University of Twente.
Faculty of Behavioural Management and Social Sciences
Master of Environment and Energy Management - MEEM

M.Sc. Thesis

Governance of nature-based solutions for societal challenges: lessons from Utrecht and Leipzig to reinforce implementation

Mohammad Rafi Qazizada
Student number: S2605880

Supervisors:
Associate Prof. Dr. Kris Lulofs
Assistant Prof. Dr. Gül Özerol

Academic Year: 2021-2022

Abstract

Nature-based solutions (NbS) can be crucial in increasing resilience against climate change while addressing urban challenges. Coherence in policies and actions between multilevel and multi-sectoral governance are needed to drive NbS for climate change adaptation at the city (municipality) level. This thesis has two objectives: 1) to explore how NbS entered the agenda at various levels from the EU to the city level; 2) to improve the understanding on the implementation of NbS across levels, and within urban planning and decision-making, contributing to climate change adaptation. In this thesis, I compared four cases from two European cities (Utrecht and Leipzig), each with a different governance system and multiple NbS initiatives. I used multilevel governance (MLG) and agency theories to develop a framework for examining NbS absorption at different levels. Furthermore, I applied the NbS concept to develop pre-selected lenses on success and failure factors for adopting and strengthening the implementation of NbS. I have reviewed fifty policy documents at multiple levels, including EU-level, country-level, and local levels, and 13 interviews with relevant actors and experts took place.

The results indicate that municipalities are the main agency behind NbS projects. Additionally, environmental NGOs and universities seem to support the promotion of NbS. The agency for NbS within municipalities is affected by multiple factors, such as city council decisions, political party influence, and central policies. A review of the relevant policies at the EU level revealed that the NbS concept had been explicitly considered in 86% of the policy documents, which is 84% in the Netherlands, and 81% in Germany. However, there has also been implicit use of NbS in policies. Climate resilience, water management, biodiversity, and health are among the significant responsibilities expected from the NbS in these two cities. Furthermore, the results show that the three most critical factors for the successful adoption of NbS in these two cities were citizen engagement (physically and financially), increased collaboration among actors across levels and sectors, and an effective mechanism for disseminating information. At the same time, the primary factor of failure for NbS absorption at the city level consisted of less awareness of citizens regarding the cost and benefits of the NbS, poor engagement of actors and citizens, bureaucracy and poor communication of information, and limited subsidies.

This thesis suggests four paths forward to reinforce the implementation of NbS at the city level: (1) from a policy perspective, further integration of NbS approaches into national and decentralized policies (NbS proofing of the policy documents). (2) From a knowledge and information perspective, building citizens' awareness and sharing information. (3) From a governance perspective, strengthening engagement of stakeholders (public and private), and (4) from an economics perspective, recognizing the value of municipal subsidies and finance as a critical factor for mainstreaming NbS. Due to scope and time limitations, this thesis also suggests in-depth research on the four pathways discussed to institutionalize fully and absorb NbS locally.

Keywords: nature-based solutions (NbS), climate change adaptation, multilevel governance, agency theory, cities.

Table of Contents

List of Tables

List of Figures

List of Acronyms

CCA	Climate Change Adaptation
DPRA	Deltaplan Ruimtelijke Adaptatie
DRR	Disaster Risk Reduction
EC	European Commission
EEA	European Economic Area
EIA	Environmental Impact Assessment
EU	European Union
GDP	Gross Domestic Production
GHG	Greenhous Gas
INSEK	Integrated Urban Development Concept for Leipzig 2030
IUCN	International Center for Conservation of Nature
MLG	Multilevel Governance
NATURVATION	NATure-based URban innoVATION
NbS	Nature-based Solutions
NGO	Non-Governmental Organization
NS	Nederlandse Spoorwegen
PBL	Planbureau voor de Leefomgeving
R&I	Research and Innovation
SDGs	Sustainable Development Goals
SFDRR	Sendai Framework for Disaster Risk Reduction
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNFCCC	United Nations Framework Convention on Climate Change
WFD	Water Framework Directive
WTO	World Trade Organization

Acknowledgements

For several years, I have worked in the natural resource sector in Afghanistan's mountainous valleys and deserts. I have seen that local practices and materials have helped shape sustainable solutions that have opened new perspectives for people about their future and given them hope about addressing societal challenges. Even so, I have seen that most top-down, centralized plans and ideas did not succeed until they were designed in harmony with nature and local people, and touched the earth. I, therefore, have become passionate about nature-based practices and processes and have used this as an impetus to start researching NbS, especially in the area of climate change adaptation.

Governance of nature-based solutions isn't a concern for developing countries. Still, due to the diversity of actors and sectors involved, there is a need for exploration and research into optimizing governance approaches to streamline practices for practical implementation in various contexts. The semester I spent on this research was full of learning, enjoyment, and sharpening my thinking about the complexity of decisions and plans about city-level climate change adaptation and NbS. In many ways, this research project enhanced my capabilities. Therefore, I am very thankful for the support I received from several people.

With tremendous gratitude, I sincerely thank my supervisor Dr Kris Lulofs, for his support, pieces of advice, and careful reviews of my thesis. I appreciated our meetings and gained insights that will improve my academic performance and growth. Thank you for the significant support from Dr Gül Zerol, who gave me valuable insight and feedback. I am sincerely thankful for you both.

Moreover, I sincerely thank the interviewees and experts who contributed time to this research and their open sharing of knowledge, experience, and ideas. I am grateful to all MEEM lecturers and academic staff who have generously invested in my knowledge and capabilities over the past year of my journey in this master's program. I would also like to thank the coordinators and academic advisors for their cooperative and inspiring behaviour that made the MEEM program so exciting and productive. I am thankful to all my classmates from varying educational and professional backgrounds for their fruitful group discussions and group work that have enriched my knowledge by sharing their ideas.

I sincerely present my heartfelt thanks and appreciation to my father, Mohammad Arif Qazizada, and to my mother, Lailuma Qazizada, whose love, inspiration, and unending faith in me have given me the strength to succeed.

Finally, this journey would not have been so meaningful and valuable without my wife Farhnaz Shahim's support, inspiration, and endless love. I am sincerely thankful to her.

CHAPTER 1: INTRODUCTION

Nature-based Solutions (NbS) can deliver a range of solutions to societal challenges. Climatic issues require efforts towards mitigation and adaptation in a balanced manner to serve the needs of individuals, their capability to earn an income, and the sustainability and resilience of the planet. Using less abiotic materials and more renewable biotic materials and using the forces of nature in engineering are relevant for handling overuse of resources, exhaustion of resources, threats to environmental quality and emission of greenhouse gasses. Responding to climatic change requires input from multiple sectors and actors at various levels. Therefore, it calls for collaboration, co-production of knowledge, and having a shared vision that is institutionalized in a way that adheres to the economic rationales, meets the people's needs, and aligns to principles of sustainability and resilience.

Having adequate governance at each level and across levels is critical to a policy's success, because actors and sectors participate from both a legitimacy standpoint and a technical perspective of how policies are used to manage behaviour. To materialize multilevel governance (MLG) for societal challenges embracing nature based solutions, there should be strong agency leadership at both the horizontal and vertical tiers, as well as effective collaboration at all tiers to mobilize power, resources, and capabilities (Katrin et al., 2019).

Hence, this research aims to shed light on how NbS entered the policy agenda at various levels from the EU to cities, and how NbS implementation across levels can be strengthened, especially within urban planning and decision-making, envisioning a contribution to climate change adaptation and renaturing. This thesis has considered a desk review of relevant articles and reports and interviews with experts for a comparative analysis of cases within two European cities (Utrecht and Leipzig).

1.1. Background

As climate change accelerates, the intensity and frequency of climatic hazards and extreme events such as heatwaves, storms, heavy precipitation, flooding, and droughts also increase (EEA, 2021). To reduce the impacts of climate change, NbS have a significant potential to improve biodiversity, increase urban resilience, and help municipalities and communities play a proactive role in adaptation (Kabisch et al., 2016).

Since 2015, NbS has been widely advocated by policymakers and practitioners as a feasible, resource-efficient, locally adjustable, equitable, and optimized option for wellbeing and addressing societal challenges, specifically in responding to the impacts of climate change (Dumitru & Wendling, 2021b). NbS are used as an umbrella concept to describe a range of nature-based practices and approaches to climate change adaptation, and resilience enhancement (EEA, 2021). The NbS concept is framed in a similar manner to other conceptual models of interventions falling under the scope of ecosystem-based adaptation, ecosystem-based disaster risk reduction, ecological restoration, and ecological engineering (Cohen-Shacham et al., 2019). Defining NbS typology is characterized based on the extent to which engineering of biodiversity and ecosystems is involved, along with the groups of actors and beneficiaries targeted (Cohen-Shacham et al., 2019). This characterization emphasizes that NbS action can range from protection-oriented to

management-oriented and even creating a new ecosystem to fulfil the needs of affected stakeholders and the environment (Cohen-Shacham et al., 2019). In the same vein, it ultimately responds to societal needs, such as food and water security, the mitigation of disaster risk, adaptation and/or mitigation of climate change, and biodiversity conservation (Cohen-Shacham et al., 2019; Kabisch et al., 2016).

IUCN defines NbS as measures that protect, restore, and sustainably manage natural ecosystems in order to meet societal challenges in ways that benefit both human well-being and biodiversity conservation (Cohen-Shacham et al., 2019). This definition covers an ecosystem approach that incorporates conservation practices with human well-being and promotes the inclusion of diverse sectors and actors, including the private sector, with a practical approach that can be integrated into policies and actions.

The EC defined NbS as "solutions inspired and supported by nature, designed to address societal challenges which are cost-effective, simultaneously provide environmental, social and economic benefits, and help build resilience" (European Commission, 2019a). The NbS definition by the EC focuses more on innovating with nature to build sustainable and resilient societies, while also contributing to growth and jobs in urban areas. Considering the high population density of Europeans living in cities and the need for health, climate change adaptation, and nature conservation, the EC definition is more applicable to urban ecosystems (Cohen-Shacham et al., 2019).

Since, in an era of climate change, cities are under increasing pressure to reconfigure for sustainable development (Hawxwell et al., 2019). Thus, urban areas need to contribute significantly to addressing biodiversity loss, protecting habitat, adapting to climate change, and reducing climatic disasters and risks by establishing green infrastructure, creating parks and green spaces, green corridors, urban gardens, green walls, and green roofs, introducing pollinators, and installing sustainable drainage systems (EEA, 2021). According to EEA (2021) for European cities, the key NbS intervention suggested is the establishment of parks, urban forestry, planting trees, water management, and green building to lower the temperatures and heatwaves, floods, and other multiple climatic hazards.

The city-level, or municipal governance of climate change is influenced by multi-sectoral and multilevel policies and actors that are governed by their related policies and legislation (van der Heijden et al., 2019). The decision from these actors and sectors across levels often define the boundaries and powers of municipalities related to urban climate planning and implementation. Furthermore, decision-making occurs across diverse sectors such as water, energy, spatial planning, and transport, in a fragmented fashion with their relevant actors (government, companies, civil society, small and large industries) (van der Heijden et al., 2019). Hence, cities suffer from political underperformance due to multi-sectors and their policies, but they could still be of significant value in improving climate governance as agents for addressing climate change by transforming governance arrangements through action and catalysing change in relationships between actors, that can help institutionalize climate governance on a large scale (van der Heijden et al., 2019).

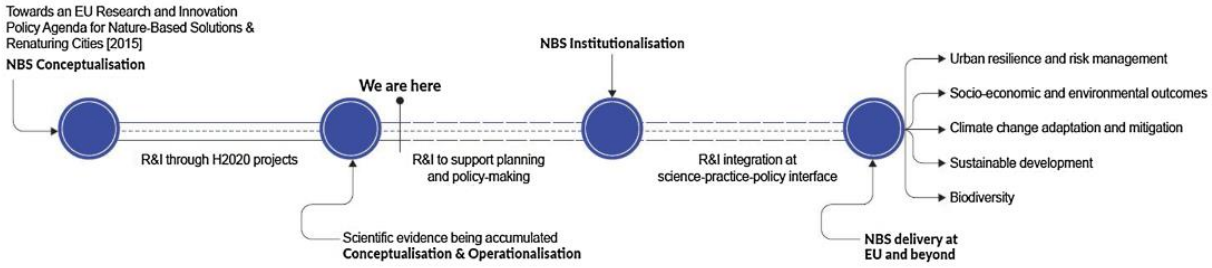
Frey and Ramirez (2019) argue that the effectiveness of municipalities in adapting to climate change rests on their ability to engage local communities and citizens, and have smooth interactions with multilevel policies for their adaptation activities. This should be arranged to enable cities to be agents of change and take into account the agency of the city (Frey & Ramírez, 2019).

However, a top-down (state-led) approach does not respond to the disasters and risks of climate change and requires an MLG strategy to join forces across scales and sectors for collective action toward climate adaptation (Frey & Ramírez, 2019). Since urban climate change adaptation is highly complex and multi-sectoral, it requires a shift from government to governance and reallocating the roles and responsibilities of state and non-state actors with specific contexts to plan and manage urban areas (Frey & Ramírez, 2019; Hawxwell et al., 2019). In the same vein, municipalities have the potential to exercise soft power through the facilitation and empowerment of citizens, minority groups, and players in climate governance (van der Heijden et al., 2019). This will enable them to address social, environmental and economic sustainability in balance (van der Heijden et al., 2019).

This thesis focuses on the role of NbS in urban climate change adaptation. To contextualize this focus, the EU perspective is relevant. On the high political level, the EU aspires to position Europe in a forefront place globally for NbS research and innovation (Davies et al., 2021). In the EU's adaptation to climate change strategy, NbS is seen as a cross-cutting priority for implementing climate change adaptation activities at all levels of governance (Dumitru & Wendling, 2021b; Mendes et al., 2020). The EU realizes the NbS as a contributor to the achievement of other EU policies and strategies (Dumitru & Wendling, 2021b; Mendes et al., 2020). In this way, the EU contributes to the financing of scientific development and the transfer of NbS technologies to establish a resilient and vibrant community (Davies et al., 2021). However, the NbS principles should be embedded into the design, policies, measures, and actions to comprehensively capture adaptive management, effectiveness, and multi-stakeholder participation in the governance system for responding to the societal challenges (Cohen-Shacham et al., 2019).

The EU set the goals of urging that EU-level policies and frameworks to enhance conditions for NbS and mainstream them as a cross-sectoral issue, promote research and innovation communities, and uptake and expand innovative practices (European Union, n.d.). Davies et al. (2021) portrayed a road-map based on the EU journey of NbS, to present the steps being taken and future steps required to achieve targeted outcomes. As illustrated in Figure 1, the roadmap shows that there are many steps to be taken to integrate research and innovations and institutionalize the NbS at the EU level to respond to the societal issues (Davies et al., 2021).

Figure 1: A roadmap of the journey of NbS implementation in Europe



Source: Davies et al. (2021: 53)

In the meantime, barriers and opportunities for the implementation of NbS, and way for the replicability, scalability, and transferability, need to be assessed (European Union, n.d.; Davies et al., 2021).

1.2. Problem Statement

Taking care of ecological capital in Europe requires us to step back from practices driven by economic efficiency alone and seek a future in which innovation and transformation guide societal sectors towards future states that perform positively on people, planet, and profit indicators alike. This triple bottom line is envisioned among others by NbS. Decentral problem-solving initiatives introduced these solutions, and the European arenas became 'infected'. At present, NbS is not being examined so much for its potential as for its implementation across levels and sectors in Europe. A roadmap has been envisioned based on the EU policies toward the institutionalization of NbS implementation to address the societal challenges, as depicted in Figure 1 by Davies et al. (2021). This road map presents that there is a long way towards the institutionalization of NbS in the EU that needs research and innovations to support plans and policies and the interface between science, practice, and policies. Coherence in policies and actions between multilevel and multi-sectoral governance is essential to be explored to address the knowledge gap regarding how policies and actions drive NbS for climate change adaptation at the city (municipality) level and answer the doubt about whether markets will fully support NbS implementation or whether hierarchical structures across administrative levels interfere more substantially, and if so, how.

1.3. Research Objectives

This thesis has two objectives: 1) to explore how NbS entered the agenda at various levels from the EU to the city level; 2) to improve the understanding on the implementation of NbS across levels, and within urban planning and decision-making, contributing to climate change adaptation.

1.4. Research Questions

To meet the research objectives, I have formulated three main research questions. Research question one corresponds to the first objective of this thesis. Similarly, objective two, as explained above, is answered by research questions number two and three. Further reasoning on the structuring of sub-questions is given in the Conceptual Framework section of chapter 3.

1. How did NbS enter the policy agenda of the EU?
   1.1. How did the concept of NbS get agency within the EU?
   1.2. What role of NbS is envisioned in multilevel decision-making (governance) across Europe?

2. How supportive for NbS are decision-making processes at the level of cities?
   2.1. To what extent are NbS absorbed in urban space and societal sectors?
   2.2. What factors explain the success and failure of adopting NbS?

3. What are the possible pathways to effectively reinforce the implementation of NbS?

CHAPTER 2: LITERATURE REVIEW

This chapter defines the theoretical lenses used in this research for answering the research questions. The thesis utilizes the multilevel and multi-sector governance theory, and agency theory (principal-agent) to assess how NbS has been incorporated into EU-level decisions and then influenced sub-sectors and impacted decisions at the lower levels for adoption and implementation of NbS. Secondly, the NbS concept has been explored to define the factors for the successes and failures of the implementation of NbS, specifically in urban areas. Further, the theories related to NbS implementation are discussed to give insight into what makes a policy work and how to implement it efficiently that will explain what criteria to rely on to assess cases to provide recommendations. Appendix 1: Definition of Concepts provides the definitions of the key concepts of the thesis.

2.1. Multilevel Governance

The issue of climate change deals with different levels of government, scales, sectors and actors; therefore, it is widely perceived as a multilevel problem, and focusing on a singular and specific level or scale and actor cannot address the issue (Sun & Baker, 2021).

Governance is referred to as the act of formulating and transferring public policies through a legitimate process (Sun & Baker, 2021). The term governance has emerged from the term government, where a top-down and hierarchical system of policy services has given way to a network of actors, with power distributed horizontally and vertically, both downward and upward (Sun & Baker, 2021). Thus, there is no longer a scholarly position to study governance and policies or urban studies from a single specific government level and scale (Sun & Baker, 2021).

According to Gustavsson et al. (2009), MLG refers to the process by which collective goals are identified and pursued, and the government is not necessarily the primary actor in this process. Regime involves the interaction and negotiation between state actors or groups of state actors (Gustavsson et al., 2009). There are two types of MLG. One is made up of multiple levels such as cities, states, and countries, and type two is dominated by networks of public and private sectors (state actors and non-state actors) across the societal levels (Gustavsson et al., 2009).

As a way of presenting the dynamic relationship between the level of governance and the government in the European context, MLG received the closest attention in policymaking (Jänicke, 2017). This concept was initially used in a European context by scholars in the 1990s. The goal was to clearly understand the EU as a political system (Marquardt, 2017). While at the global scale, MLG was introduced at the Rio Summit in 1992 as a novel method for mobilizing global actors to achieve sustainable development, and then MLG has been presented extensively to climate governance (Jänicke, 2017).

Although environmental governance is among the top topics that have been studied from an MLG perspective, because the issue of the environment is not a concern for national planning, but rather is shaped by the pressures and planning at the global, national, and sub-national levels as well as businesses, and citizens whose actions influence the handling of climate change and its threats (Marquardt, 2017).

The mechanism of policymaking has become increasingly dynamic and diverse, and MLG is becoming increasingly relevant and influential (Sun & Baker, 2021). As MLG led to a transformation of the geography of governance in numerous spatial units, including national, regional, local, transnational, supranational, etc., power and authority are being distributed at different levels and scales, horizontally and vertically (Sun & Baker, 2021). As a result, there are multiple levels of synergy, and coordination is required across different levels to facilitate policy implementation (Marquardt, 2017).

According to Brande (2014), the most common challenges ahead of effective MLG are gaps in information, capacity, financial/funding, administrative, and policy. The information gap stems from the fact that not all levels have the same amount and quality of data and information for policy development and implementation (Brande, 2014). The capacity gap is defined primarily by the limitation of human resources and their interconnected skills. In contrast, the financial aspect is expressed by a lack of funds and dependence on support from higher levels of government (Brande, 2014). The administrative challenge lies in the absence of response to corresponding functions in other socio-economic areas (Brande, 2014). Finally, the policy gap focuses on the challenges of inter-sectoral collaboration (Brande, 2014).

MLG typologies are characterized by the distribution of resources, tasks, and powers between levels as hierarchical or vertical and in horizontal or polycentric fusion (Sun & Baker, 2021). It is further argued by Sun & Baker (2021) that scaling and levels can be examined with more flexibility and that there are four modes of accommodating MLG in climate studies that is self-governing, governing by enabling, governing by providing, and governing by regulation. The last three modes of governance (excluding self-governing) express a specific capacity ranging from traditional forms of state intervention to more soft intervention in governance. In contrast, self-governing can overlap with other types (Sun & Baker, 2021).

The spectrum of power is also located from a hard to soft governance authority such as regulation uses hard governance, while enabling facilities to use soft governance (Sun & Baker, 2021). Furthermore, the policies can be classified as legally or non-legally binding, with their implementation ranging from rigid to flexible. Their typology of regulatory classification can be categorized based on five levels: coercion, framework, regulation, targeting, technical regulation, pilots, and voluntarism, as presented in Table 1 (Sun & Baker, 2021).

