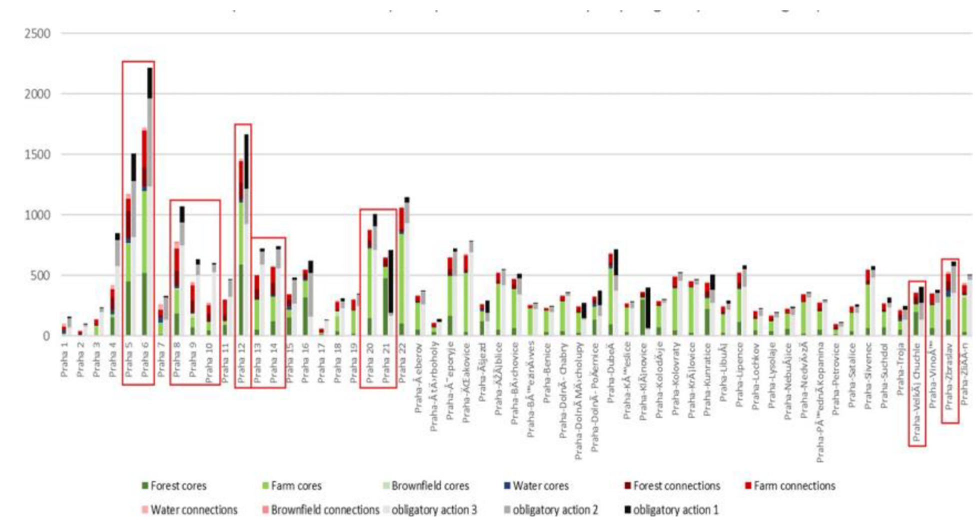


Figure 17: Cores and connections from MSPA overlaid over broad LAFU types (Source: Author, 2024)