Table 1: Forms of governance in the policy dimension

/		Implementation flexibility		
		Rigid	Medium Flexible	Very Flexible
Legally binding	Yes	Coercion	Framework regulation	Targeting
	No	Technical regulation	Pilot	Voluntarism

Policy types	Legally binding or not	Implementation flexibility	Definitions
Coercion	Legally binding	Rigid implementation	This usually prescribes detailed and fixed instructions and standards that policy actors or taker must follow with in implementation.
Framework regulation	Legally binding	Medium flexible	This usually contains some regulated frameworks, while leaving moderate room for flexible delivery.
Targeting	Legally binding	Very flexible	This remains within the realm of binding policy instruments. Implementation can be very flexible.
Technical regulation	Not legally binding	Rigid implementation	It is subject to actors to decide whether or not take technical regulations. If yes, they must follow strictly with the detailed prescription.
Pilot	Not legally binding	Medium flexible	Pilot governance is voluntary in China. Actors can apply to become demonstration and pilot projects and follow some standards and guidelines in relation to the pilot. Moderate flexibility for delivery is given.
Voluntarism	Not legally binding	Very Flexible	This is based on non-binding instruments and only defines broad goals, leaving much room for actors to deliver.

Source: Sun & Baker (2021:5)

Marquardt (2017) asserted that power theory can contribute to advancing the definition and conceptualization of MLG studies. He claims that decisions in MLG are highly influenced by the distribution and exercise of power among actors at the levels and between each level, which can block, compete, conflict, and shape policy outcomes (Marquardt, 2017). A reasoned-based understanding of power, the measurement of power, and the characterization of power with a defined agency are challenges (Marquardt, 2017). Likewise, power is enhanced by societal relationships and identities, which require a deeper examination of social values and norms (Marquardt, 2017).

Focusing from the lens of power on MLG is about exploring the structure, resources, and capacities, for achieving outcomes (Marquardt, 2017). Nevertheless, in complex climate governance, power relations shape the agent and the structure (Marquardt, 2017). The table below presents a relationship of power dimensions with the multilevel and scale of governance.

Table 2: The power dimensions in multilevel climate governance

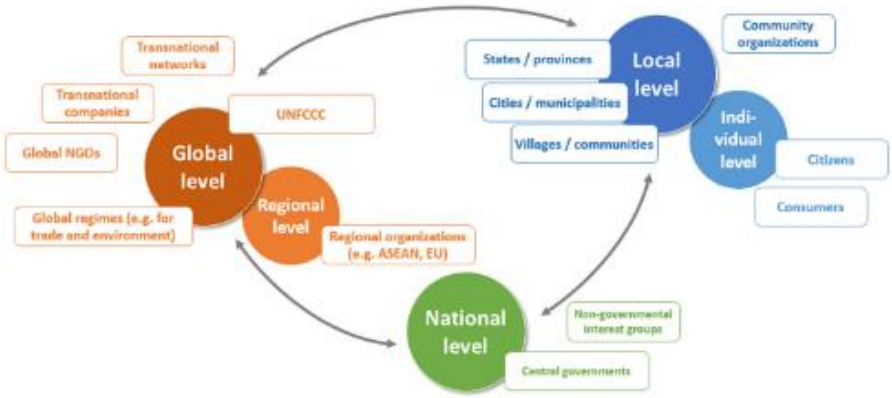
Power dimension	Structures	Resources	Capacities
Focus of analysis	Complex governance structures	Distribution of resources	Ability to mobilize resources
Key question	*What are the relevant governance structures that shape climate politics?*	*How are power resources distributed among different jurisdictional levels?*	*How is the ability to mobilize power resources distributed among different jurisdictional levels?*
Elements of interest	**Jurisdictional levels** ▪ national government ▪ provincial government ▪ municipal government **Central-local relations** ▪ Inter-jurisdictional coordination and conflicts	**Hard power resources** ▪ constitutional resources ▪ regulatory resources ▪ political resources **Soft power resources** ▪ agenda-setting ▪ framing	**Capacities** ▪ trained staff ▪ financial capacity ▪ information

Source: Marquardt (2017 : 171)

Multiple actors' preferences, powers, and interests influence decision-making, policies, and implementation. For example, the decision-making at the UNFCCC for climate negotiations is an example of the role of power in MLG (Marquardt, 2017). Similarly, the EU is a coalition of actors (Marquardt, 2017).

To understand the influence of power in an MLG setting, in the first place, it is essential to define the actors, their roles, and their groups at various jurisdictional levels, where this will map the structural aspect of power, as illustrated in Figure 2. The second is recognizing and mapping the soft and hard power based on resources. Lastly, the actors' ability to mobilize resources is determined based on capacity, as presented in Figure 3 (Marquardt, 2017).

Figure 2: MLG structure for climate policy making



Source: Marquardt (2017:172)

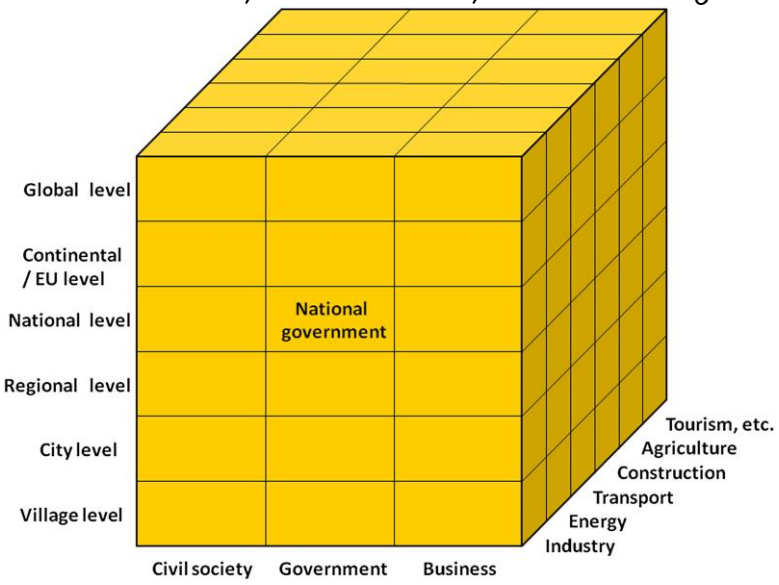
As explained in above, in Figure 3, shows the hard and soft power resources for climate policy, as well as the actual ability of different jurisdictional levels to mobilize these resources.

Figure 3: Resource and capabilities at different jurisdictional levels

Source: Marquardt (2017:173)

An MLG model is based on a multi-sectoral and multi-stakeholder approach, which is essential for creating opportunities for engagement (Jänicke, 2017). To achieve the Sustainable Development Goals (SDGs), MLG has become a prominent model for mobilizing actors at different levels in diverse political systems around the world (Jänicke, 2017). The model proposed for multilevel and multi-stakeholder governance according to Rio Summit is presented in Figure 4.

Figure 4: The model of multilevel, multi-stakeholder, and multi-sector governance

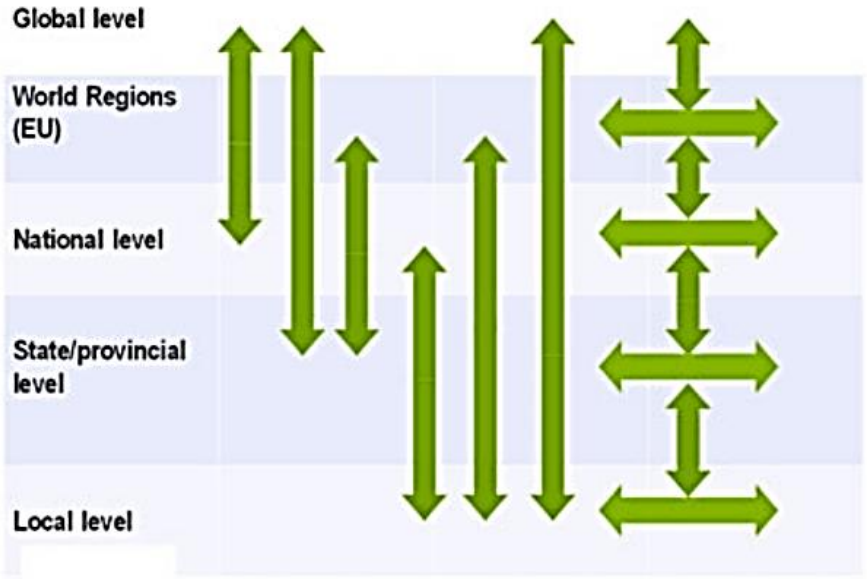


Source: Jänicke (2017: 110)

The Rio model illustrated in the Figure 4, was first used as a governance model for sustainable development and Agenda 21, and then as an application for climate protection and the green economy. It targeted a broad range of actors, not limited to the government but business and civil society actors at all levels, to attain sustainability. Even the focus widened further with the launch of the particular network of regional governments for sustainable development (Jänicke, 2017).

MLG serves as a medium-range theory to facilitate the analysis of a socio-technical structure for a transition to sustainability (Geels, 2011). As part of MLG, the horizontal interlinks open learning, sharing, and cooperation opportunities. In contrast, the vertical interlinkages provide the potential for scaling up good practices through high levels (Jänicke, 2017). The diversity of interactions among the levels among the different levels of governance has been highlighted in Figure 5.

Figure 5: The possible multiplicity of interaction in an MLG model



Source: Jänicke (2017:112)

In light of the impact of climate change on multiple sectors and societal domains, climate change adaptation is also a cross-cutting governance issue across levels to effectively implement policies (Bauer & Steurer, 2014). When discussing multilevel climate governance, it is also understood as multi-sectoral and multi-stakeholder governance that includes various interest groups and actors besides the scales it engages (Jänicke, 2017). MLG emphasizes the complex nature of how climate action is polycentric and distributed among multiple actors and sectors (Katrin et al., 2019).

Materializing MLG for climate change aims to present a strong leadership and sustainability agenda; to achieve the MLG agenda, the mobilization of networks as well as the building of relationships between the levels of government, horizontally and vertically, and the ability to overcome barriers to interdependence must be considered (Katrin et al., 2019). In addition to the engagement of interested groups and citizens, the multiplicity of actors facilitates the process of negotiating resources, mobilizing norms and values, and fostering inclusion and collaboration (Katrin et al., 2019).

The role of non-state actors in shaping the politics of climate change and dealing with the international regimes for the provision of common goods is crucial. Federalism and decentralization are more about making decisions on complex multilevel systems (Marquardt, 2017). However, it is imperative to keep in mind that economic stakeholders or interest groups may also pose barriers to the changes and policy objective setting and implementation (Katrin et al., 2019). Economic actors

can influence political elites in environmental decisions at different levels – Specifically, in urban climate discussions political-economy elites often control decisions (Katrin et al., 2019).

To summarize, the emergence of a multilevel, multiscale, multisector, and multi-stakeholder approach reveals system complexity. It offers options for analysing and exploring adaptation practices, addressing the barriers, and maximizing the opportunities that emerge from multiple lenses of governance to manage climate change adaptation. Since societal challenges are multifaceted and behavioural management opportunities may arise when connecting levels, sectors, and actors. The Rio model of MLG is still presented as a comprehensive definition of MLG, which means engagement across different spatial levels such as global, supranational, national, regional, provincial, and local, as well as across sectors and from the public to businesses, and citizens.

Therefore, having the right scale and type of governance is key to a policy's success, because actors and sectors see themselves in the process from a legitimization standpoint, as well as from a technical standpoint as to the rules of the game (e.g. policies) for the management of behaviour, and to be able to put into effect measures of a severe to a soft standard. In addition to its bureaucratic nature, the materialization of MLG for societal challenges also ensures strong leadership at both the horizontal and vertical levels.

In this thesis, the MLG theory was applied to explore how policies related to urban climate change adaptation are linked. MLG also contributed to analysing coordination, communication, and knowledge exchange, as well as identifying the silos and blockages that hinder cross-sectoral and cross-level communication and functions in a governance system.

2.2. Agency Theory

The agency theory traces ideas that have diffused and transformed within a socio-economic context. It examines the socio-fabric, identifies the agency's relationship to the organizations, examines related strategies, social controls, and deviations that the agent delivers to the principal, and identifies vulnerabilities (Shapiro, 2005). This theory is primarily concerned with the connection between the principal and agent in an organization, where both act in their interests and believe that they are rational economic actors; therefore, the cost structure and control play an essential role between them to achieve a result (Biesenthal & Wilden, 2014).

The concept of agency was born out of the idea of sharing risk because of the different attitudes towards risk among the cooperating parties (Eisenhardt, 1989). In this sense, agency theory extends the risk-sharing concept to address the agency problem (Eisenhardt, 1989). An agent is delegated responsibility to carry out tasks on behalf of the principal, while the principal wishes to minimize costs to meet the contract's objectives (Kassim & Menon, 2003).

Principal-agent relationships are specific social relationships that happen through the exchange of resources, where the principal is the one who disposes of resources, but not the kind of resources it is interested in, like having the money but without the expertise. In contrast, the agent has the knowledge and expertise but needs the money. Therefore, the principal and agent try to meet their interests (Braun & Guston, 2003). The principal-agent theory is becoming increasingly valuable due to bureaucratic politics, which is taking place in a broader spatial and socio-political context (Dunlop & James, 2007). Most scholars of the EU have primarily used the principal-agent

model to review the delegation of authority from one actor or set of actors to another - as the agent and to explain the rationale, methodology, and consequences (Delreux & Adriaensen, 2019).

Delegation is the fundamental tenet of the principal-agent theory, and similarly, as we see in the example of the EU, the delegation of authority from member states to a supranational organization is the basis of the process (Delreux & Adriaensen, 2019). This delegation process allows an organization to make a ruling decision, and this scope has been expanding for EC since the 1950s to deal with more complex issues (Delreux & Adriaensen, 2019).

The delegation of authority may be driven based on the political interest, the institutional design, the functional need, and the anticipated effects, which also consider cost minimization (Kassim & Menon, 2003). Besides, the delegation of authority to an agent provides the opportunity to overcome a problem of collective action, improve the quality of policy or technical matters based on the agent's speciality, overcome regulatory issues and competition, be responsible for unpopular decisions, and resolve instability in policies (Kassim & Menon, 2003). Delegation may occur from one actor or institution to another institution for the political decision; however, at the EU level, the formation of a supranational level of decision-making is a result of the delegation of rule-making power from the member states to the institution for decision-making (Delreux & Adriaensen, 2019).

Eisenhardt (1989) asserts that agency theory addresses two main problems. First, there is the agency problem, in which the goals of the principal and agent are different and conflict with each other; therefore, it is impossible to verify what the agent is doing (Eisenhardt, 1989). Secondly, it is about the approaches to the problem, when the principal and agent have different viewpoints, measures, preferences, and actions, and they may use different assessment methods; hence, due to its bounded rationality and the explicit sharing of information, the agency theory allows control of behaviour and avoids the self-interests and risks associated with it (Eisenhardt, 1989). Eventually, it will help to pave the way for regulation and dealing with the issue even at the micro-level (Eisenhardt, 1989).

Table 3: Overview of the agency theory

Key idea	Principal-agent relationships should reflect efficient organization of information and risk-bearing costs
Unit of analysis	Contract between principal and agent
Human assumptions	Self-interest Bounded rationality Risk aversion
Organizational assumptions	Partial goal conflict among participants Efficiency as the effectiveness criterion Information asymmetry between principal and agent
Information assumption	Information as a purchasable commodity
Contracting problems	Agency (moral hazard and adverse selection) Risk sharing
Problem domain	Relationships in which the principal and agent have partly differing goals and risk preferences (e.g., compensation, regulation, leadership, impression management, whistle-blowing, vertical integration, transfer pricing)

Source: Eisenhardt (1989:59)

For delegating authority to institutions, the principal-agent model zooms in on the contract, identifies the act of delegation, establishes controlling acts for the monitoring system, and reduces the risk (Delreux & Adriaensen, 2019). So, the theory of principal-agent provides an answer to the question of **why** and **how** the principal delegate's authority to the agent, which is the politics of delegation, and secondly, **when** to fulfil the role of the delegated task, which is the politics of post-delegation (Delreux & Adriaensen, 2019). While, Tallberg (2002) presented somehow differently and stated that the theory of principal-agent provides a foundation for the recognition of the roots of **why**, **how**, and through **what** consequences authority is delegated from one actor to another actor, of whom the former is a principal and the latter an agent. At the same time, both define the same approach for determining the scope and task from pre and post-delegation perspectives.

Practical reasons for delegation include resolving collective action issues, solving a problem of incomplete contracting, providing technical expertise, reducing uncertainty and instability, and setting agendas. Furthermore, it contains the costs to be paid to satisfy the outcome of the delegation (Delreux & Adriaensen, 2019). The principal decides how to control the agent's behaviour and mitigate delegation costs (Delreux & Adriaensen, 2019). As a consequence, control is a function confined to principal-agent theory and indicates to what extent the agent is autonomous or not (Delreux & Adriaensen, 2019). The contractual agreement between the principal and agent also provides a hierarchical arrangement where the principal can withdraw delegation authority, but at a political cost (Delreux & Adriaensen, 2019).

As is the case with the EU, the member states perform their functions through an intergovernmental conference. Hence, the European Commission serves in most cases as the

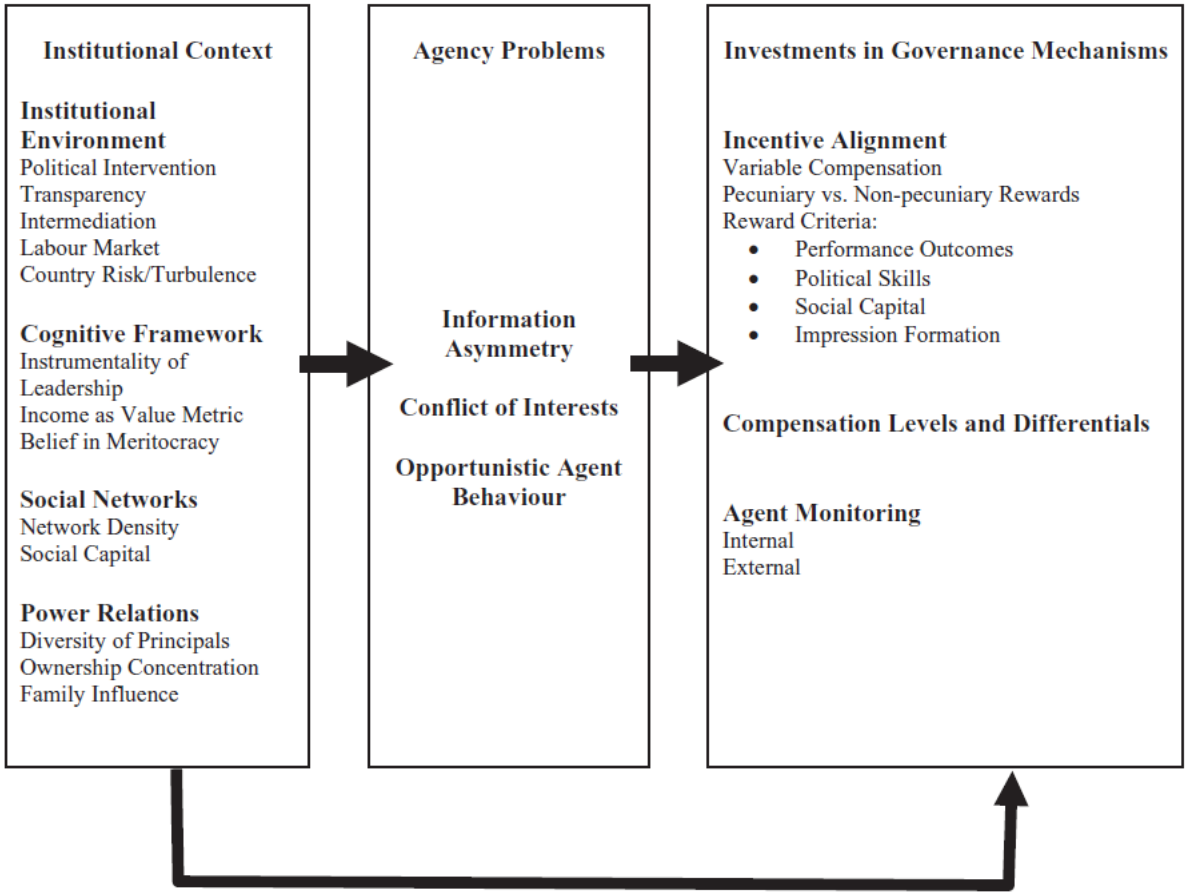
principal, too, due to the direct representation of the member states (e.g. EU parliament) in the decision-making process (Delreux & Adriaensen, 2019). Consequently, the principal-agent analysis helps study delegation and decision-making from a delegation established by other EU actors (Delreux & Adriaensen, 2019).

In some cases, the agent can be the group actor and the agent-to-agent (intra-agent) politics between multiple agents. There are two specialities in the EU - an actor can be an agent of a principal and a principal of another agent, forming a chain of delegation of authority (Delreux & Adriaensen, 2019). The degree of authority is determined from the viewpoint of the principal to the agent, which is how the EU was created, where the states have delegated their partial authority to the EU, and the member states focused on more than just the concept of efficiency; they aimed to demonstrate a credible commitment as well (Delreux & Adriaensen, 2019).

The control mechanism forms the base for the principal-agent relation and its effectiveness. All contractual agreements contain an agency element, where the perspective of the principal-agent is based on the principal's problem. Hence, the control mechanism is critical for a task to be delegated to an agent and for the agent to perform well (Blom-Hansen, 2005). Incentive incompetence and unequal information sharing could be the reason for the agency's losses. There are two types of control - ex-ante controls and ex-post oversights. Ex-ante control mechanisms define the scope of operations, practices, and procedures. In comparison, ex-post oversights are focused on sanctions, budget restrictions, and reviewing the agenda to check agent behaviour and align the agency (Kassim & Menon, 2003).

Wiseman et al. (2012) asserted that agency theory could be applied in non-traditional contexts due to its core elements (e.g., self-interest, information asymmetry, control mechanisms), flexibility and urges, taking into account the institutional context in which principal-agent relationships occur when reviewing agency-based models. Institutions, cognitions, networks, and power are the social mechanisms that influence the roles of agents and principals (Wiseman et al., 2012). Each of these mechanisms identifies several societal perspectives that contribute to the interaction between agent and principal, and the nature of the problem arises from their interactions (Wiseman et al., 2012). Wiseman et al. (2012) used a deductive approach to evaluate the interaction of society and economics for assessing the agency problem for defining the principal-agent relationships, where a deductive approach gives a generalized framework for developing a theory of governance.

Figure 6: The effect of the institutional context on the interaction of principal-agent



Source: Wiseman et al., (2012:206)

As Figure 6 shows, the relationship between agent and principal varies depending on the context and boundary. It also emphasizes the issue of asymmetry of information, conflicts of interest, and opportunistic behaviour as long as delegations exist.

Based on Figure 6, the institutional environment reflects society's agreed norms and conventions, such as laws, etc. The principal-agent relationship is defined by governments' roles in controlling and promoting economic exchange, where economic and political institutions are closely connected; for example, the political institutions facilitate economic exchange by providing ground infrastructures and a judicial system for contracting (Wiseman et al., 2012). Furthermore, Cognitive frameworks express how members of society think about a worldview, such as expressing beliefs, understandings, interpretations, and experiences at various levels (Wiseman et al., 2012). The networks shape the identities and form of institutions, which occurs at multiple levels and boundaries of analysis of a firm or industry—organizational performance benefits from the networks for mobilizing access to resources and information. The density of social networking plays a critical role in reducing or increasing information asymmetry as well as pressure on agents and principals to limit their opportunistic behaviours (Wiseman et al., 2012). Finally, our ability to shape our world and the types of relationships in the governance structure are presented in power relations - firms and agents may be forced to act following the interests of the stakeholder who has the power to impose them (Wiseman et al., 2012). Table 4 elaborates on the consequences of different social

institutional contexts on principal-agent relations or the agency problem, which shapes different identities, interests, organizations, and strategies.

Table 4: The role of institutional arrangement over the role of the Principal-Agent

Institutional context		*Agency behaviour and investments in governance mechanisms*
Institutional environment	Transparency intermediation	The higher the level of intermediation and transparency: (a) the less likely agents will act opportunistically; (b) the more likely agents' appraisal and rewards will be tied to performance information provided by external markets; (c) the lower the resources devoted to internal monitoring systems and the greater the role of independent observers or intermediaries in appraising and rewarding agents' performance.
	Political intervention	The higher the political intervention: (a) the lower the variable pay mix and pay-for-performance sensitivity; (b) the lower the use of performance criteria based on financial outcomes – on the contrary, the emphasis will be on the agent's political skills; (c) the greater the role of external monitors with strong political connections in rewarding or disciplining executives.
Cognitive framework	Instrumentality of leadership	The higher the romance of leadership and the importance attached to pecuniary rewards:
	Income as value metric	(a) the greater the proportion of residuals an agent will extract from a firm in the form of larger pay packages; (b) the greater the compensation differential between CEOs and people at other organizational levels; (c) the more likely that agent pay will be associated with impression formation criteria such as perceived charisma, and individual's reputation.
Social networks	Network density	The higher the density of social networks surrounding P–A relations: (a) the lower the information asymmetry between principals and agents; (b) the less likely that agents will act opportunistically; (c) the more likely that principals will defer to the social network to monitor the agent's behaviours and deemphasize formal controls.
Power relations	Ownership concentration	The higher the ownership concentration: (a) the lower overall agent compensation in relative terms; (b) the more likely incentive alignment and monitoring will be used in a complementary fashion; (c) the more agents will be held accountable for observed firm performance outcomes; (d) the higher the use of internal monitoring because benefits to principal outweigh costs, and the principal has both the interest and the ability to monitor the agent's behaviour.
	Diversity of principals	The greater the number of different principals: (a) the lower the use of variable pay linked to performance criteria, since there is less agreement among principals on which performance criteria to use; (b) the more likely that agent monitoring will be conducted internally through formal bodies that represent multiple stakeholders; (c) the more likely that agents will be rewarded according to their ability to identify and enforce political compromises among principals with conflicting objectives.
	Family influence	The greater the role of family ownership in controlling business interests: (a) the lower the family agent's compensation in relative terms; (b) the higher the non-family agent's pay-for-performance sensitivity; (c) the more likely that non-financial criteria will be used to evaluate agent performance; (d) the higher the use of internal monitoring.

Source: Wiseman et al., (2012 :215)

In summary, agency theory examines the relationship between the principal and agent, where an actor or group of actors delegate their authority (partly or fully) to another actor or set of actors with better capabilities, expertise, and relevance for completing a task while considering economization. There is a need for clarity in a contractual agreement to define the task and its scope. A control mechanism is vital for contracting and success; this recommends two types of control: ex-ante control and post-confirmation control. The EC formation is an agent of member states to form a supranational governance system to meet the rising challenges. Still, due to the direct representation of the member states, it is also functioning as a principal for delegating tasks and authorities to other agencies. The core part of delegation is about why delegating the task, how the agent uses the authority, and when to fulfil the delegated task in what kind of manner. In addition, the core problem of the agency is information asymmetry, conflict of interest between principal and agent, and opportunistic agent behaviour. At the same time, the social and institutional context (institution, cognitive framework, social networks, and power relationships) affects the agency problem and shapes different identities, interests, and strategies. In conjunction with the MLG theory, the agency theory was applied to determine who holds what political power and influence they have over actors' behaviour and the governance structure of an NbS intervention. In addition, the theory has been applied to define the critical agency problems in an MLG setup, such as information sharing, coordination, and transparency. Thirdly, this theory is used to enhance the agency's knowledge, information and governance practices in an MLG setup.

2.3. Nature-based Solutions

Besides the multi-disciplinary approach, NbS focuses on the connection between nature and human well-being, with a focus on natural forces and traditional knowledge. Furthermore, this concept emphasizes the importance of nature supporting people and focuses on cultural context and cultural values (Cohen-Shacham et al., 2019).

IUCN defines NbS as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits." (IUCN, 2016; Cohen-Shacham et al., 2019). Cohen-Shacham et al. (2019) asserted that the NbS approach is rooted in the ecosystem-based approach derived from the UNCBD convention to develop and build resilient ecosystem services supporting biological conservation and human well-being. Based on the IUCN definition of the NbS, an ecosystem refers to all types of ecosystems, including natural or modified ecosystems. Social means that NbS directly addresses societal challenges, and actions mean that the solution and all the interventions shall be ecosystem-based and not include interventions not inspired by NbS (IUCN, 2016).

The EU defines NbS as “solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions” (European Commission, 2019a).

NbS has been placed under five categories, as: to restore ecosystems, forests, and landscapes; to address specific issues such as ecosystem-based adaptation, mitigation, and disaster risk reduction; to establish natural infrastructure and green infrastructure; to manage ecosystems

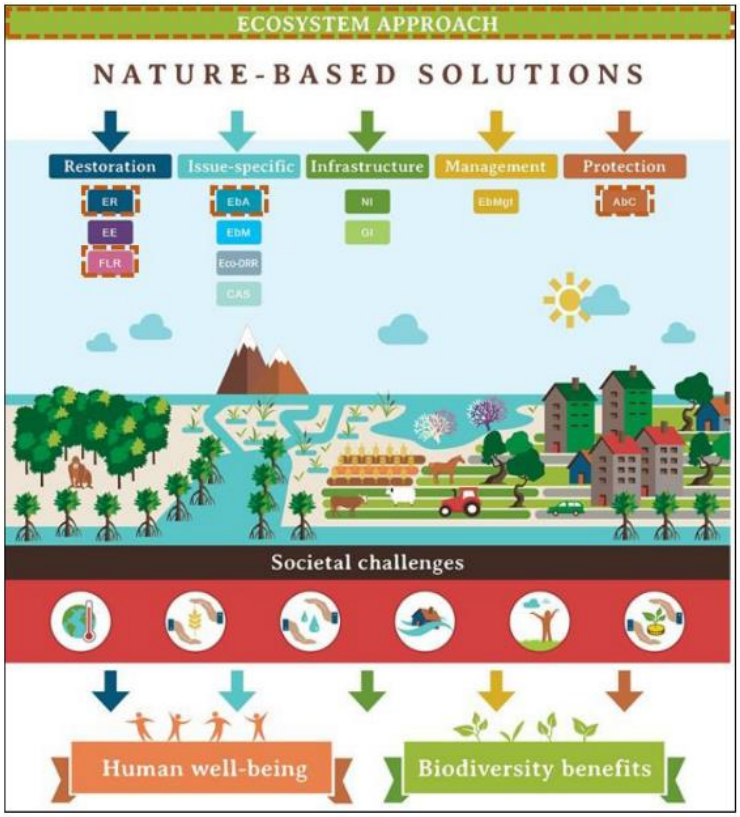
such as coastal areas, and water resources; and finally, to protect the ecosystem and conduct area-based conservation (Cohen-Shacham et al., 2019).

The eight principles of the NbS, according to IUCN (2016) and Cohen-Shacham et al. (2019), consist of:

1) Focused upon conservation norms and standards, it does not substitute nature conversation **practices;** however, all conservation activities are not NbS.
2) Can be integrated with other solutions to form hybrid solutions for addressing societal challenges, while NbS can stand alone.
3) The solutions rely on the site specification and require local knowledge, norms, traditions, and understandings.
4) Equitably provisioning societal benefits against societal challenges to promote transparency and participation.
5) Over time, the cultural diversity and biodiversity to be conserved and maintained.
6) To be applied at the larger spatial scales such as watershed or landscape scales.
7) To address the trade-offs between nature, economic development, and future options that are not hindering the ecosystem services for the future, and finally,
8) the NbS is to be mainstreamed systematically in policy, design and action to address societal benefits.

Figure 7 presents how NbS is an umbrella concept for addressing societal challenges to benefit biodiversity conservation and human wellbeing ultimately.

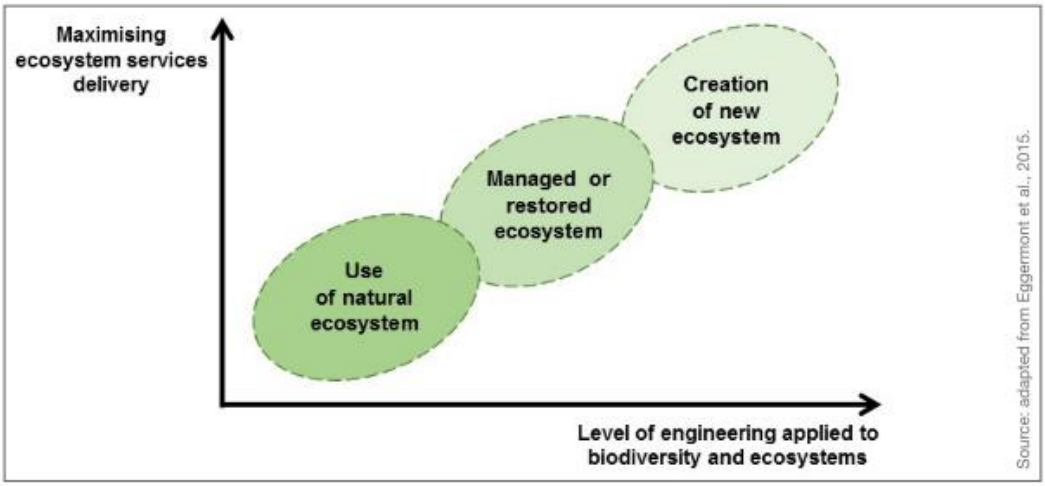
Figure 7: The NbS role as the principal concept for addressing the societal challenges



Source: Cohen-Shacham et al. (2019:23) and IUCN (2016 :16)

According to IUCN (2016), there are three types of NbS. These types require some engineering of ecosystems or biodiversity and those that only promote ecosystem services and restoration. However, the typology of NbS consists of (1) those solutions that use existing nature in a better way, (2) solutions developed following the protocols of sustainable management and restoration, and (3) those types of solutions that involve creating a distinct type of ecosystem, such as the establishment of green infrastructure, etc. (IUCN, 2016).

Figure 8: Typology of NbS based on the IUCN

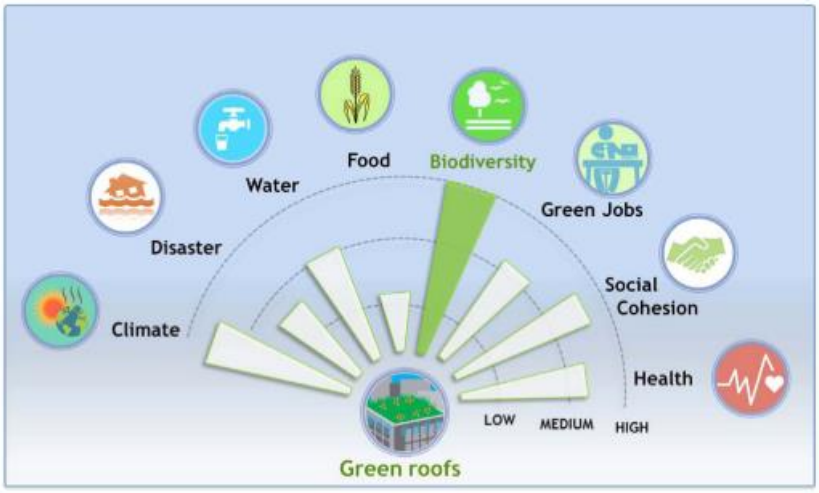


Source: IUCN (2016: 9)

The concept of the NbS has mostly been used in policies and programs due to its uniqueness in providing solutions inspired by nature. Thus, this concept has been used at policy and activity levels, bringing diverse sectors together. (Cohen-Shacham et al., 2019).

The UN 2030 Agenda emphasizes addressing the negative changes affecting the global economy, environment, and society; thus, NbS research and innovation play a crucial role in achieving SDGs (Faivre et al., 2017). The NbS approach aims to bring back nature to the cities and degraded ecosystems to connect nature and biodiversity to humankind's wellbeing and to respond to multiple societal challenges. For example, water resource management, enhancement of the resilience of communities and ecosystems, sustainable use of resources and energy, reducing carbon emissions and increased sequestration that ultimately supports the provision of ecosystem services for human welling (Faivre et al., 2017). In Figure 9, green roofs' potential environmental and social benefits are outlined in a practical example.

Figure 9: The potential socio-ecological benefits of green roofs



Source: Faivre et al. (2017:510)

Egusquiza et al. (2019) categorize the barriers and drivers to the implementation of NbS into three groups of knowledge, governance, and economics, described below:

1) **Knowledge barriers:** this category includes uncertainties and risks in operations due to changes in standards and protocols for design, implementation, and maintenance. In addition, there are limitations in the evidence available for use in policies, and legal issues that might arise because of a lack of quantitative information (Egusquiza et al., 2019). Further, knowledge barriers result from a lack of accessibility to information or an overload of information resulting from multiple levels of governance (Egusquiza et al., 2019). This information is not sorted in a way suitable for policy and planning. In addition, knowledge barriers arise when science, technology, and simple concepts are not ready for specific locations, which means readymade and customized science is unavailable (Egusquiza et al., 2019).
2) **Governance barrier**: this set of obstacles results from a disconnect between long-term goals and immediate objectives (Egusquiza et al., 2019). As a result, decision-making in the short term will not be well-coordinated to support the long-term responsibilities, creating difficulties for the actors to perform well. For example, the performance at the municipal level may not address the long-term goals. It may not result in sustaining or maintaining an intervention, and responsibilities may not have been specified (Egusquiza et al., 2019). In addition, institutional barriers are impairing the governance process; these may include poor coordination between actors and levels, traditional thinking patterns and sectoral silos; rigid decision-making structures (departmental performance is prevalent); and a lack of support systems, such as frameworks and policies, which cause excessive bureaucracy and reduce innovation and adoption (Egusquiza et al., 2019). Additionally, complexity in the structure may lead to misalignment of actors and reduce collaboration. Ambiguity in the actors' roles may hinder transparent and active engagement (Egusquiza et al., 2019). Poor participation and lack of awareness- are other barriers under governance that stem from uncertainty about nature's solutions. The top-down structure ignores the participation of citizens and actors (Egusquiza et al., 2019).
3) **Economic berries:** is due to an underestimation of the NbS benefits. NbS benefits are perceived as softer and not as direct (Egusquiza et al., 2019). Additionally, they believe that NbS does not provide an immediate return and have no insight into how a higher investment now would lower costs later. Sometimes vandalism damages the image and undermines the viability of NbS

(Egusquiza et al., 2019). In addition, budget constraints make implementing NbS challenging, as most city governments do not prioritize NbS, and a lack of fundraising capacity is another challenge (Egusquiza et al., 2019). Lastly, the risk perception among the actors is still high, and there is less motivation for the private sector to invest (Egusquiza et al., 2019).

Wamsler et al., (2020) argue that the main strategies involve the private sector, academic institutions, and other cities in the assessment process to learn and share knowledge. Strategic citizen involvement is needed to increase awareness. Furthermore, cooperation and coordination among sectors must move away from building sectoral blocks. However, there are also opportunities to outsource the implementation and encourage science-policy integration (Wamsler et al., 2020).

Kabisch et al., (2016) stress addressing the key barriers related to NbS in urban areas; added that there were mainly five types of obstacles: fear of unknowns, disconnection between short-term objectives and long-term goals, disconnectedness between short- and long-term actions, and paradigm of growth and sectoral silos.

Egusquiza et al., (2019) reviewed the drivers for NbS under the same categories of knowledge, governance and economics and explained to them as follows:

1) **Knowledge drivers:** are being developed through the generation of evidence to apply lessons learned from the previous project (Egusquiza et al., 2019). For the NbS to be a driving force, research and the generation of measurable data and information about the NbS' costs, benefits, and effectiveness are critical. Additionally, collaboration and the creation of networks are essential drivers that help legitimize and facilitate the adoption of practices and the co-creation of practices (Egusquiza et al., 2019). Building awareness at multiple scales and involving multiple actors is essential to learning about the benefits of NbS for climate change adaptation and ecological system conservation (Egusquiza et al., 2019).
2) **Governance drivers:** these drivers may include the improvement in the efficiency of the process via enhanced collaboration among sectors, actors, and levels and clarity of the roles to be played (Egusquiza et al., 2019). Besides improving governance, it is necessary to take an action-oriented approach to instruments, finance, and the capacity of actors, and capacity building is vital to minimize uncertainties. Self-governance through individuals is essential to inspire innovation (Egusquiza et al., 2019). In addition, it is imperative to support adaptive methods based on the complexity of challenges. This involves all stakeholders and thinking across sectors and actors to establish partnerships (Egusquiza et al., 2019).
3) **Economic drivers:** risk-sharing methods rely on collective responsibility, a division of duties, and a risk management strategy (Egusquiza et al., 2019). Moreover, incentives are necessary to attract more investment, remove or reduce administrative barriers and build on partnerships. Further, a new business model should be explored to support finance for the NbS, such as cooperative support, actual states, self-financing, etc. (Egusquiza et al., 2019).

Hawxwell et al., (2019) have outlined six significant governance-related barriers to uptake of the NbS at the municipal level, which include:

1) The lack of knowledge and awareness of municipal employees, decision-makers, businesses, and citizens about NbS, climatic risks, and NbS benefits.
2) Limitations on political commitments to facilitate the adoption of the NbS.

3) The structural barrier has hindered sustained uptake at the policy level and insufficient cross-sectoral cooperation to generate data and information for practical cross-sectoral collaboration.
4) Inability to justify the benefits and costs of NbS, where it pays directly and indirectly in the long run and paves the way for lowering costs over the long run, and not able to support it well in finance and NbS procurement.
5) Barriers to social and environmental justice and land use trade-offs that include green gentrification, unjust distribution of NbS in the city, and competition for land and other resources could impede ecosystem services.

In summary, NbS research and innovation are crucial in achieving the SDGs. NbS is an umbrella concept that will ultimately benefit human wellbeing and biodiversity conservation. An ecosystem includes natural and modified ecosystems, as defined by the IUCN (2006), and the social purpose of NbS is to provide solutions that address societal challenges. NbS has been used primarily on policies and programs due to its unique ability to offer solutions that are inspired by nature. Therefore, this concept has been applied at the policy and activity levels and has brought together diverse sectors. The barriers and drivers to implementing NbS can be categorized into three main categories: knowledge, governance, and economics. This concept is used in this research for provisioning measures to answer the success and failures of NbS adoption.

CHAPTER 3: METHODOLOGY

3.1. Research Design

In this thesis, I examined NbS governance at the multilevel, reviewed NbS integration into EU policy and strategy, explored its practical effects in two distinct geographies, in the Utrecht and Leipzig, and examined their implications over four case studies. The literature review answered the first research question and partially addressed the second research question. To answer the second and third research questions, I conducted experts and/or stakeholder interviews. Therefore, this research combined both a review of relevant policies at different levels as secondary data, as well as interviews about NbS application and practices. As a result, recommendations are portrayed as pathways to strengthen NbS implementation, and address the societal challenges, particularly in the field of climate change adaptation in cities.

The concepts and theories in (Table 5) were defined to design the conceptual framework, and the research boundaries.