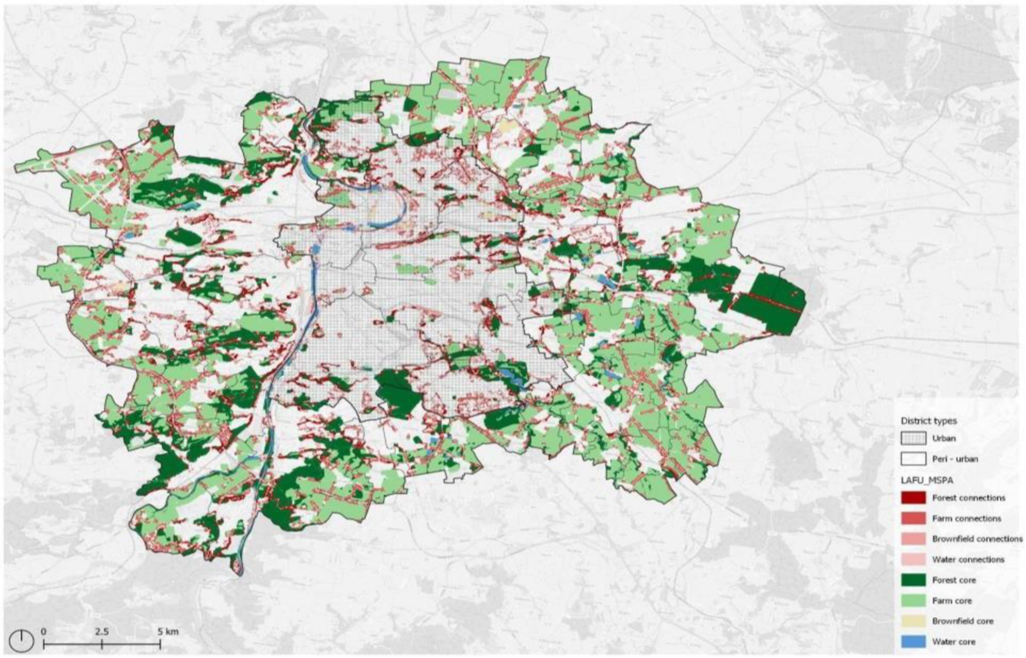
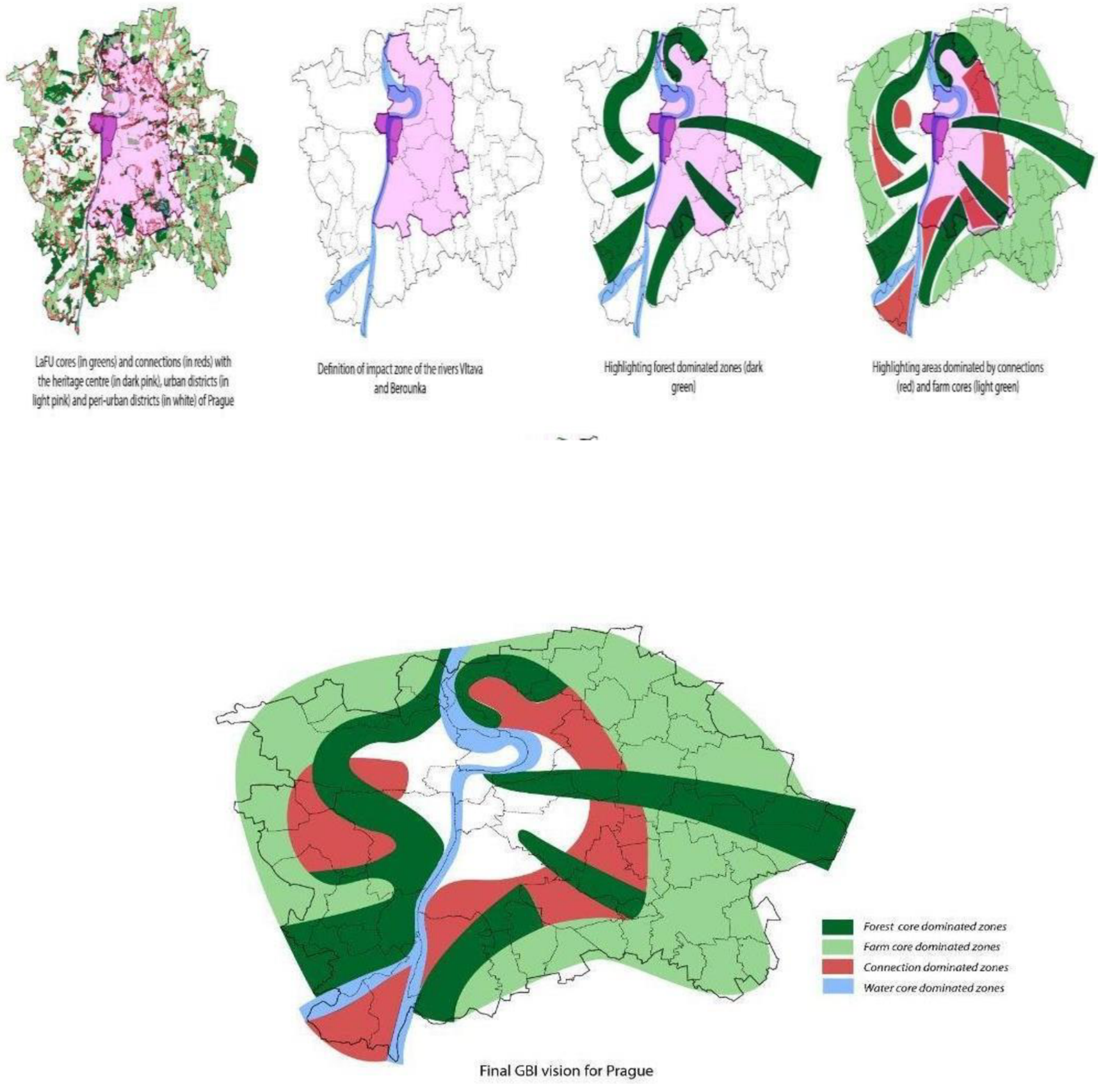


Figure 18: GBI transformation vision formulated from LaFU MSPA insights (Source: Author, 2024)



7.2 Implications for Future Research

7.2.1 Incorporating Green Infrastructure in Territorial Planning

Incorporation of GI within territorial planning has substantial implications for where and how people will live in future; such as community wellbeing while providing a sustainable and vibrant environment. Such an approach has the potential to bring urban environments on par with natural systems, emphasizing the coordinated co-merging of new green spaces, biodiversity conservation, and sustainable development practices (Hansen et al., 2019). Embracing GI in territorial planning will also have multifaceted implications which vary from conservation of the environment to economic stability and advantages for society. At its crux, incorporating GI within planning frameworks helps to create resilient cities. By blending natural components into urban environments, it balances the impacts associated with climate change/global warming without contributing to further resource degradation. Techniques such as rain gardens, green roofs, permeable pavements, and urban forests play the role of sponges that absorb excess rainwater, provides natural places for flooding while alleviating burdens upon conventional catchment systems (Staddon et al., 2018). Subsequently, this may reduce the net pollution while maintaining and improving quality of water, and creating environments that are healthy for wildlife as well as humans. In addition, incorporation of green spaces in urban regions would not only be important for improving the aesthetic quality but also contributes to enhanced physical and mental well-being for people. Having access to gardens, natural settings, and parks can and does lower levels of human stress, while augmenting physical activity and enhanced quality of air, which eventually improves the quality of life within communities (Bertram & Rehdanz, 2015). From an economic perspective, integration of GI provides ample scope for economic growth through job creation. Green projects such as renewable energy systems, green roof development and urban forestry tend to generate employment while fueling investment and innovation in sustainable technologies (Staddon et al., 2018). From a future perspective, extensive adoption of green infrastructure within territorial planning would be instrumental in reshaping models of urban development around the world. It will also warrant the need for collaborative initiatives between urban planners, policymakers, local communities, and environmentalists, for ensuring its effective execution. Consistency in research, innovation, and adaptation of GI policies would be necessary to tackle emergent challenges while maximizing the advantages of this approach.