Table 5: List of theories and concepts applied in this research

Theories	Concepts
Multilevel governance (MLG): to explore deeply the levels, scale, sectors, and actors that are involved in NbS policy decisions. **Agency (Principal-agent) Theory:** to assess how EU policies have been infected by the NbS and influenced the decentral level governance.	**Nature-based solutions (NbS):** to define its principles and relevance to climate change adaptation and identify the typology of barriers and enablers to NbS implementation. **Climate change adaptation and mitigation:** precisely present the definitions, and needs for ecosystem resilience to climatic changes. (See Appendix 1: Definition of Concepts **Urban development:** to present what it means in this research (See Appendix 1: Definition of Concepts **Societal challenges:** to identify the priorities listed by the EU and what challenge pertains to in this research. (See Appendix 1: Definition of Concepts **Levels and sectors:** to present what administrative level, geographical boundaries, and societal sectors have been touched in this research. (See Appendix 1: Definition of Concepts

3.2. Research Strategy

In this thesis, four cases have been selected in the urban areas of Utrecht and Leipzig. The cases have focused on urban / cities and climate change adaptation. Besides, all four cases have contributed to several societal challenges: water management, green infrastructure, green space management, biodiversity, air quality, place regeneration, social justice and social cohesion, health and well-being, and new economic opportunities and green jobs. The cases have been initially identified and pre-selected from the webpage of "urban nature atlas of Europe" (Naturvation, 2021).

The selection criteria were as follows:

1. Locations were selected in two European cities - Utrecht and Leipzig, in two EU member countries.
2. Cases relevant to adaptation to climate change at the municipal level.
3. It would be helpful to be able to contact and communicate with experts, if the project had already begun, been in progress, or ended.
4. Ideally, multiple actors should be involved in governance.
5. Preferably to be financed by multiple actors, but not a must.

Based on criterion (1), I could identify ten NbS projects in Utrecht and eleven projects in Leipzig. Relevance to climate change adaptation at the municipal level was mandatory for selection. Thus, out of the selected cases based on criteria (1), four projects were relevant to urban climate change adaptation in Utrecht City, and I found three projects in Leipzig – relevant to criteria (2). Due to time constraints and finding relevant experts and actors within the time limit given for this assignment, I chose two cases per each city. Hence, four of the total 7 cases in two cities had to be selected for further evaluation. The most suitable cases that met criteria 3 to 5 were selected. A detailed list of the cases is presented in Appendix 6: Case Projects Identified and Selected for the Thesis. Hence based on the criteria, I selected the following cases:

1. Roerplein Pocket Garden in Utrecht, The Netherlands
2. the bio-wash machine in Utrecht City, The Netherlands
3. Kletterfix Green Walls in Leipzig City, Germany
4. Elster-Luppe wetland Revitalization and Renaturalization in Leipzig City, Germany

After selecting the cases, identifying the relevant experts and stakeholders was another major challenge in conducting interviews and doing research. However, due to the unavailability of the relevant experts of Roerplein Pocket Garden for an interview, despite numerous communications, and similarly not having a connection with the experts of two other cases listed; thus, based on the criteria, the Sustainable Roofs Project was chosen at the Utrecht municipal level. As this was an ongoing project, the experts were identifiable via the project-related links (NMU, 2022).

3.3. Data Collection

A relatively balanced amount of data came from three sources for this thesis. The sources include scholarly literature, NbS-infected policies, strategies, reports, and stakeholder interviews. Utilizing the above-mentioned three data sources, the thesis has described the facts, evaluated the current situation, and suggested pathways for reinforcement of NbS implementation.

Details of the literature review, institutional documents and reports, and stakeholders' interviews are elaborated in the following subsections.

Table 6: Data requirements and sources for analyzing per each research question.

Research question	Data requirements	Data sources
1. How did NbS enter the policy agenda of the EU? ▪ How did the concept of NbS gain agency within EU? ▪ What role of NbS is envisioned in multilevel decision-making (governance) across Europe?	▪ Journals to describe and unpack the theoretical frameworks ▪ Relevant national and decentral policies of the Netherlands and Germany for describing how NbS has been incorporated.	▪ Semi-systematic search from academic journals accessed openly via Google Scholar, Science Direct. ▪ Policies and reports are accessible through Google and organizations' webs.
2. How supportive for NbS are decision-making processes at the level of cities? ▪ To what extent are NbS absorbed in urban space and societal sectors? ▪ What are the factors that explain success and failure of adopting NbS?	▪ Stakeholders' and experts' opinions about the level of absorption of NbS and factors of success and failure.	▪ Stakeholders interview to check if the right case is selected, to explore answers for the second research question, and verify the secondary data from previous studies.
3. What are the possible pathways to reinforce implement of NbS effectively?	▪ Review the findings of the research question 1 and 2, in order to discuss the commonalities, divergence and dominant factor.	▪ Data explored from the results of research question 1 and 2, would give the foundation for exploring the pathways.

3.3.1. Literature Review

I conducted a theoretical literature review in this research to establish the research framework based on the available knowledge. Hence the searching conducted by applying keywords such as "multilevel governance", "nature-based solution", "NbS principles", "NbS barriers and opportunities", "NbS success and failures", "agency theory", "NbS governance", "EU Climate policies" and "climate adaptation". The data has been reviewed from scientific literature depending on multiple keywords, and the searching year has not been specified. However, I chose the more cited literature.

Further, the search algorithms have been customized for filtering recent literature, covering the EU region in the English language, and focusing on the urban / city or municipal level. Screening and selection of scientific papers have been prioritized according to peer-review status, the relevance of title, keywords, and abstracts, as well as their geographical and sectoral relevance. After the primary selection of the literature, I reviewed the contents of each paper and chose the relevant articles for analysis.

I used ScienceDirect and Google Scholar to select relevant papers on the theories and key concepts to support the exploration of a conceptual framework for this research and contribute to answering research questions, as outlined in the Table 6.

3.3.2. Document Review

NbS-relevant policies, roadmaps, strategies, and reports considering the scales of trans-national, national, sub-national, and municipal institutions with more focus on the case geography and societal sectors of urban development have been accessed from the EC webpage, project-related webpages, and official pages of the counties related institutions. This review aimed to deepen understanding regarding NbS integration into their policies and the roles envisioned by the institutions at the multilevel and scales for governance and decision-making concerning the societal sector of urban development.

3.3.3. Interviews

Interviewing stakeholders and experts was essential for answering the evaluative and design part of the research questions - specifically, finding out the reasons for the success and failure of the NbS and finding ways to reinforce the implementation of the NbS. Two interviews were planned for each case, while the moderate situation was to seek additional experts and/or actors from the relevant partners and actors for interviewing. As a result, 13 interviews for 4 cases have been conducted (See Appendix 5: List of Interviewees). The interview respondents include the municipality administration, planning experts, scientists and academia, consultant companies, and NGOs. Interviews were conducted in a semi-structured format, guided by a questionnaire designed to cover the areas in which information is needed and to ensure reliable, comparable, and qualitative data. (See Appendix 4: Questionnaire for Interviews. The interviews were conducted online and in English. I recorded the discussions. Based on the recordings, the content was transcribed and noted in an Excel sheet for thematic and content analysis.

The key outputs of the interviews were:

- The collection of data.
- Verification of the data and facts.
- Contributing to assessment.
- Fill the gap of missing data from their experiences and opinions for proposing a design for strengthened implementation of NbS.

3.4. Conceptual Framework

Step 1: to answer the first research question on the NbS entry to the EU policy agenda

To clarify the "NbS entry into EU policy agenda", I initially broke down the research question into two sub-questions. So, the sub-question (1.1.) explores how NbS gained agency and how it is integrated into EU policies. This question looks at the agency concept through the prism of policies, power relations, and the type of tasks delegated to the member states and decentralized level, as well as exploring what policies the EU has endorsed and how it stresses the NbS concept concerning the global agenda. In sub-question (1.2.), I am looking at the policies with a more practical perspective by determining if the policies contain NbS and "what clear role is envisioned at the EU level and the member state and decentral levels". An outline of the potential parameters for

assessing this narrative across EU and decentral policies is provided in Appendix 3: Potential List of the Indicators for Exploring NbS Entry into EU Policy

Step 2: To answer the second research question on the supportiveness of decision-making. This question has also been deconstructed into two sub-questions. To assess the level of support for NbS based on the evidence of "extent of NbS absorbed" at the city level and identify the "factors of NbS success and failure" that affect the decision for NBS adoption. Thus, the interview indicators and measures were developed to construct the interview questions. The indicators for this question were designed benefiting from the NbS concept in integration with the agency theory in an MLG outlook. The details are outlined in Table 7.

Table 7: Indicators and measures to answer the second research question

SN	Indicators	Measures	Related interview question
1.	To what extent are NbS absorbed in urban space and societal sectors?		
1.1.	**Institutional context:** interaction and agency leadership and commitment. *Adopted from the model of the effect of the institutional context over the interaction of principal-agent (Wiseman et al., 2012:206), and the Power dimensions model in multilevel climate governance (Marquardt, 2017:171)*	▪ Political commitment (policy instrument) ▪ The existence of structure driving NbS ▪ The existence of a vision, plan, and program for NbS ▪ The existence of change drivers (e.g., networks, social capital)	▪ Part 3: all question related to assessment of the NbS absorption at the municipal level. ▪ Part 2: question 5 and 6. ▪ Part 4 b: question 20, 21, 22, 23, 26
1.2.	**Agency problem** *Adopted from the model of the effect of the institutional context on principal-agent interaction (Wiseman et al., 2012:206)*	▪ Information Asymmetry ▪ Conflict of interest ▪ Transparency	▪ Part 4 A: question 13, 14, ▪ Part 4 B: question 21, 22, ▪ Part 4 C: question 29
2.	What are the factors that explain success and failure of adopting NbS?		
2.1.	**Knowledge** *Adopted from Egusquiza et al., (2019) and Hawxwell et al., (2019)*	▪ Research and data generation on NbS and its costs and benefits ▪ Collaboration and creation of networks ▪ Co-creation of practices ▪ Access to information ▪ Awareness at multiple scales	▪ Part 4 A: all the questions. ▪ Part 4 B: question 21, 23, 26
2.2.	**Governance** *Adopted from Egusquiza et al., (2019) and Hawxwell et al., (2019).*	▪ Collaboration among sectors, actors, and levels ▪ Instruments, finance, and capacity	▪ Part 4 B: all the questions, ▪ Part 3, question 8, 9, 10, 11, 12

		▪ Self-governance capacity through innovation ▪ Adaptation of practices based on a challenge ▪ Existence of an NbS structure ▪ Synergy in actors' vision (shared vision) ▪ Establish partnership (Co-production)	▪ Part 4 C: question 27,
2.3.	**Economics** *Adopted from Egusquiza et al., (2019) and Hawxwell et al., (2019).*	▪ Return on investment (cost/benefit) ▪ Finance ▪ Capacity to raise funds ▪ Private sectors interest ▪ Risk management	▪ Part 4 C: all the question ▪ Part 4 B: question 26

In Table 7, the critical dimensions have been designed based on the NbS drivers and/or barriers (knowledge, governance, and economic) concept of Egusquiza et al. (2019), which was further expanded by Wiseman et al. (2012) interaction of principal-agent (agency) theory such as 'institutional context' and the 'agency problem'. Furthermore, by using MLG to navigate the factors across the levels. Hence, I came up with five dimensions to address two sub-questions related to the second main research question:

1) Intuitional context analysis
2) Agency problem analysis (information asymmetry)
3) Analysis of knowledge drivers and barriers
4) Analysis of governance drivers and barriers
5) Analysis of economic drivers and barriers

The dimensions were equipped with measures based on both theories, considering multilevel policies and multi-sectoral outlooks. In addition, the measurements and indicators that overlapped between both theories were combined.

Step 3: To answer the third research question on pathways for the NbS implementation.
The goal has been to discuss and determine the most prominent and critical common factors associated with success and failure based on the analyses of the narratives of both cities (under research question two) in addition to the policies analysed (under research question one) to provide pathways, in terms of policies, knowledge/information, governance, and economics.

3.5. Data Analysis

3.5.1. Method of Data Analysis

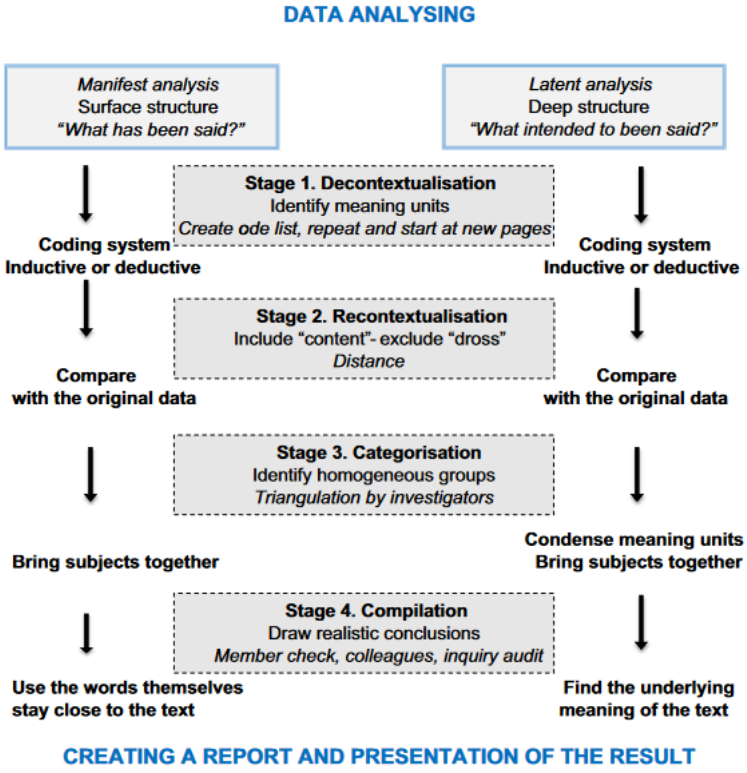
I collected data from scientific literature, institutional policies and reports, and interviews with stakeholders and experts. This thesis has mainly adopted a qualitative approach to provide detailed descriptions and explore the complex issues (Shoshanna, 1999) related to multilevel governance of NbS for climate change adaptation in cities. Hence, the data is mainly qualitative. Three types of interview questions were used:

1) Contextual questions to clarify the form and nature of case projects.

2) Evaluative questions to assess the effectiveness.
3) Strategic or design questions contribute to exploring new policy recommendations and actions.

Since most of the interview questions are qualitative, the data are analysed through four stages of content analysis, as outlined by Bengtsson (2016): de-contextualization, re-contextualization, categorization, and compilation. However, these stages could be repeated multiple times to get a trustworthy result from the analysis and maintain the quality of results (Bengtsson, 2016).

Figure 10: Overview of the process of qualitative data content analysis



Source: Bengtsson, (2016:9)

However, the coding would remain consistent for questioning. The critical measure and indicators applied as the codes for measurement are presented in Table 7 and Appendix 3: Potential List of the Indicators for Exploring NbS Entry into EU Policy, while for making questions, the questioning words such as: what, how, why, and to what extent has been used. Thematic and content analysis was necessary to align contents, record repeating views, and define patterns. Moreover, the interviews allowed the experts to present stories. The analysis method depended on the type of qualitative data, information, and discourse uncovered through the research.

3.5.2. Validation of Data

The data for this research was collected from three sources: scientific literature, institutions reports, and interviews. The scientific data explain the theories and the principles of the game. At the same time, the policies and reports in sequential order from the EU level narrowed down to the decentral, and municipal levels assured consistency, minimized errors, and increased validity. Besides, interviewing experts and actors further supported verifying the data and sources and triangulating the data from multiple sources. In this thesis, four cases were chosen, with two cases per city; on average, three interviews per case were conducted, which enhanced confidence in causal relationships among factors and explored the most common and repeated ones to demonstrate the validity of the research. However, compared to the number of projects and experiences that may exist in the EU, the size and number of the cases may be very small. Concerning the selected cities in the context of urban climate adaptation, the project was chosen based on a coherent criterion to support a relatively generalization of understanding.

3.6. Research Ethics

I carried out this research following the ethical instructions for the social sciences and in compliance with the norms applied by the MEEM program of the faculty of BMS at the University of Twente. The research involves human participation through the interview process. The interviewees' responses were recorded for smooth data collection and analysis; thus, I considered all the relevant privacy matters, and the interviewees were informed fully to have their consent for the interview. At least two days before the interview, I shared the interview questions and consent forms with all interviewees via email to enable them to review the questions and provide their consent. Moreover, all interviewees were informed of the process and consent notes before the interview began. They offered their oral consent to have interviews and to use the data for the research, to record the interviews, and to anonymise their names. Furthermore, the data and records will be destroyed after the completion of the thesis project. The template of questions, including the consent note, is presented in Appendix 4: Questionnaire for Interviews.

3.7. Limitations

Most of the interviews were conducted online to enhance the efficiency time. This thesis was bounded to a specific timeframe. Therefore, an attempt has been made to apply the theories and their aspects considering time limitations. In addition, arranging interviews with the experts required more time, and most of the projects were accomplished previously; thus, finding the relevant resource person was a challenge. Most of the actors contacted have not shown up for an interview. Finally, some of the decentral policies were in national languages; I translated them through the google-translate machine for analysis.

CHAPTER 4: RESULTS

4.1. The Emergence of NbS in European Policies

As indicated by the EEA assessment in 2021, UNFCCC, UNCBD, New Urban Agenda (Habitat III) and SFDRR (2015-2030) have explicitly used the NbS-related term to address climate change adaptation and disaster risk reduction, whereas the SDGs, UNCCD, and Ramsar conventions implicitly use terms related to NbS (EEA, 2021).

I reviewed EU policy documents with their relations to global policies. The list of policies was selected based on the keywords of climate change policies, environment policies, urban policies, and NbS policies from the EU webpage and considering the previous studies conducted about the NbS policies at the EU by Dumitru & Wendling, (2021) and Davis et al., (2018a) and (EEA, 2021). Further, the policy documents are divided into four thematic areas related to:

1. Environment and climate.
2. Agriculture, water and soil.
3. Habitat, biodiversity and forest.
4. Growth and regional development.

A total of 21 policy documents (e.g., directive, law, policy, strategy, action plan, roadmap) were examined, and their linkage has been defined with relevant global policies as summarised in Table 8.

Table 8: The list of EU policy documents reviewed for NbS integration

Thematic areas	Type of policy doc.	Date of enforcement	Policy document	Relation to global policies
Environment and Climate	Law	30-Jun-21	European Climate Law for 2050	To deliver the commitment for the implementation of the "**Paris Agreement – 2015**" based on the United Nations Framework Convention on Climate Change (UNFFC) (European Commission, 2021e)
	Strategy	24-Feb-21	The new EU Strategy on Adaptation to Climate Change	To deliver the commitment conducted concerning adaptation to climate change under the European Climate Law (EC, 2021e) based on the global goal for the adaptation highlighted in **article 7 of the Paris Agreement** and **SDG 13** (European Commission, 2021c)
	Action Plan	12-May-21	Zero Pollution Action Plan	To deliver the critical actions identified under the EU Green Deal initiative and the EU Chemical Strategy for Sustainability while contributing toward the commitment to the **SDGs 3, 6, 11, 12,**

				14, and 15. (European Commission, 2021a)
	Directive	27-Jun-85	Environmental Impact Assessment Directive (EIA)	In alignment with the **UN Conference 2012 held in Rio about Sustainable Development** and to deliver the critical action requested by the **UNCBD** to assess the projects' adverse effect on biodiversity and minimize the effects (European Parliament and the Council of the European Union, 2014).
Agriculture, Water and Soil	Strategy	2-Dec-21	Common Agriculture Policy	To deliver the commitment for the **SDGs** and the **WTO** agreements on agriculture (European Parliament and the Council of the European Union, 2021).
	Strategy	20-May-20	Farm to Fork Strategy	Based on the **EU Green Deal** policy framework, which aims to contribute to the **SDGs.** (European Union, 2020)
	Strategy	17-Nov-21	EU Soil Strategy for 2030	Stemming from the **EU Green Deal** and aims to contribute to EU Biodiversity Strategy for 2030, and SDG 15.3 (European Commission, 2021d)
	Directive	23-Oct-00	WFD	To address the commitment to the international conventions on water protection and management, specifically the **UN Convention for the Protection and Use of Transboundary Watercourses and International Lakes** (European Parliament and the Council of the European Union, 2000)
	Directive	23-Oct-07	Floods Directive	To deliver to the commitments to the international principles adopted under the **UN Convention on Protection and Use of Transboundary Water Courses and International Lakes.** (European Union, 2007)
Habitat, Biodiversity and Forest	Directive	21-May-92	Habitats Directive	The Directive has not outlined its linkage for the global commitments while it is under the **Treaty Establishing the European Economic Community** (European Commission, 1992). However, it has linkage to the **UNCBD agreement / treaties and Ramsar Convention** (EEA, 2021). Also, this contributes to the general objectives of sustainable development (European Commission, 1992)
	Directive	30-Nov-09	Birds Directive – 1979 - 2009	Adopted under the EC treaty, the EU treaty and Euratom treaty without outlining any international agreement (European Union, 2009). However, this

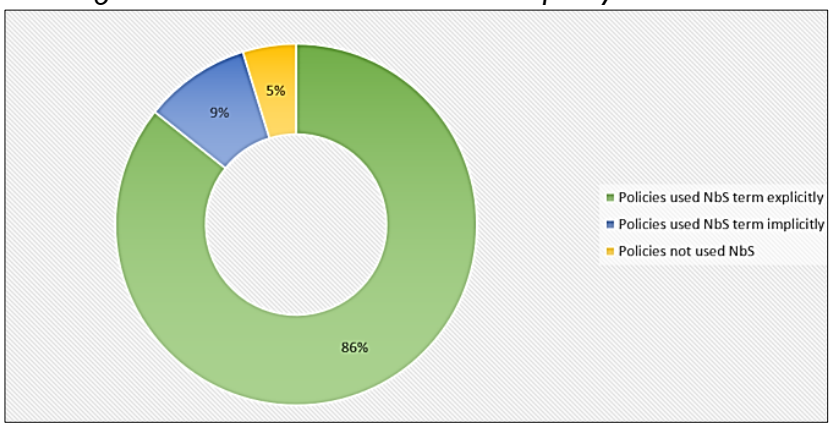
				directive contributes to the **UNCBD agreement and Ramsar Convention** (EEA, 2021).
	Strategy	16-07-21	The new EU Forest Strategy	Delivering the commitments for **SDG** 15 as the EU contribution to the global agenda 2030 (EC, 2021).
	Directive	17-Jun-08	Marin Strategy Framework Directive (MSFD)	The MSDF is contributing toward the commitments of the EU to the **World Summit on Sustainable Development** and the **UNCBD** (European Union, 2008).
	Strategy	20-May-2021	EU Biodiversity Strategy for 2030	It is delivering to the commitments for adopting a transformative post-2020 global framework at the 15th Conference of the Parties (COP)of the **UNCBD** to assure that ecosystems are resilient, adequately protected, and restored by 2050. Further, this contributed to the **SDGs** and the **Paris Agreement** (European Commission, 2021b).
Growth and Regional Development	Strategy	13-Sep-12	Blue Growth Strategy and guideline	Contributes to the EU MSFD, which in term it is contributing to the commitments of the **Rio+20 summit** for sustainable use of diverse marine ecosystem (European Commission, 2012).
	Policy Agenda	30-May-2016	Urban Agenda for the EU Pact of Amsterdam	Concerned with the commitment under the New Urban Agenda (Habitat III) of the UN, the **SDGs and the Paris Agreement** (European Commission, 2016).
	Strategy	11-Oct-2018	Strategy for Sustainable Bio-economy for Europe	Delivers the commitments for the **agenda 2030 of Sustainable Development Goals (SDGs)**, and it further contributes to the target of the land degradation neutrality of SDG by 2030, which in term contributes to the commitments to the **UNCCD.** (European Commission, 2018).
	Strategy	06-May - 2013	Green Infrastructure Roadmap	Delivers to the actions suggested by the **UNFCCC** climate policies (European Commission, 2013a).
	Policy	12-Dec-2013	Green Infrastructure policy	Delivers to the commitments for the **Aichi Targets** of the 'Strategic Plan for Biodiversity 2011- 2020' of UNCBD (European Commission, 2013b)
	Action plan	11-Mar-20	Circular Economy Action Plan for a Cleaner and More	To address in line with the commitments for a circular economy at the global level to implement the 2030 **SDGs** (European Commission, 2020).

			Competitive Europe	
	Roadmap of Key Policies	11-Dec-2019	EU Green Deal	Agenda 2030 for Sustainable development, **SDGs** (European Commission, 2019b)

The 1985 EIA Directive was the first document to touch on the NbS concept implicitly by focusing on screening the effects of projects and interventions on natural and semi-natural areas, which are tied into areas protection. The 1992 Habitats Directive was the second EU legislation that dealt implicitly with NbS issues via protected areas and water bodies. The Habitat Directive was the basis for many policies and strategies, such as biodiversity strategies, forest policies, and many others. In 2000, the WFD was the first EU directive that emphasized ecosystem-based and sustainable ecosystem approaches, which can be interpreted as an explicit pronunciation of NbS in EU policy. The EU Green Deal 2019 as an umbrella roadmap represents one of the key documents at the EU level that specifically mentions NbS and influences multiple legislations, policies, roadmaps, and strategies for absorbing the NbS concept. The EU climate law is established based on the treaty of functioning of the EU, which considers the issue of climate as a transboundary issue. The law emphasizes that the EU will be emission-neutral by 2050. Accordingly, the EU Climate Law 2021 is key mandatory legislation at the EU level that was established based on the Paris Agreement to limit the global temperature increase to 1.5 degrees. It has explicitly referred to the concept of NbS for the benefit of climate change mitigation, adaptation, and biodiversity protection.

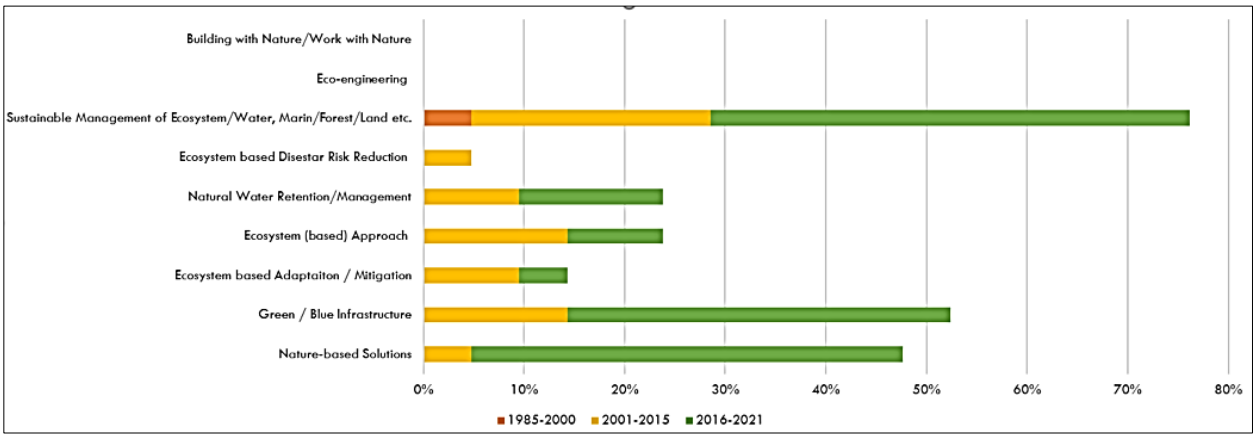
Based on the review of the policy documents, it can be observed that global policies have a crucial influence over the policy development process in the EU. These studies show that NbS is rooted in several key policies of the EU. From the review of 21 EU policies, there was 86% indication for the explicit use of NbS, 9% of the policies have used NbS approaches implicitly, and only 5% did not use the NbS concept at all.

Figure 11: Use of NbS term in the EU policy documents



Davis et al. (2018a) have defined eight explicit equivalent or related terms to NbS. Consequently, this thesis found out that the term "Nature-based Solutions" is directly stated in 48% of the policies, whereas "sustainable management of ecosystem/water/forest etc." is cited in 76% of the policies, as visualized in Figure 12. It is further realized that the NbS concept has been widely used and adopted in policy documents from 2016 onward. The Figure 12 presents the explicit use of the NbS-related term in EU policies on time-wise as well.

Figure 12: Use of NbS-related terms in EU policy documents



A detailed overview of the EU policies infected with NbS-related terms are presented in Table 9. This table further shows that a majority of 17 of 21 EU policies have specific attention to cities and urban areas.

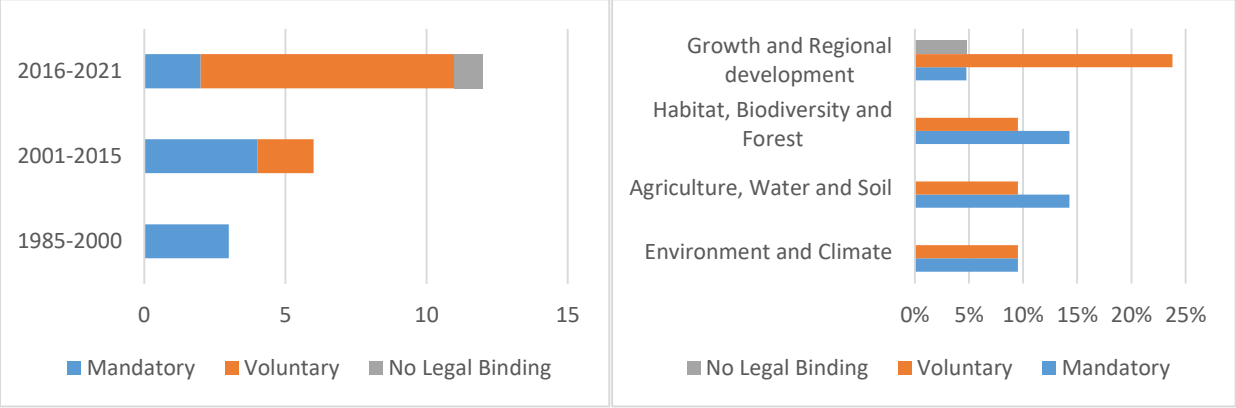
Table 9: List of the EU policies infected with the NbS-related terms

List of policy instruments	Explicitly NbS-related term used									NbS term Implicitly used	NbS term not used	focus areas	
	Nature-based Solutions	Green / Blue Infrastructure	Eco-system based Adaptation / Mitigation	Ecosystem (based) Approach	Natural Water Retention/Management	Ecosystem based Disaster Risk Reduction	Sustainable Management of Ecosystem/Water,	Eco-engineering	Building with Nature/Work with Nature			Cities/Urban	General
European Climate Law for 2050	✓		✓										✓
The new EU Strategy on Adaptation to CC	✓	✓			✓		✓					✓	✓
Zero Pollution Action Plan	✓	✓										✓	✓
EIA Directive										✓		✓	✓
Common Agriculture Policy					✓		✓						✓
Farm to Fork Strategy	✓	✓					✓					✓	✓
EU Soil Strategy for 2030	✓	✓		✓	✓		✓					✓	✓
Flood Directive					✓		✓					✓	✓
WFD							✓					✓	✓
Habitats Directive										✓			✓
Birds Directive											✓		✓
The new EU Forest Strategy		✓		✓			✓					✓	✓
Marin Strategy Framework Directive				✓			✓					✓	✓
EU Biodiversity Strategy for 2030	✓	✓					✓					✓	✓
Sustainable Bio-economy Strategy for Europe							✓					✓	✓
Blue Growth Strategy and Guideline		✓		✓			✓						✓
Urban Agenda for the EU Pact of Amsterdam	✓	✓					✓					✓	
Green Infrastructure Roadmap,	✓	✓	✓	✓	✓	✓	✓					✓	✓
Green Infrastructure Policy		✓	✓				✓					✓	✓
Circular Economy Action Plan	✓	✓					✓					✓	✓
EU Green Deal	✓						✓					✓	✓

9 out of 21 policy instruments have a mandatory implementation state, which implies that they are legally binding with rigid implementation. In contrast, 11 policies have a voluntary implementation state, which means that they are legally binding but with flexibility in implementation. In contrast, one document is not legally binding at all.

Analysing the trend from a historical perspective, it is observed that the EC communicated most of its mandatory policies before 2015. Furthermore, most voluntary and flexible policies have been introduced in recent years after 2016, and it seems that new EU policies are moving toward more flexible and encouraging approaches. Similarly, most mandatory policies relate to habitat and biodiversity, agriculture and water policies; however, most flexible policies relate to growth and regional development.

Figure 13: The legal status of policies



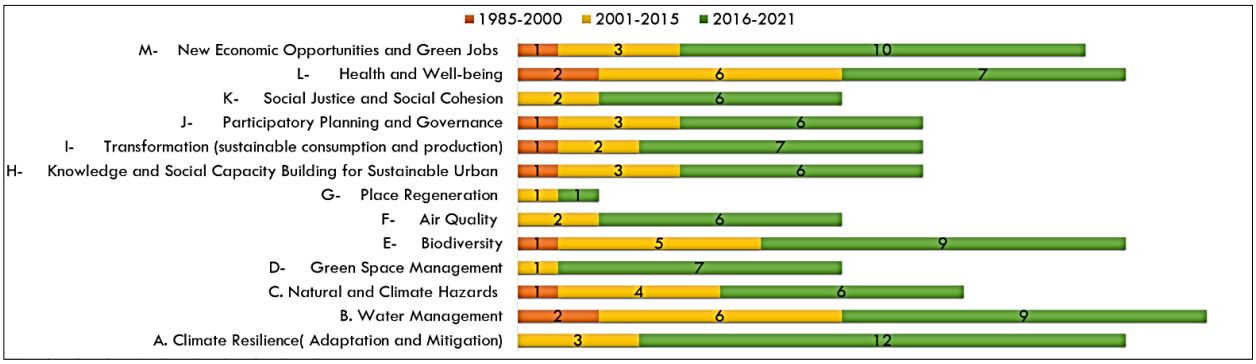
The policies reviewed in this chapter indicate that the Member States are the first responsible agents for enforcing mandatory policies. These documents include directives, regulations, and laws. As for the voluntary policies and strategies, these policies play more of a persuading role and encourage the EU Commission first to take action and move toward the policy goals.

4.2. The Role of NbS in EU Multilevel Governance

4.2.1. The Role Envisioned for NbS in the EU policies

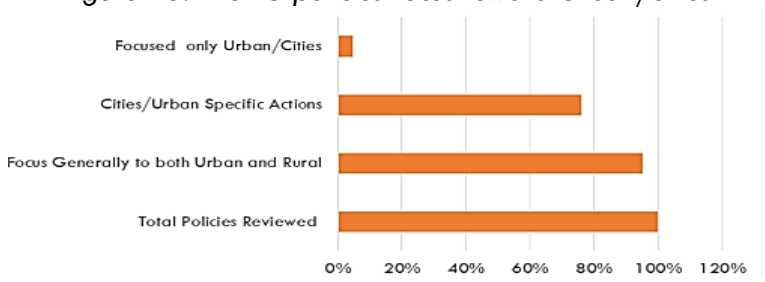
Based on the conceptual definition of the societal challenges in the EU context, as defined in Appendix 1: Definition of Concepts, the NbS are expected to respond to 13 critical societal challenges. Using the historical review of EU policies, the data shows that the NbS has played a vital role in water management in 17 out of 21 policies, followed by biodiversity conservation in 16 out of 21 policies, and climate resilience (adaptation and mitigation) in 15 out of 21 policies. Moreover, data shows that since 2015, the role of NbS has significantly been defined in enhancing climate resilience as the top priority in 12 out of 21 policies, followed by new economic opportunities and green jobs as the second priority in 10 out of 21policies. Figure 14 presents the details.

Figure 14: The role of NbS determined by the EU policies



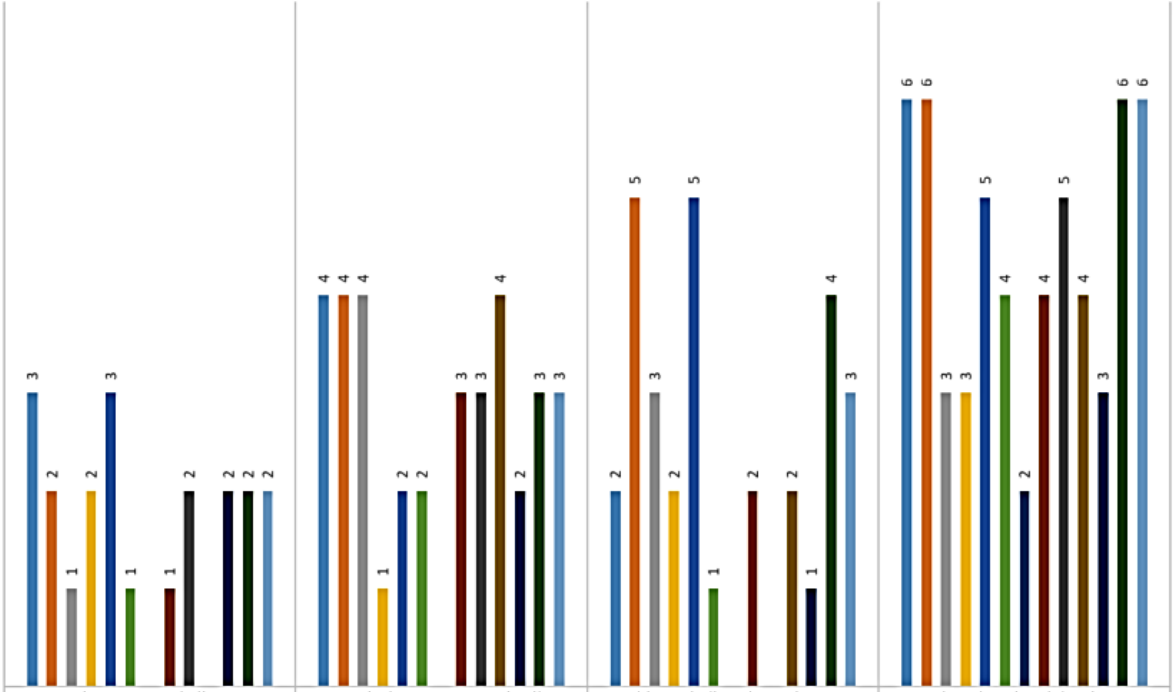
Similarly, based on the policies review, it has been identified that 86% of the policies have specific activities focused on the urban/cities level NbS. In contrast, 95% were generally focused on both urban and rural. However, 5% of the policy was only focused on urban areas.

Figure 15: The EU policies focus toward Urban/cities



To examine the NbS role expected for addressing of the societal challenges under the 4 thematic categories used in this research, it is revealed that NbS roles in climate resilience, water management, health and well-being, and biodiversity conservation have been on the top, but the highest level of societal benefits is expecting from NbS to respond for support of the theme of growth and regional development. The detail is illustrated in Figure 16.

Figure 16: The role expected from NbS in EU policies based on the four thematic areas proposed in this research



	Environment and Climate	Agriculture, Water and Soil	Habitat, Biodiversity and Forest	Growth and Regional development
A. Climate Resilience(Adaptation and Mitigation)	3	4	2	6
B. Water Management	2	4	5	6
C. Natural and Climate Hazards	1	4	3	3
D- Green Space Management	2	1	2	3
E- Biodiversity	3	2	5	5
F- Air Quality	1	2	1	4
G- Place Regeneration				2
H- Knowledge and Social Capacity Building for Sustainable Urban	1	3	2	4
I- Transformation (sustainable consumption and production)	2	3		5
J- Participatory Planning and Governance		4	2	4
K- Social Justice and Social Cohesion	2	2	1	3
L- Health and Well-being	2	3	4	6
M- New Economic Opportunities and Green Jobs	2	3	3	6

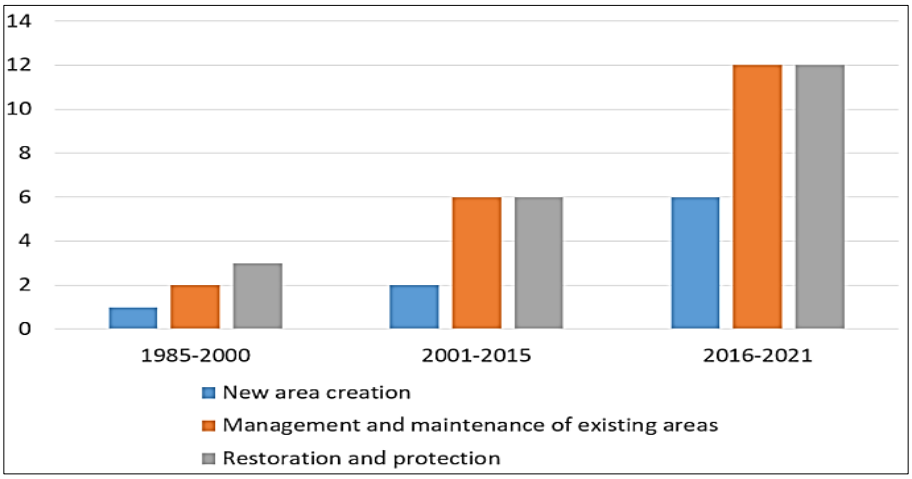
The table below illustrates the details of each EU policy's role expected from NbS in responding to societal challenges.

Table 10: The NbS role expected in each of the EU policies

Policies	A. Climate Resilience(Adaptation and Mitigation)	B. Water Management	C. Natural and Climate Hazards	D- Green Space Management	E- Biodiversity	F- Air Quality	G- Place Regeneration	H- Knowledge and Social Capacity Building for Sustainable Urban	I- Transformation (sustainable consumption and production)	J- Participatory Planning and	K- Social Justice and Social	L- Health and Well-being	M- New Economic Opportunities
EIA Directive													
Habitats Directive		✓			✓							✓	✓
WFD		✓	✓					✓	✓	✓		✓	
Flood Directive	✓	✓	✓							✓		✓	
Marin Strategy Framework Directive		✓	✓		✓			✓				✓	
Birds Directive		✓			✓							✓	
Blue Growth Strategy and guideline		✓			✓				✓		✓	✓	✓
Green Infrastructure Roadmap,	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Green Infrastructure Policy	✓	✓	✓		✓	✓		✓		✓		✓	✓
Urban Agenda for the EU Pact of Amsterdam	✓			✓		✓	✓		✓	✓			✓
Sustainable Bio-economy Strategy for Europe	✓	✓			✓			✓	✓	✓		✓	✓
EU Green Deal	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓
Circular Economy Action Plan	✓	✓										✓	
Farm to Fork Strategy	✓										✓		✓
The new EU Strategy on Adaptation to CC	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓
Zero pollution action plan	✓	✓		✓	✓	✓			✓		✓	✓	✓
EU Biodiversity Strategy for 2030	✓	✓	✓	✓	✓			✓		✓			✓
European Climate Law for 2050	✓				✓								
EU Soil Strategy for 2030	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓
Common Agriculture Policy	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
The new EU forest Strategy	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓

IUCN (2016) stipulates that NbS activities consist of (1) creating new areas, (2) managing and maintaining existing areas, and (3) protecting and restoring them, and the study found that the majority of the policies tend to emphasize management and maintenance of existing areas and restoration measures. However, the focus on area creation has been increasing in policies since 2016. The details are presented in Figure 17.

Figure 17: The NbS activities mix expected in the EU policies



4.2.2. The Role of NbS in Dutch Policies

Based on the EU level policies review in Section 4.1., a search for documents of similar nature at national and decentral levels has been conducted. A total of 13 relevant policy documents have been reviewed. Out of 13 policies, 8 were national, and 5 were specific to Utrecht province and Utrecht City. Table 11 presents the detailed policies, their aims, and connections to the EU and global agenda.