7.2.2 Geographical Limitations of Green Infrastructure

The findings obtained through this research would have severe ramifications with regard to research on future limitations of GI for studies pertaining to the environment and urban areas. Developing and understanding about diverse geographical settings would be helpful in guiding policymakers, ecologists, and urban planners in designing more context-specific and effective systems for green infrastructure. Research in this area in the future should focus on the complex relationships between geographical aspects like the physical terrain, and biodiversity within natural systems and its influence on the effectiveness and design of GI. Investigating the way in which diverse regions and landscapes respond to and derive advantages from diverse sizes and types of green spaces would be intrinsic to planning urban green spaces. Such research would be beneficial in customizing strategies to maximize environmental, social and economic advantages in particular geographical contexts, thereby contributing to highly sustainable, adaptable, and resilient environments globally.

7.2.3 Successful Zoning for Green Infrastructure in Territorial Plans

Empirical evidence that highlights the efficiency of zoning for GI within territorial plans provide a base for extensive avenues for future research, helps to create sustainable development, promotes environmental conservation, strengthens urban planning, and fosters socio-economic progress (Bajić et al., 2022). A key area for future research would lie in the understanding the beneficial socio-economic impacts of green infrastructure zoning. Investigating how such strategies would directly impact property values, well-being of community, and social equity within regions might present valuable inputs into optimizing territorial plans for inclusive and equitable development. Examining the direct link amongst zoning for parks and open spaces and economic advantages like increased value of property and lowered costs of healthcare owing to enhanced public health from improved green spaces could offer meaningful inputs to urban planners and policymakers.

In addition, the environmental benefits of green infrastructure zoning necessitate an in-depth investigation. For example, research should concentrate on long-term ecological advantages and resilience from such strategies such as the planning for thwarting the impacts from climate change, biodiversity conservation, and management of natural resources (~~C.~~ Coutts & Hahn, 2015). Comprehending the interrelationship between varied types of green infrastructure and its ecological impacts would be vital in refining territorial plans for maximum environmental effectiveness. Another key area of research in future should be better understanding governance and policy making in support of GI, etc. Evaluating the impact of current policies for zoning for GI and recognizing any barriers to its execution could make the way for policies that are highly robust, scalable, and adaptable. Research could also look into governmental structures and policy frameworks that stimulate collaborative initiatives among stakeholders, smoothen the process of decision-making, and encourage adaptive management approaches which will improve the execution of GI in territorial planning.

Furthermore, innovations in technology and their incorporation with GI planning offers a significant area for research. Investigating the use of advanced technologies such as Geographic Information Systems (GIS), remote sensing, and artificial intelligence in monitoring, designing, and assessing GI could bring about a revolution in terms of efficiency and impact of zoning plans (Zhang et al., 2021).

7.2.4 Public Participation in Green Infrastructure Design

Future research on how to better integrate public participation in green infrastructure planning and design offers an important area of inquiry to improve sustainability relative to urban development. Creating an understanding about the effectiveness and dynamics of public involvement during planning and implementation of GI is an excellent area for future research. Examining how various socio-demographic groups engage in such procedures and the factors that influence their participation could be instrumental in providing valuable inputs. In addition, future research could also delve into fine tuning methods and tools for effective public engagement, ensuring inclusivity, and considering varied perspectives. Investigating the impact from public involvement on long-term success and maintenance of GI projects is a necessity (Wilker et al., 2016). Furthermore, examining the role played by technology and digital platforms in facilitating wider and highly inclusive participation warrants future research (Steen Møller & Stahl Olafsson, 2018). Developing an understanding about the sociological and psychological facets of public participation in GI design will be instrumental in providing novel strategies for nurturing engagement within a community (Goličnik Marušić, 2015). Future research within this area should make way for highly sustainable, impactful, and community-centric GI development in future.

Continuing with research related to public participation in green infrastructure planning and design in the future should also examine the synergies among climate resilience and public participation (Hügel & Davies, 2020). Examining the way in which involvement of community could contribute to improving the resilience of green infrastructure when confronted with climate change and extreme weather events is of utmost importance. Future research should focus on the adaptive capability of communities and the role played by public participation towards the development and maintenance of resilience systems of GI (Barclay & Klotz, 2019). In addition, future research on GI also stands to gain from investigating the economic ramifications of including the public in such projects. Evaluating the economic benefits and cost-effectiveness from community-driven GI projects in comparison with top-down designs could shed light on the long-term financial sustainability of such initiatives (Ying et al., 2022). In addition, the interrelationship between biodiversity and public participation in green infrastructure design also needs to be examined (Arya & Vishwavidyalaya, 2018). For example, future research should examine the way in which community engagement could improve and support biodiversity within such systems, thereby contributing to ecological balance and encouraging urban sustainability.