Table 11: The list of the Dutch policy documents reviewed for NbS integration

Type of Policy document	Publishing / Enforcement year	Policy document	Aim and relation to global policies
A. National Level Policies			
Policy	2019	Climate Agreement (National)	This policy was developed in alignment with the EC council decision on 20-June-2019 for the agenda of climate neutrality for 2050. The main goal is to reduce GHG emissions. It is linked to the **Paris Climate Agreement** and **EU Green Deal** (Netherlands Ministry of Economic Affairs, 2019).
Directive /Law	2019	Environment and Planning Act (unofficial translation)	This law is spread over numerous laws relating to soil, construction, noise, infrastructure, environment, etc. Therefore, the law was enacted to improve transparency, coherence in environmental decisions, and speed of decision-making, and there was a need for coordination. Secondly, this law serves as key support for sustainable development. The law is aligned with **SDGs** and **EU Climate Law**

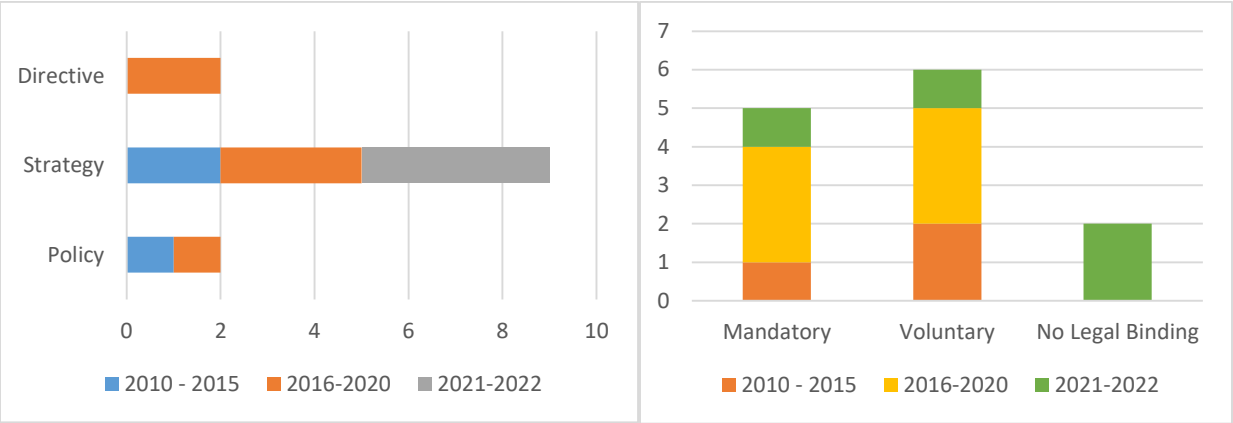
			(Ministry of Infrastructure and Environment, 2014).
Directive /Law	2019	Netherlands Climate Law	This law presents a framework for developing policies related to the reduction of GHG emissions and energy for limited global warming. This law is aligned with the **EU Energy Directive** (Staatsblad Jaargang van het Koninkrijk der Nederlanden, 2019).
Strategy	2011	Climate Adaptation in the Dutch Delta (Strategic Options for a Climate-Proof Development of the Netherlands)	This strategy primarily focuses on the management and development of dykes, ecosystems, biodiversity, and urban development-specific measures for climate-proofing water supplies. The strategy is also moving toward a climate-proofed spatial strategy (PBL, 2011).
Strategy	2016	National Climate Adaptation Strategy (NAS)	According to the vision, the 9 sectoral areas (e.g. water and spatial management, nature, agriculture/horticulture/fisheries, health and welfare, recreation and tourism, infrastructure, energy, IT and telecommunications, and public safety and security) will be able to adapt to four future scenarios (hotter, wetter, drier, and rising sea level). This strategy is in line with the **Paris Agreement, SDGs, and EU mechanisms for monitoring** and **reporting greenhouse gas emissions** (Ministry of Infrastructure and the Environment, 2016)
Strategy /plan	2022	Delta Programma 2022	This plan is contributing to the Climate Adaptation Strategy 2016 (stated above) and **EU Green Deal** (Ministerie van Infrastructuur en Waterstaat Ministerie van Landbouw, 2021)
Strategy	2013	National Coastal Strategy	Coastal zone safety, attractiveness, and economic viability are the goals of this strategy. This strategy supports the **delta programs** (Delta Programme | Coast, 2013).
Policy	2015	National Water Plan 2016-2021	Providing a higher level of perspective, principles, and directions for a national water policy through 2050. This policy is in line with the **Environment and Planning Act of the Netherlands** (Ministry of Infrastructure and the Environment Ministry, 2015).
B. Decentral Policies			
Strategy	2017	Omgevingsvisie Beurskwartier en	This strategy is one of the key documents to support the spatial strategy, and smart

		Lombokplein: naar een groter centrum (Utrecht Municipality Environment Vision for a Larger Centrum)	regulation of mobility, zoning, housing, energy, routes, and economic agenda (Municipality of Utrecht, 2017).
Strategy	2022	Investeren in Utrecht: kiezen voor gelijke kansen, betaalbaar wonen en klimaat - (Investing in Utrecht: Opting for Equal Opportunities, Affordable Living and Climate 2022 - 2026)	To deal with the major crisis the city is facing, and this investment plan focuses on housing, climate, and equal opportunity (Utrecht, 2022).
Strategy	2020	Op Weg Naar Een Klimaatbestendig Utrecht Programma Klimaatadaptatie 2020 – 2023 (Towards One Climate Safe (Utrecht Program Climate Adaptation 2020 – 2023)	This strategy's ultimate objective is to assure that Utrecht province will be climate-proof and water-safe and that the city will be ready to absorb the impact of climate change within the next 30 years (Utrecht Province, 2020).
Strategy	2021	Ruimtelijke Strategie Utrecht 2040 (Spatial Strategy Utrecht 2040) -	This is one of the core documents that support the spatial planning of Utrecht for a vision of 2040. This is based on the **Environment and Planning Act** (Gemeente Utrecht, 2021).
Strategy	2021	Visie Klimaatadaptatie Utrecht (Vision Climate Adaptation Utrecht)	This vision document seeks to ensure a climate-proof city by 2050 and to address vulnerabilities for a pleasant, liveable city. This vision is in line with the National Delta Plan on Spatial Adaptation (DPRA) (Kees Diepeveen, 2022).

From the review of the above documents, it is apparent that most national policies are formulated to facilitate the implementation of the Paris Agreement, SDGs, and EU Green Deal and Climate Law, which all support a vision of emission neutrality by 2050.

Based on the review of the policy documents, 9 were strategies and plans, 2 were laws or directives, and 2 were national-level policies. In the same way, 6 out of 13 policy documents had a voluntary implementation status, 5 out of 13 had a mandatory implementation status, and the rest (2 out of 13) were not legally bindable. Figure 18 presents in detail.

Figure 18: The types and legal status of the policies



The Dutch policy documents overview indicates that energy and its connection to emissions reduction is a significant focus of the policies. For example, the Climate Law of the Netherlands only emphasized energy and GHG emission reductions without any explicit or implicit focus on NBS-related practices or roles. Similar to that, the Dutch National Climate Adaptation Strategy (2016) and the Environment and Planning Act (2019) only have an implicit indication of the NbS-related approach.

Comparing Dutch policies, such as the Climate Law, the National Climate Adaptation Strategy, and the Environmental and Planning Act, to the EU policies, such as the EU Climate Law, the EU new Climate Change Adaptation Strategy, and the EU Zero Pollution Action Plan, it is evident that the three EU policies explicitly focus on NBS and ecosystem-based adaptation whereas the three Dutch policies do not have any explicit focus.

The Dutch Delta Programs (2022), the Dutch Strategy of Climate Adaptation in the Dutch Delta, and the Dutch National Water Plan are among the policy documents that use NBS and multiple related terms. Similarly, at the decentral level, Utrecht Vision for Climate Adaptation for 2050 and Investing in Utrecht (2022-2016) firmly and explicitly focused on NbS. It means that these documents are well NbS proofed.

Figure 19: Use of NbS-related terms in the Dutch policy documents

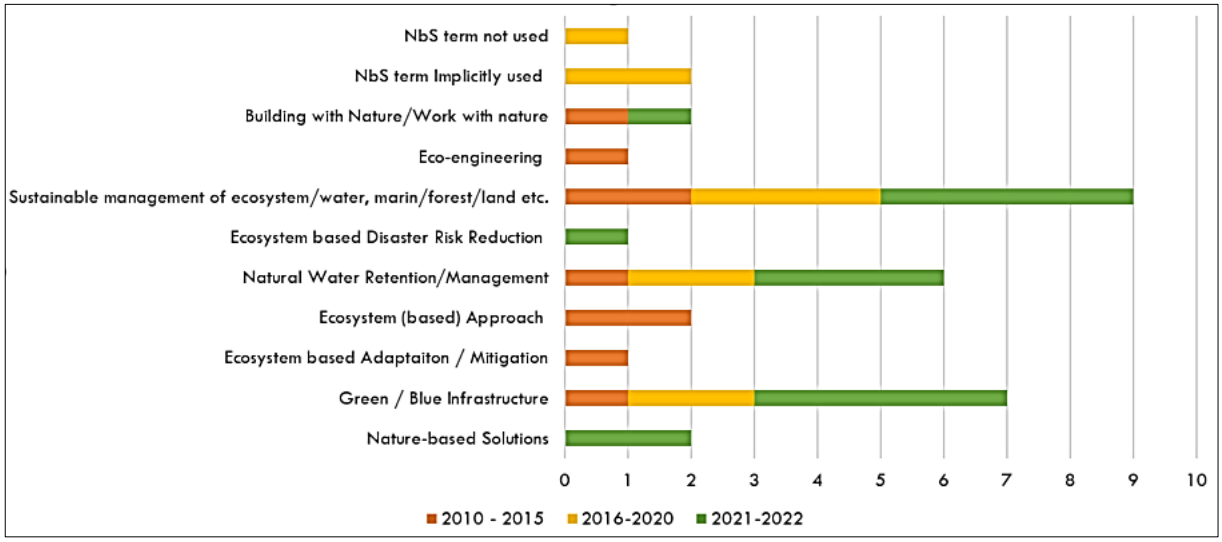


Figure 19 presents a detail of NbS-related terms used in Dutch policy documents. According to this thesis, the term NbS has been directly used in only 15% of Dutch policies (2 out of 13), which is after 2020. Among the significantly NbS-related explicit terms used in the Netherlands policies are "sustainable management of the ecosystem, energy, or water" in 69% (9 out of 13) of policies, followed by "green/blue infrastructure" in 53% (7 out of 13) policies, and "natural water retention/management" in 46% (6 out of 13) policies. Compared to EU-level policies, the direct use of the NbS concept in EU policies is (48%).

As indicated above, according to this thesis, the concepts of "Sustainable Management" and "Green/Blue Infrastructure" are among the top NbS-relevant concepts used in Dutch policies, similar to the EU policies. However, the use of the term "natural water management" in the Dutch policies is almost double that of the EU level. In addition, data shows that the direct use of NbS term in Dutch policies started late (after 2020) compared to EU policies.

Figure 20:The role of NbS determined in the Netherlands policy documents

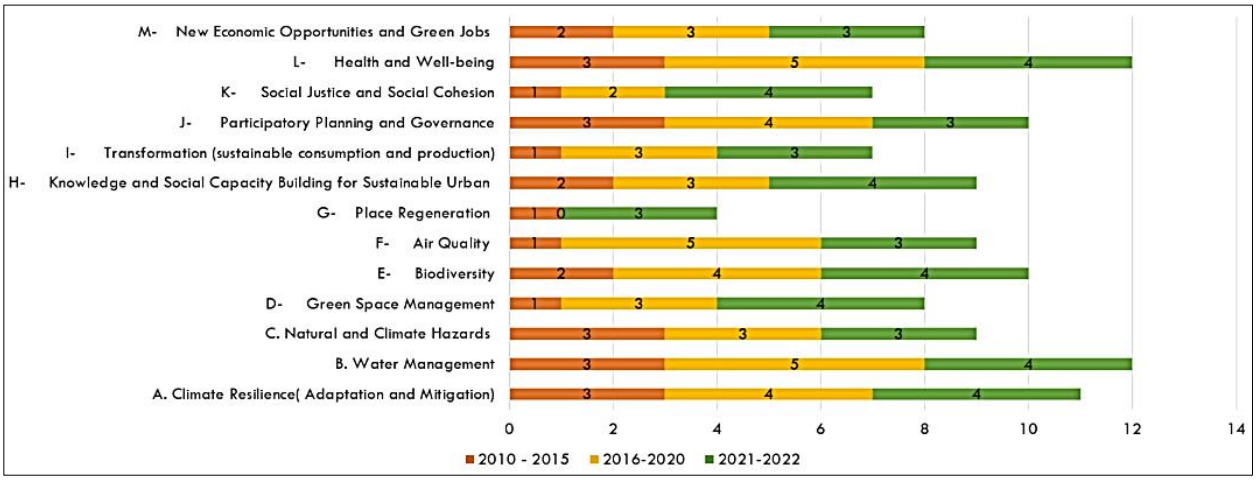


Figure 20 describes the role expected in policies for responding to societal challenges in the Netherlands and Utrecht City context. At the national and decentralized Dutch policies, the NbS plays an influential role in water management 92% (12 out of 13 policies) with equal significance for the goal of health and well-being, and in second-ranked (11 out of 13 policies) 84% for climate resilience (adaptation and mitigation). In addition, it is worth mentioning that 92% of the Dutch policies had a specific focus on cities. Compared with EU-level policies, there is greater coherence in the expectations of roles. In contrast, water management is among the top priorities in EU policies, and climate resilience is among the second highest priorities.

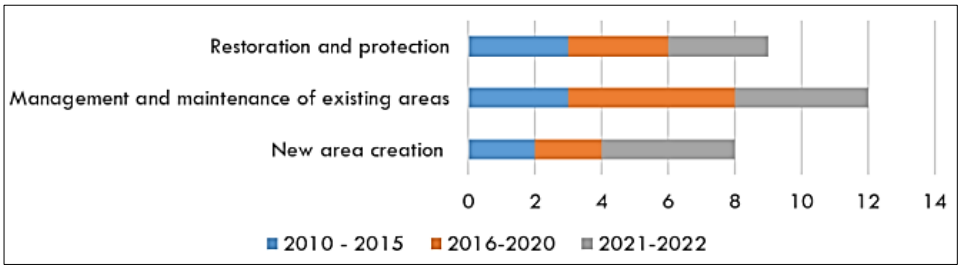
In Table 12, the details of the role expected from each policy in responding to the societal challenges are illustrated.

Table 12: The details of NbS role expected in each of the Dutch policy documents

List of policy instruments	**A.** Climate Resilience(Adaptation and Mitigation)	**B.** Water Management	c. Natural and Climate Hazards	**D-** Green Space Management	**E-** Biodiversity	**F-** Air Quality	**G-** Place Regeneration	**H-** Knowledge and Social Capacity Building	**I-** Transformation (sustainable consumption and production)	**J-** Participatory Planning and Governance	**K-** Social Justice and Social Cohesion	**L-** Health and Well-being	**M-** New Economic Opportunities and Green Jobs
Climate Adaptation in the Dutch Delta (Strategic Options for a climate-proof development of the Netherlands)	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓
National Coastal Strategy	✓	✓	✓				✓	✓		✓		✓	✓
National Water Plan 2016-2021	✓	✓	✓		✓			✓	✓	✓		✓	
National Climate Adaptation Strategy (NAS)	✓	✓	✓		✓	✓		✓		✓		✓	
Utrecht Municipality Environment Vision for a larger centrum	✓	✓		✓	✓	✓			✓		✓	✓	✓
Climate Agreement (National)	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓
Environment and Planning Act		✓	✓			✓				✓	✓	✓	
Netherlands Climate Law													
Toward One Climate Safe (Utrecht Program Climate Adaptation) 2020 - 2023	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
Delta Programma 2022	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
Spatial Strategy Utrecht 2040	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vision Climate adaptation Utrecht	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Investing in Utrecht: opting for equal opportunities, affordable living and climate 2022 - 2026	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓

In accordance with IUCN (2016) categorization of the NbS activities mix, the Dutch policy identifies the management and maintenance of the existing areas as one of the most notable types of activities, followed by restoration and protection measures. The detail is presented in Figure 21. This is the same to the EU-policies focus.

Figure 21: The NbS activities mix in the Netherlands policy documents



4.2.3. The Role of NbS in the German Policies

Considering the method applied in section 4.1., by searching the keywords and interviewees' opinions, a total of 16 policy documents have been reviewed in detail. 13 out of 16 were German national policies, and 3 were Leipzig city-level policy documents. The selected policies' aims and relevance to EU and global commitments are presented in Table 13.

Table 13: The list of German policy documents reviewed for NbS integration

Type of policy document	Publishing/ enforcement year	Policy document	Aim and relation to global policies
A. National Level Policies			
Directive /Act	2012	Circular Economy Act (Kreislaufwirtschaftsgesetz – KrWG)	This act aims to promote a circular economy for environmental and human well-being by conserving natural resources. This act is in line with the **EU Directive 2018/851 on Waste** (Bundestag & Bundesrat, 2012).
Policy	2016	Climate Action Plan 2050: Principles and Goals of the German Government's Climate Policy	Provides guidance and targets for achieving the national targets for adaptation to climate change in all sectors. It is in line with the **Paris Agreement** (BMU, 2012).
Directive /Act	2019	Federal Climate Change Act (Bundes-Klimaschutzgesetz)	It is intended to protect against the impact of global climate change on multiple levels - economic, ecological, and social - in order to limit warming to 1.5 degrees Celsius and meet the long-term goal of GHG neutrality by 2050. This is aligned with the **Paris Agreement** (Federal Ministry of Justice and Consumer Protection & Federal Office of Justice, 2019).
Strategy	2006	Concepts and Strategies for Spatial Development in Germany	This policy supports a sustainable spatial planning vision that reconciles the social-economical needs of space in a balanced way and preserves and enhances the ecosystem and cohesion of regions (German Federal Ministry of Transport & Affairs, 2006).
Directive /Act	2009	Act on Nature Conservation and Landscape Management	Biological diversity, the balance of nature, the beauty and recreational value of landscapes, protection from fragmentation, and preserving green spaces, trees, etc., are all protected by this law. This is in line with the **UNCBD** (Act et al., 2010).

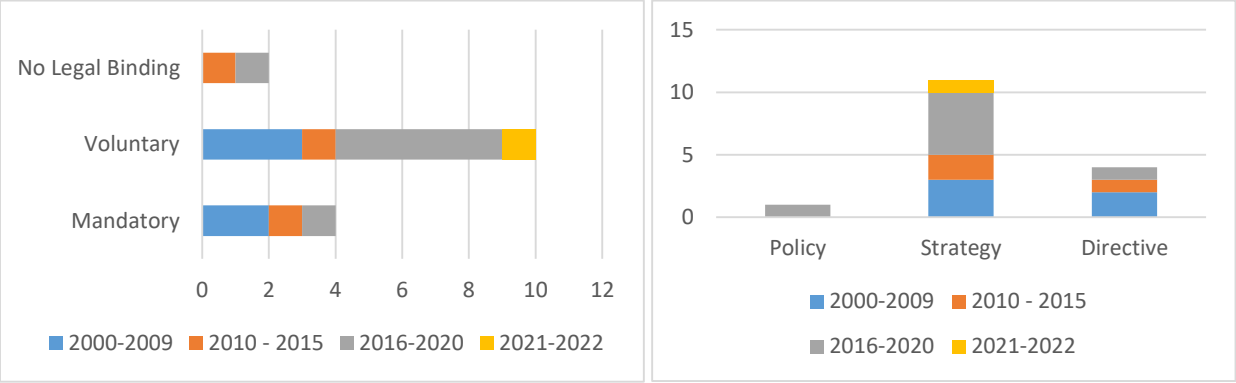
Strategy	2021	National Water Strategy (Draft)	This strategy aims to protect the water resources and ensure sustainable use of water in all areas. This is in line with the **EU Water Directive and SDGs** (of Environment & Water, 2021).
Directive /Act	2002	Amended Version of the Federal Water	This act supports the implementation of the **EU Water Directive** (The Federal Minister for the Environment Nature Conservation and Nuclear Safety, 2002).
Strategy	2017	Federal Green Infrastructure Concept	By establishing green infrastructure, this paper aims to conserve and restore ecosystems and protect natural capital (Federal Agency for Nature Conservation, 2017).
Strategy	2015	Grün in der Stadt –Für eine lebenswerte Zukunft Grünbuch Stadtgrün (Green in the city – for a future worth living in)	By establishing green infrastructure, this paper aims to conserve and restore ecosystems and protect natural capital (BMUB, 2015).
Strategy	2007	Nationale Strategie zur biologischen Vielfalt (National Biodiversity Strategy)	This is in line with **UNCBD** guidelines for implementing the convention at the national level and contributing to global biodiversity conservation (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit (BMU), 2007).
Strategy	2011	Adaptation Action Plan of the German Strategy for Adaptation to Climate Change	This plan aims to lay down options and actions for the implementation of the National Adaptation Strategy, and it is also in line with the **UNCBD** (BMU, 2012).
Strategy	2008	German Strategy for Adaptation to Climate Change	This strategy proposes a framework for addressing the consequences of climate change. This strategy contributes to the **UNFCCC** goals (German Federal Government, 2008).
Technical Doc/Strategy	2018	White Paper: Green Spaces in the City – for a more livable future	In this paper, the Federal Government provides recommendations on creating green space in cities. This paper is in line with the national strategy for biological diversity (Eyink & Heck, 2018).
B. Decentral Policies			
Strategy	2020	City Vision Leipzig 2050	It aims for a vision of a carbon-neutral city in 2050 and to be resilient and adaptive to climate change (EU, 2020).
Strategy	2016	Klimawandel Anpassungsstrategien für Leipzig (Climate	It aims to have a liveable city with favourable environmental conditions in the future and be capable of addressing the

		Change Adaptation Strategy for Leipzig)	effect of climate change (Stadt Leipzig, 2016).
Strategy	2018	Integriertes stadtentwicklungskonzept leipzig 2030 - [Integrated Urban Development Concept Leipzig 2030 (INSEK)]	This concept envisions systematic implementation of the sustainability goals of the city by 2030 (Stadt Leipzig, 2018).

Based on the policies examined, most of them are aligned with the global commitment to reduce emissions. They support the Paris Agreement and contribute to Agenda 2030 of sustainable development goals. Further, the UNCBD convention and biological diversity are also prominently featured in the policies. Similarly, the policies are contributing toward the EU vision of emission neutrality by 2050.

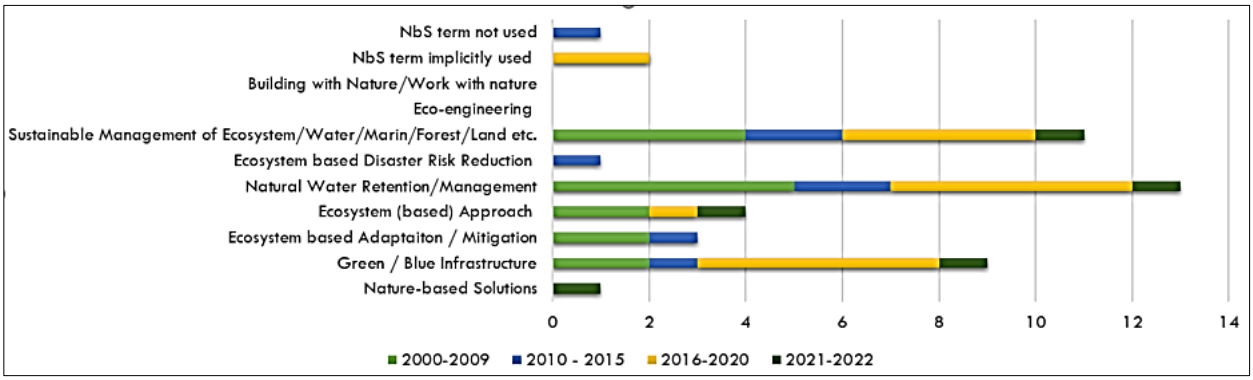
Regarding the documents' compositions, 25% (4 out of 16) were laws/directives with mandatory implementation, 69% (11 out of 16) were strategies and action plans, and only 1 out of 16 were national-level policies. From policy, strategy, and plans, 10 out of 12 had voluntary implementation (legally binding, encouraging action, and flexible), while two were statements or plans that were not legally binding. Figure 22 presents the detail of the composition and legal status of the policy documents.

Figure 22: The type and legal status of the German policy documents



However, moving to the content of these policies, I found that out of 16 policies, only one (6%), the draft national water strategy, developed in 2021, has directly used the term NbS. The Circular Economy Act hasn't mentioned any relevant terms explicitly or implicitly related to NbS. Two policies, the Federal Climate Change Act and City Vision Leipzig 2050, have only implicit indications of NbS. Compared with EU-level policies, such as the European Climate Change Law, the new EU Adaptation Action Plan, the EU Circular Economy Action Plan, and the EU Zero Pollution Action Plan, all the mentioned EU policies explicitly cited the term NbS itself. They also include practices associated explicitly with NbS, such as ecosystem-based approaches, green infrastructures, natural water retention techniques, and sustainable management techniques.

Figure 23: Use of NbS-related terms in the German policy documents



Based on the study of the German national and decentral (Leipzig) policies, as indicated in Figure 23, 81% (13 out of 16) policy documents noted "natural water retention/management" as explicit relation to the NbS concept. This is followed by "sustainable management" of ecosystems/water/energy/forest in 67% (11 out of 16) policies and "green/blue infrastructure" in 56% (9 out of 16) policy documents. However, other related terms have been noted less frequently. Compared with EU-level policies, the top NbS-related term in EU policies is "sustainable management" of ecosystem/water/energy/forest in 76% of documents, followed by "green or blue infrastructure" in 52% of policies, and the term NbS directly in 48% of EU policies. However, in German policy documents, the top priority is "natural water retention/management" at 81%. And it is also worth noting that the decentral policy of Leipzig is implicitly focused on the NbS concept.

Regarding the NbS role in addressing societal challenges, the German national and decentral policies have given 87.5% focus to climate resilience (adaptation and mitigation). The second most frequently cited role is health and well-being in 81% of policies. A summary of the NbS roles in the German NbS policies is shown in Figure 24. It also states that 75% (12 out of 16) of the policies focus on cities and the urban agenda. As part of said policies, NbS has also received considerable attention for its role in participatory planning, governance, and transformation (sustainable consumption and production). Figure 24 presents that there has been a significant shift in the role of NbS, where in policies till 2010, a considerable part was given to participatory planning and governance, while this trend has changed, and now the critical role is given to climate-related issues. The role of NBS in German policies is aligned with that of EU-level policies. However, it has also emerged that German policies give greater weight to place regeneration than EU policies.

Figure 24: The role of NbS in the German policy documents

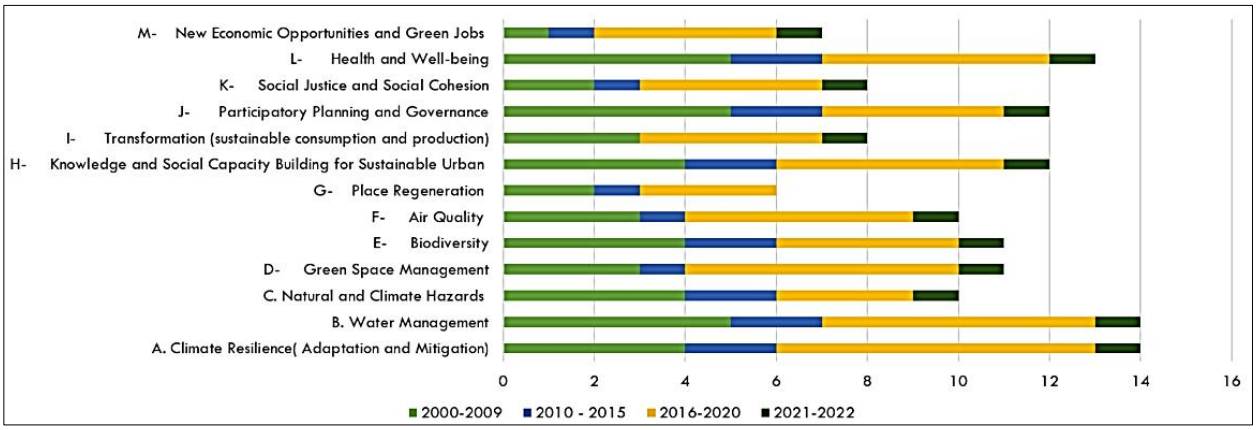


Table 14 illustrates the details of the role expected from each German policy in responding to societal challenges.

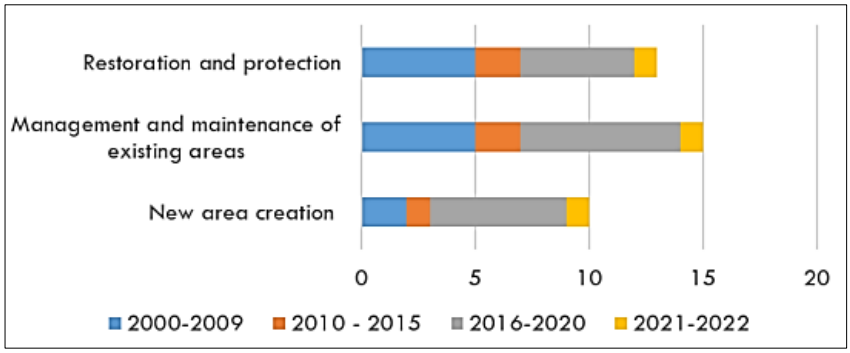
Table 14: The details of NbS role expected in each of the German policy documents

List of policy instruments	A. Climate Resilience(Adaptation and Mitigation)	B. Water Management	C. Natural and Climate Hazards	D- Green Space Management	E- Biodiversity	F- Air Quality	G- Place Regeneration	H- Knowledge and Social Capacity Building for Sustainable Urban	I- Transformation (sustainable consumption and production)	J- Participatory Planning and Governance	K- Social Justice and Social Cohesion	L- Health and Well-being	M- New Economic Opportunities and Green Jobs
Amended Version of the Federal Water Act		✓	✓						✓	✓		✓	
Concepts and Strategies for Spatial Development in Germany	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	
National Biodiversity Strategy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
German Strategy for Adaptation to Climate Change	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	
Act on Nature Conservation and Landscape Management	✓	✓		✓	✓	✓		✓		✓		✓	
Adaptation Action Plan of the German Strategy for Adaptation to Climate Change	✓	✓	✓		✓			✓		✓		✓	
Circular Economy Act													
Green in the city – for a future worth living in Green Paper Urban Green	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓

Climate Action Plan 2050 Principles and goals of the German government's climate policy	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Climate change Adaptation strategies for Leipzig	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
Federal Green Infrastructure Concept	✓	✓		✓		✓			✓		✓	✓	
White Paper: Green Spaces in the City - For a more liveable future	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	
Integrated Urban Development Concept Leipzig 2030 (INSEK)	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Federal Climate Change Act	✓	✓						✓					
City Vision Leipzig 2050	✓			✓					✓				✓
National Water Strategy Draft	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓

The German policy stipulates that management and maintenance of existing areas are the significant activities in NbS, followed by restoration and protection measures according to the IUCN (2016) classification. Figure 25 shows the details. It is the same as the focus on EU policies.

Figure 25: The NbS activities mix in the German policy documents



4.3. Absorption of NbS in Urban Societal Sectors

> ***"the NbS thinking is mostly on the policy side - by the municipality or environmental based organization of the city. For most actors, it is the economy that drives their decision; because NbS projects are costly. [Hence] The municipality is the main agency behind the project ... the people had a referendum for the green development ... the citizens voted"*** **(Interviewee 1).**

Based on interviews, municipalities were the leading agency that initiated all 4 cases at the city level. The NbS-interested units within municipalities consisted of the water, energy, climate, and nature conservation, to realize the city strategy and vision for climate change adaptation in line with their national strategies. Further, municipalities reported horizontal coordination with the infrastructure, housing, and spatial planning experts from municipalities or other agencies to contribute to NbS actions. The city-level decisions were mainly affected by the city council decisions,

e.g. adoption of strategies and political parties' influence concerning the environment and green economy. The Utrecht Bio-Washing Machine project decisions and implementation were also influenced by companies and businesses (NS and Rabobank). For the green roof and green wall initiatives (case 2 and case 3) in both cities, environmental NGOs also contributed to driving and spreading the idea and implementing the practices along with the municipalities (Interviewees 5, 8, 11).

Similarly, the interviewees stated that in the case of Lebendige Lupe, Leipzig University was the key partner for originating the project idea and working closely with Leipzig Municipality (Interviewee 12). This presents evidence that there is potential for further institutionalizing the NbS by partnering with corporations, environmental NGOs and universities. The EU's contribution to some of the projects, such as the Bio-Washing Machine, has acted as a sharing of experience and techniques for applying NbS practices (Interviewee 1). For instance, in the case of the Utrecht Bio-washing machine, the EU's role was to support the development of a technical M&E tool for the practice (Interviewee 1).

Regarding the sectors covered in the cases, besides climate adaptation in cities, all projects were intended to contribute to biodiversity, water management, and green spaces (Interviewees 5, 6, 7,10, 12, 13). Two of the cases (case 1 and case 2) in Utrecht were also focused on energy transition, and one case in Utrecht concentrated on the reduction of pollution as well (Interviewees 1, 2, 3, 4, 5).

All 4 case studies cited solid political commitment of the cities, and interviewees noted that the policies established at the national, state, and/or local levels mark political commitment. Interviewees also said municipalities are looking forward to moving toward climate-neutral and climate-adaptive cities by the year 2050 (Interviewees 6, 8). According to the interviewees, the municipalities of both cities did not commonly use the term NbS in their plans (Interviewees 7, 12). Nevertheless, many essential elements of NbS are included in their activities and policies, including green infrastructures, green master plans, building with nature, etc. (Interviewees 6, 7, 8, 10, 12).

"Everyone likes green, but who's gonna pay for it? The cost ultimately belongs to the citizen". The significant barriers to the sustainable building are that it takes more time and costs more money. Furthermore, people don't think about their roofs, and they don't realize their impact and how it (roofs) can contribute. The municipality of Utrecht offers a subsidy program for green roofs, in which up to 50% of the funds could come from the municipal budget. In contrast, the roofs require long-term maintenance costs that ultimately fall on the owner's shoulder (Interviewee 5).

Besides, the interviewee expressed that more is needed to be improved in terms of policy alignment, capacities, and finance for NbS practices (Interviewee 7). The gap between policy statements and practical implementation has been highlighted by those interviewed in case 2 and case 3 in both Utrecht and Leipzig (Interviewees 5, 6, 7, 8). Limitation of investment and less willingness of owners and individuals to contribute is also highlighted in cases 2 and 3 (Interviewees 5, 10, 11).

Interviewees rated the political commitment of municipalities as excellent in 3 cases, with scores above 76% (Interviewees 1, 3, 4, 5, 6, 7). One interviewee noted Leipzig's political commitment to range from low to acceptable (Interviewee 8). The reason was the lack of financial instruments for intensifying and accelerating green walls (Interviewee 8). According to the interviewee, subsidies were recognized as support for strengthening performance and a measure of political commitment (Interviewees 6, 8). Further, according to interviewees, the private sector's and citizens' limited engagement financially and technically is one of the critical challenges for

scaling NbS practices (Interviewees 1,4, 5, 8, 10). However, interviewees believed that capacity and awareness raising is needed to increase the potential for absorption of NbS at the scale and across sectors and citizens (Interviewees 2, 5, 6, 7, 8). A key opportunity is the existence of networks of academia and partners (Interviewee 5), and local planning for NbS is influenced by: national and European policies (Interviewee 9), subsidies and incentives (Interviewees 8, 11), funds provided by state and city organizations (Interviewee 13), and the EU's funding and incentives for NBS (Interviewee 12). However, the challenge remains in changing individual habits, statuesque and institutional processes toward NbS adaptation (interviewees 5, 8, 9).

> ***An interviewee of the green walls in Leipzig stated: "Attitudes matter. We stick to what we know and don't try anything new" (Interviewee 8).***

In Leipzig, in 2019, the city declared a climate emergency. As a result, it has pushed to improve the city's climate change policies and strategies and emphasized water storage, biodiversity, greenery, and restoration (Interviewee 11). Political commitment to the project has also been influenced by the project's value, size, and visibility (Interview 11, 12) and the way that political parties have influenced city policy, such as if the ruling party(ies) are more focusing on the green or are conservatives (Interviewee 12, 13).

In Utrecht, the projects had a multi-layer effect on water management, reduction of soil contamination, energy transition in case 1, and biodiversity and climate-friendly impact (case 2). In the case of Bio-Washing Machine, it is also argued that NbS should be institutionalized in business communities (Interviewee 1). The municipality could be moderating in pushing down NbS practices by enhancing private companies' direct participation in project financing (Interviewee 1). However, it deems that awareness-raising at the societal level for the beneficiaries could be fruitful for project buy-in within the private sector (Interviewees 1, 4, 5, 7). The collaborative approach to working with the research and development partners resulted in a novel concept design for the Bio-Washing Machine and its implementation (Interviewees 1, 4). At the same time, policy flexibility has been pronounced as room for creativity in the design (Interviewees 1, 2).

Decentral decision-making and horizontal collaboration have been realized as an institutional advantage for NbS practices (Interviewees 2, 3, 6, 7). Apart from the complexity of the decision-making, the involvement of multiple stakeholders at a horizontal communication level proved positive in terms of conceptual design and novelty (Interviewees 1, 4). However, some interviewees argued that partnerships are affected by poor information exchange (Interviewee 4). In the case of the Sustainable Roofs project in Utrecht (case 2) and Keletterfix Green Walls (case 3) in Leipzig, due to the small size and ease of design and implementation, the NGOs role in advisory, conceptualization, and execution has been more fully realized by municipalities and become more productive (Interviewees 5, 11). However, meso-level projects, such as the Bio-Washing Machine and the Lebendige Luppe project, were funded by state actors without direct participation from the private sector or businesses. NGOs effectively build citizens' capacity for the adoption and implementation of NbS (Interviewee 11).

Table 15 summarizes the frequency of pro(s) and con(s) per case for the absorption of NbS at the city level.

Table 15: The pro(s) and con(s) for absorption of NbS at municipal level

No	Pro(s)	evidence cases
1	**Municipalities' solid political commitment** was the key driver of NbS principles. Municipalities are the leading agency behind the NbS project. However, environmental NGOs and universities seem to be supportive and able to oversee stewardship. Various factors affect the agency for NbS within municipalities, e.g., city council decisions, political party influences, and central policies.	All cases
2	**None of the NbS projects is sector-specific.** All the cases were multi-sectoral with multiplier effects to address societal challenges. The selected cases addressed societal challenges through contributing to urban climate adaptation, water management, and biodiversity conservation while transforming energy production and use and reducing pollution.	All cases
3	**Multiple partners** were involved in each of the projects. In support of conceptual design and implementation with municipalities, the following type of entities has more collaborative roles. o NGOs o Universities, o Consulting companies/Institutes o Government actors / partners	 Case 2, 3, 4. Case 1, 4. Case 1, 4. Case 1, 4.
4	**Decentral decision-making and policies** at the city level and horizontal collaboration of actors have been realized as an advantage. However, more centrality of policies and vertical planning and reporting end to more bureaucracies that may hinder NbS absorption.	Case 1, 2.
5	**Subsidies are assumed to be strongly connected to adoption and political commitment.**	All cases
No	**Con(s)**	**Cases**
1	In general, there is a **perception that NbS activities are taking up more time and resources** (costing more money) and that private companies' and citizens' interests are not as comprehensive as expected.	Case 2, 3.
2	**Inadequacies in knowledge and capability related to emerging issues and the know-how of NbS for new challenges.** Slow adoption habits and limited capacity (e.g. human resources and experts) at the municipal level for advice on policies, conceptualization, and implementation are obstacles to NBS absorption. **An NbS practice is not a ready-made design** but must be tailored based on the context and requires contextual knowledge and continuous improvement of practices by using multidisciplinary thinking	Case 2, 3. All cases
3	**Poor communication and coordination** among actors involved in the design process	Case 1.3.
4	**Policies are needed to incentivize and influence volunteer agencies and owners to adopt sustainable infrastructures** (e.g. green roofs, green facades, water harvesting etc.) and to adopt green solutions in their design. Also, municipalities need to negotiate with and mobilize owners and businesses to participate in NbS initiatives.	Case 2,3.

4.4. Factors of Success and Failure for Adopting NbS

This section summarized the key outcomes from the interviews conducted in both cities and the four cases. Initially, compared the cases within the cities, such as the Bio-washing machine project with the sustainable roof project conducted in Utrecht city and the Kletterfix Green wall with Lebendige Luppe floodplain restoration studied in Leipzig. Based on the conceptual framework defined in section 3.4, the factors have been mainly categorized into three areas or dimensions: knowledge and information, governance, and economics.

The factors under each category are divided into multiple bullet points in the tables (see Appendix 7: Success and Failure Factors of NbS in Utrecht and Appendix 8: Success and Failure Factors of NbS in Leipzig). Consequently, after a content analysis of bullet points, based on the critical message of bullet points, the contents were condensed into a maximum of four words (factors). Each bullet point should provide one message. However, some bullet points had two key messages. In order to determine the most prominent factors for the success and failure of NBS interventions, a summary of factors with their frequency of repetition based on the bullet points was calculated.

4.4.1. The Cases of Utrecht City

According to the explanation above, the success and failure factors have been compared in three main areas or dimensions: knowledge and information, governance, and economics, for each city.

1) The result of the knowledge and information dimension-related factors of the Utrecht cases in Table 23 (Appendix 7) revealed that the common factors of success in both cases were:

a) It is critical for the agency (municipality) to establish an open information-sharing system from the beginning/conceptualization phase. For example, the municipality's investment in establishing an open information sharing point for sustainable roof projects is valuable in exchanging information. However, in terms of the Bio-washing machine, the sharing of information and coordination among actors posed challenges at the beginning of the project. Hence, there was no precise knowledge-sharing mechanism, so all the partners were on the same page. However, the issue has been detected and resolved.
b) With an integrated or MLG approach, there is the possibility of better sharing of knowledge across themes (disciplines), leading to coproduction. For example, multiple approaches to bio-remediation and heat energy extraction are explored and applied in the case of the bio washing machine, providing a novel perspective to design. There was also the suggestion that green and solar roofs could be integrated on different roof sides.

And to compare failures, the common factor between both cases was:

a) Organization systems, processes, and individual perceptions were challenging and affected information-sharing. Silo thinking rather than integrated focus was an example that led to poor information sharing.

A detailed overview of the success and failure factors in terms of knowledge and information in Utrecht is presented in Table 23 (Appendix 7).

2) In terms of governance, according to this study, as elaborated in Table 24 (Appendix 7), the common success factors were:

a) The projects' goals were aligned with the policies. The existence of a clear policy and the flexibility of policy is viewed as an opportunity for smooth decisions in response to the challenges at the municipal level, and it is further emphasized that policy flexibility was contributing toward innovation, and this also supported the appropriate risk-taking for a novel concept for NbS implementation.
b) Decentralized decision-making processes at the city level lead to less bureaucracy, smooth decisions, and minimal vertical communication, which reduces time use.

However, the failure factors for governance that were common in both cases were:

a) The direct engagement of citizens (e.g., the private sector and businesses) was relatively weak in the sustainable roofs project, while it was absent in the Bio-washing Machine project, which leads to poor contribution of citizens to the NbS projects.
b) Poor awareness of citizen and actors, and across sectors (public and private) hinders information sharing.