7.3 Recommendations for Policy and Practice

Focusing upon the results from an evaluation of public policy and its implementation, significant lessons have emerged on how the outcomes could be leveraged to bring in a positive change, instead of an assessment just for the purpose of criticism. Though there are valid concerns regarding gaps in coverage of GI and policies, places where they occur would offer significant hooks around which more effective strategic planning policies can be designed at local and regional levels (Sa' et al., 2017). In areas that are not covered through policies, it would be imperative to identify concepts or terms that would be having robust political traction, which can be comprehended with ease by diverse stakeholders, to develop support over several public for novel policy responses. In such situations, the power of the assessment tool for GI policy would rest in its capability to act as a catalyst for positive change and dialogues. Design of a deliberative and inclusive participatory procedure which comprises of all pertinent policy sector stakeholders within GI deliberations with the use of key bridges and hooks could be instrumental in reinforcing mainstream narratives (Hislop et al., 2019).

GI could be effective in making a substantial contribution towards delivering the key policy objectives of the EU and Prague, which is linked with rural/urban and regional development, disaster risk management, climate change, environment and agriculture (Sa' et al., 2017). Key policy objectives of the EU include sustainable development, climate change mitigation and adaptation, biodiversity conservation, water quality and management, resource efficiency and circular economy, and urban and rural development. While in Prague, the main policy objectives refer to sustainable urban development, environmental protection and climate action, tourism management, historical and cultural preservation, transportation and mobility, and governance and civic engagement. This would also take under its scope the sustainable development goals of the United Nations at a broad level. For example, these include the multifunctional potential for nature-based solutions that offer significant bridges as governments and institutions are required to respond to climate, health, and biodiversity emergencies. Responses of this frequently needs robust and joint leadership which will take people beyond their typical focus areas and develops new pathway towards innovation in policies at varied regional, local, national, or global levels. In such scenarios, engagement with stakeholders in accountable and inclusive partnerships would be the key to successful outcomes.

Considering that green infrastructure refers to an eco-conscious approach to urban development, it is inclusive of a network of semi-natural and natural components such as wetlands, green spaces, and permeable surfaces that are incorporated within urban context to tackle environmental challenges. Practitioners and policymakers need to stress the key aspects that would ensure effective realization of GI on a broad and multi-jurisdictional scale. At the outset, extensive policies that encourage the multifunctionality of GI are of utmost importance. Studies that have been carried out by Lafrenz (2022), emphasize the significance of multifunctional green spaces, highlighting the fact that they offer social, economic, and ecological advantages. It is imperative for policymakers to identify and stimulate the varied roles that GI could play, specific to mitigating climate change, improving air quality, and reducing urban heat island effect, providing more effective stormwater management, and improving net biodiversity. Moreover, a policy framework that is proactive and one which stresses multi-stakeholder engagement and collaboration is vital. It has been stated by Molla (2020), that the inclusion of diverse stakeholders in the planning, implementation, and maintenance of GI would improve its potential for success and its acceptance on a broad scale. The private sector, local government, and civil society participation could ensure that varied perspectives and necessities are taken into account, resulting in highly effective and culturally suitable GI solutions.

Making investments in research and development for innovative solutions in green infrastructure would be another major facet. Current developments in technology and design could substantially improve resilience and efficacy of GI. For example, research carried out by Arabi et al., (2015), was in favor of using green walls and roofs, which presented its potential in mitigating urban heat island effect while enhancing the quality of air. Furthermore, campaigns for educating and creating awareness have a key role to play in drawing support and participation from the public. This is in alignment with the findings obtained through the study carried out by Tsantopoulos et al., (2018), which described how education and public engagement were vital in nurturing a feeling of stewardship and ownership for GI. Policies should be framed around educating citizens about the advantages presented through green spaces which would result in augmented involvement of communities and support for green initiatives. Also, practice and policy need to concentrate on long-term planning and maintenance. Sustained human resource and financial commitments are crucial to ensure effectiveness and longevity of green infrastructure projects, as highlighted through the research carried out by Awwad Al-Shammari et al., (2022).Embracing the recommendations outlined above for green infrastructure policy and practice can make substantial contributions towards the development of highly sustainable, livable, and resilient cities. It comprises of a holistic approach that takes into account social, economic, and environmental aspects, thus nurturing a highly sustainable and healthier urban environment.

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