Table 24 in the (Appendix 7) provides a detailed analysis of Utrecht's governance success and failure factors.

3) In terms of economics, according to this study, as elaborated in Table 25 (Appendix 7), the common success factors were:

a) Both cases had substantial contributions/subsidies from the municipality for initiation, design, advisory, and implementation; however, citizens also made contributions to the sustainable roofs project to a certain degree (max. 50%).
b) Both projects encourage open sharing of information and transparency that promotes trust and sustainability.

However, the failure factor was mainly:

a) Citizen, business, and building contributions were limited, which left the NbS activities at the city level mainly dependent on municipal funding.

Table 25 in the (Appendix 7) provides a detailed analysis of Utrecht's economics success and failure factors.

To summarize, after conducting a content analysis of all the factors, and condensing each factor into a maximum of four words, the overall summary of factors with their frequency of replication has been presented in Table 16 in order to determine the most prominent factors for the success and failure of NBS interventions.

Table 16: Summary of success and failure factors in NbS absorption in Utrecht

No	Success factors	FRQ	Factors of failures	FRQ
1	Municipal finance and subsidies	5	Poor (late) engagement of actors or citizens	6
2	Clear information sharing mechanism	3	Less citizens' awareness	4
3	Multiple sectors/partners collaboration	3	Lack of policy or clarity in policies	3
4	Municipal plans alignment to policies	3	Poor information sharing	3
5	Novelty of concept	3	Insufficient research / less knowledge availability	2
6	Policies flexibilities	3	Silo thinking orientation	2
7	Citizen's engagement	2	Absence of innovations	1
8	Decentralized decision-making	2	Complexity of design	1
9	Private sector investment	2	Differences of perceptual filter	1
10	National plan existence	2	Gap between policies and city needs	1
11	Transparency / public availability of Info	2	Higher cost of NbS	1
12	Clear governance structure	1	Immature market of technology	1
13	Cooperation	1	Lack of urgency for information	1
14	Human capacity	1	Less collaboration and sharing info	1
15	Learning and co-practices	1	Limited citizens' trust	1
16	Monitoring system	1	Limited human resource	1
17	Multidisciplinary team	1	Limited municipal finance and subsidies	1
18	Practical example of NbS for demo	1	Poor coordination	1
19	Reduced operation / maintenance cost	1	Risky operational procedures	1
20	Shortened bureaucratic processes	1	Separated (fragmented) communication with actors	1
21	Strengthened coordination set-up	1		
22	Synergy between policies and actors	1		
23	Robust communication mechanism	1		
24	Technology availability	1		

In accordance with the frequency of repetition of factors weighted in Table 16, the top factors contributing to the successful absorption of NbS practices at the municipal level are municipal subsidies, a precise information sharing mechanism, partners' collaboration for sharing information and coordination, alignment of city plans with policies, the novelty of NbS concepts for addressing social challenges, the flexibility of policies, strengthened citizen engagement, and decentralized decision-making. Further, the investment of the private sector and citizens seems critical to NbS absorption at the municipal level, which requires strengthened policies and a national plan, and therefore, open sharing of information and transparency is needed.

Similarly, the top factors contributing to the failure of NbS absorption at the Utrecht municipal level were poor (late) engagement of actors or citizens in the initial, design and implementation, a lack of citizens' awareness of NbS's social, economic, and ecological benefits, a lack of policies or clarity in policies regarding NbS proofing and prioritizing natural solutions, and poor information sharing among actors. Furthermore, the lack of adequate research, a lack of context-based knowledge, and silo-based thinking among actors contribute to NbS' failure to absorb.

The Figure 26 and Figure 27 in below presents a detail of the top success and failure factors for adaption of the NbS practices in Utrecht.

Figure 26: Success factors in NbS absorption in Utrecht

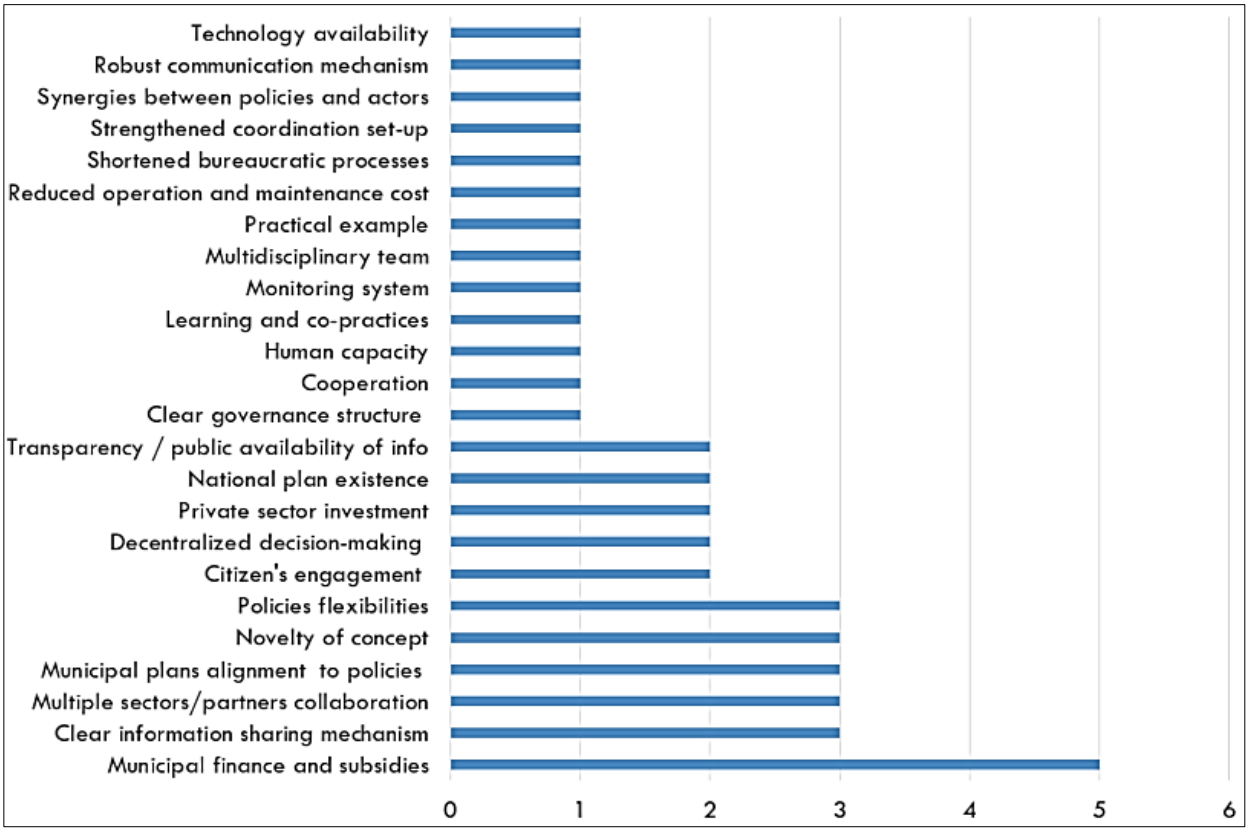
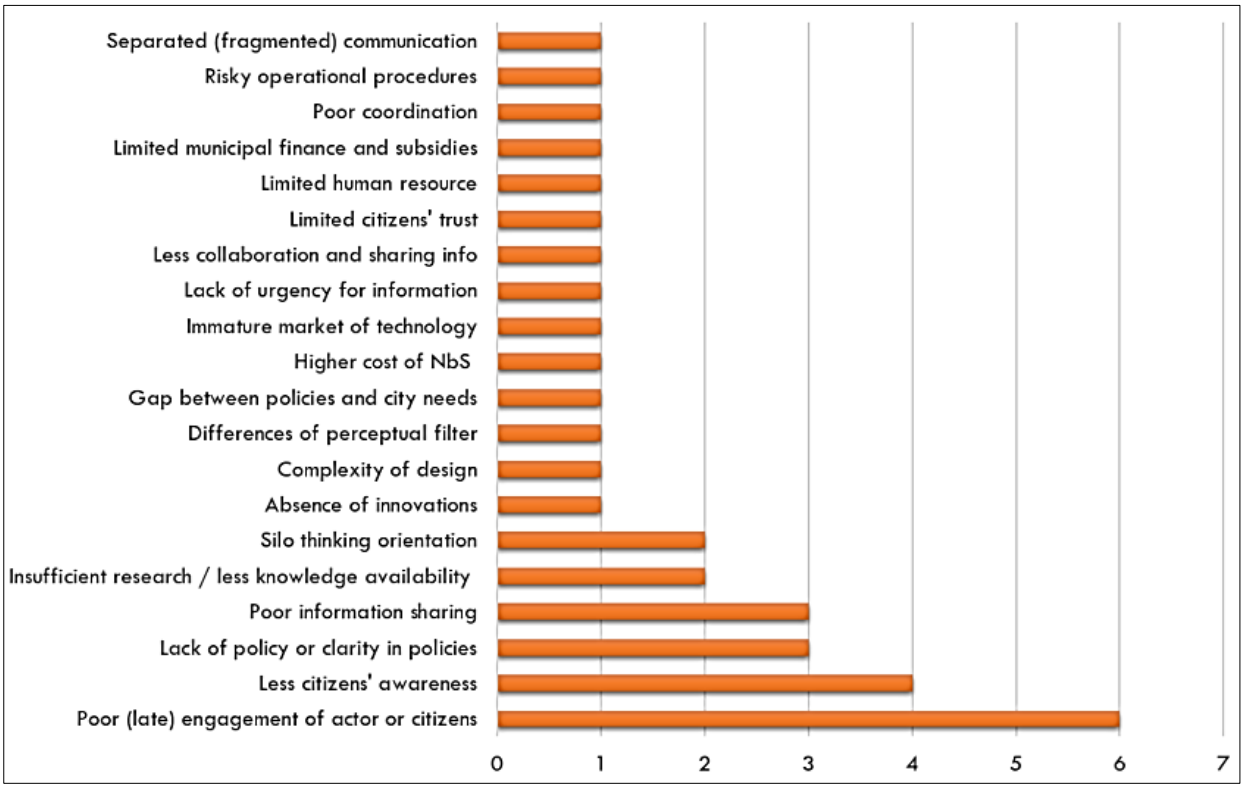


Figure 27: Failure factors in NbS absorption in Utrecht



4.4.2. The Case of Leipzig City

As in the case of Utrecht City, in this section, I have summarized the main content of the interviews from both cases of the Kletterfix Green Wall with Lebendige Luppe project, based on the themes and content of their interviews. The factors of success and failure were categorized into three areas: knowledge and information, governance, and economics. In addition, I have compared both cases to explore the common areas of success and failure.

1) The findings of the knowledge and information dimension of the Leipzig case in Table 26 (Appendix 8) express that the common factors of success in both projects were the existence of a multilevel and cross-sector collaboration between actors that contributed to improved access to science and leads to innovation. In addition, presenting models of successful practice or good examples has been recognized as having high importance for building trust and absorbing practices. While the results show that the common factor of failure in both cases was the information gap happening due to individual lenses, and perceptions resulting in variation in information sharing between agencies.

2) With regard to the governance dimension, in the same vein, in Table 27 (Appendix 8), I have summarized the success and failure factors of both cases. According to the interviews the common success points in both cases were the existence of collaboration between multilevel actors, availability of policy umbrella that support NbS practices and the alignment of the projects with the related policies at the city level.

However, the failure in governance has multiple common factors in both cases that are consisting of:

a) Citizens' direct involvement is limited or does not exist.
b) Administrative and hierarchical bureaucracy has been pointed out as a barrier to smooth collaboration and coordination regarding NbS. Some institutions' structures are less flexible for NbS, e.g. the Saxony State agency for reservoirs and rivers is an example provided by the expert.
c) Limitation of a precise coordination mechanism with some of the actors was noted.

3) As for economics, according to the study, the common success factor between cases was the relatively significant investment role of the government or municipality in the NbS project. This is because there has been limited private investment in NbS, and promotion of the open sharing of information as a tool for transparency. The details of the success and failure are included in Table 28 (Appendix 8).

To summarize the Leipzig NbS projects success and failure factors, after conducting a content analysis of all the factors, and condensing each factor into a maximum of four words, and counting of the frequency of the similar nature or similar idea factors, has presented in Table 17 in order to determine the most prominent factors for the success and failure of NBS interventions.

Table 17: Summary of success and failure factors in NbS absorption in Leipzig

No	Success factors	FRQ	Failure factors	FRQ
1	Citizen's engagement/trust	6	Bureaucracy (administrative) hinders information sharing	5
2	Multiple sectors/partners collaboration	5	Less citizens' awareness (cost/benefits)	3
3	Clear information sharing/mechanism	3	Limited citizens' trust/adoption	3
4	NGO collaboration/advisory service to citizens'	3	Limited municipal finance and subsidies	3
5	Private sector engagement/investment /intrinsic motive	3	Citizens not directly engaged	2
6	Municipal plans alignment to policies (existence of policies)	2	Conservative and centralized approach (to NbS)	2
7	Novelty of concept/innovation	2	Differences of perceptual filter (hinder info sharing)	2
8	Policies flexibilities	2	Less collaboration and sharing info	2
9	Practical example (demo site)	2	Poor information sharing / mechanism	2
10	Strengthened coordination / set-up	2	Absence of innovations (context based)	1
11	Citizen's financing	1	Complexity of governance s	1
12	Community of practices for capacity building	1	Higher cost of NbS	1
13	Consolidates Information National Wide	1	Lack of monitoring mechanism	1

14	Consultative planning phase (enriched discussion)	1	Limitation of research on citizen Science	1
15	Contribution to researches	1	Limited private sector investment	1
16	Easy access to science	1	Poor (late) engagement of actors or citizens	1
17	Informed operation team	1	Poor coordination	1
18	Long duration of project (less difference in actors idea more closer)	1	Silo thinking orientation (sectoral, thematic)	1
19	Monitoring system	1		
20	Partners finance	1		
21	Robust/easy communication mechanism	1		
22	Standardized process of installation	1		
23	State finance	1		
24	Technology availability	1		
25	Transparency / public availability of information	1		

Following the frequency of repeating factors weighted in Table 17, the top factors contributing to the successful absorption of NbS practices at the Leipzig municipal level are citizens' engagement and trust in NbS interventions, the establishment and effective use of a clear information sharing mechanism, the provision of advisory services to citizens, the private sector's engagement and leveraging of their intrinsic motives for investment, and policies and flexibility of policies. In addition, the novelty of the NbS concept and the presentation of appropriate examples are of high importance. Additionally, it has been found that having strong coordination is one of the keys to success.

According to the study, the top failure factors were the existence of bureaucracy within administrative systems, a lack of awareness among citizens about the cost and benefits of NbS, and limitations in municipal financing and subsidies. Further, lack of citizen engagement and the existence of a conservative approach in some organizations were also cited as challenges in the study. Additionally, differences in perception can impede the exchange of information; however, stronger sharing mechanisms are needed. Similarly, lack of innovation is among the key factors of failure for NbS.

Figure 28 and Figure 29 below present a detail of the top success and failure factors for the adaption of the NbS practices in Leipzig.

Figure 28: Success factors in NbS absorption in Leipzig

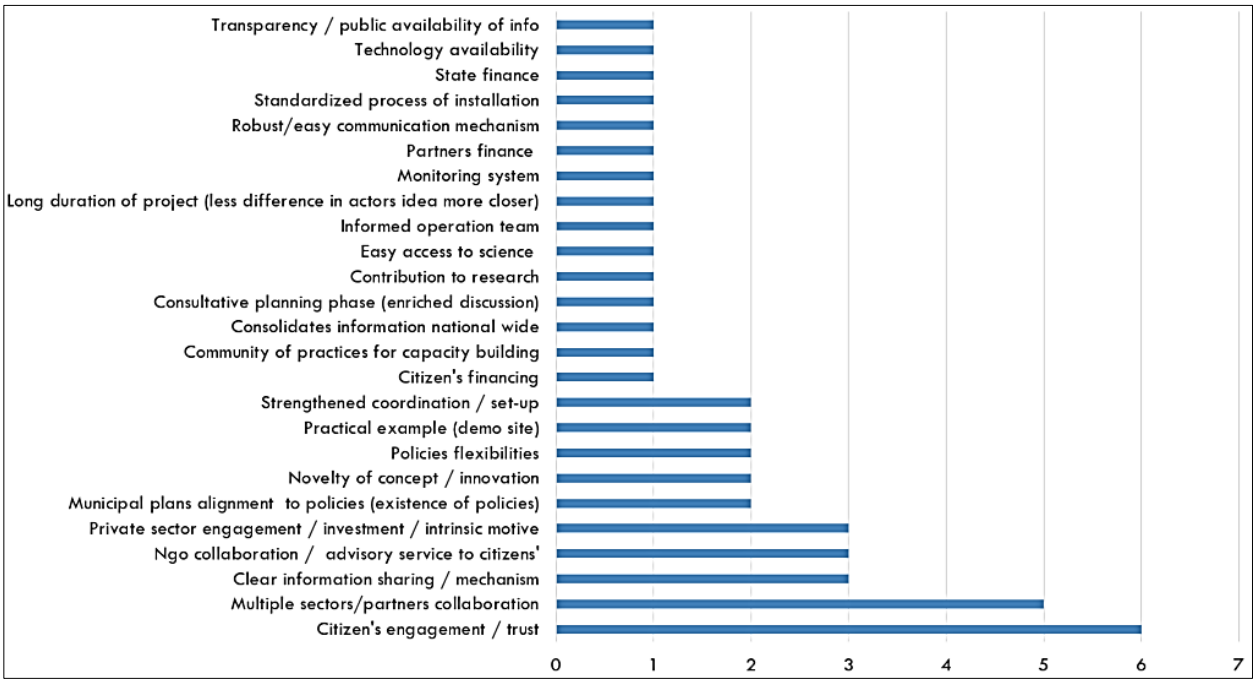
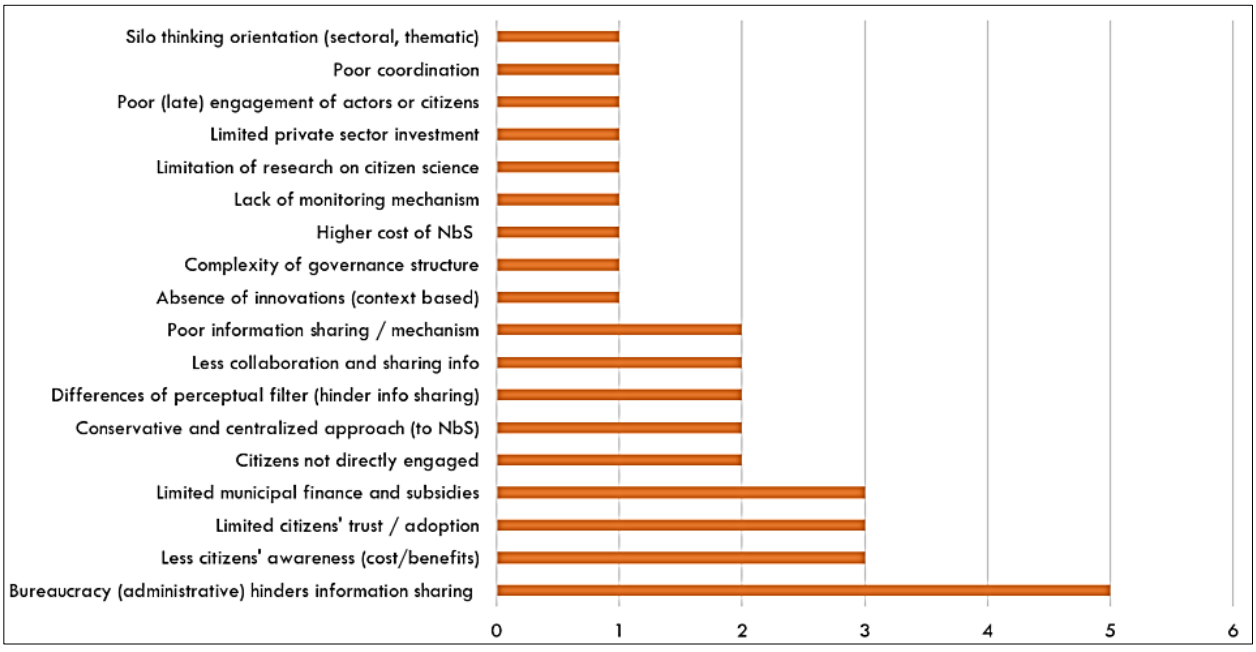


Figure 29: Failure factors in NbS absorption in Leipzig



In summary, for both cities, the three most critical factors for the adoption of NbS are that citizens are fully engaged (physically and financially) in the NbS intervention, enhanced collaboration of the actors across levels and sectors, and the existence of a precise mechanism for information dissemination that supports the actors are well informed. Additionally, the availability of municipal subsidies and financial support for implementing the NbS, clear policies and plans to emphasize NbS practices, the novelty and value of the NbS concept, flexibility of the policies, and

encouraging private sector engagement and investment are among the second-ranking factors, which have been recognized as crucial at the municipal level. In the third rank, the mechanism to assure transparency of information and strengthened coordination set-up; and the collaboration of non-governmental actors such as NGOs to expand the NbS has been ranked. Figure 30 presents a list of factors considered for the successful absorption of NbS.

While the primary factor of failure for NbS absorption at the city level, according to this study, was consisting less awareness of citizens regarding the cost and benefits of the NbS; and poor engagement of actors and citizens. In the second rank are bureaucracy, poor communication of information, and a lack of information sharing mechanism. Third, insufficient or limited subsidies and low citizen trust hinder the adoption of NbS at the city level. Figure 31 presents a complete list of factors contributing to NBS absorption's failure.

Figure 30: Success factors for absorption of NBS at the city level

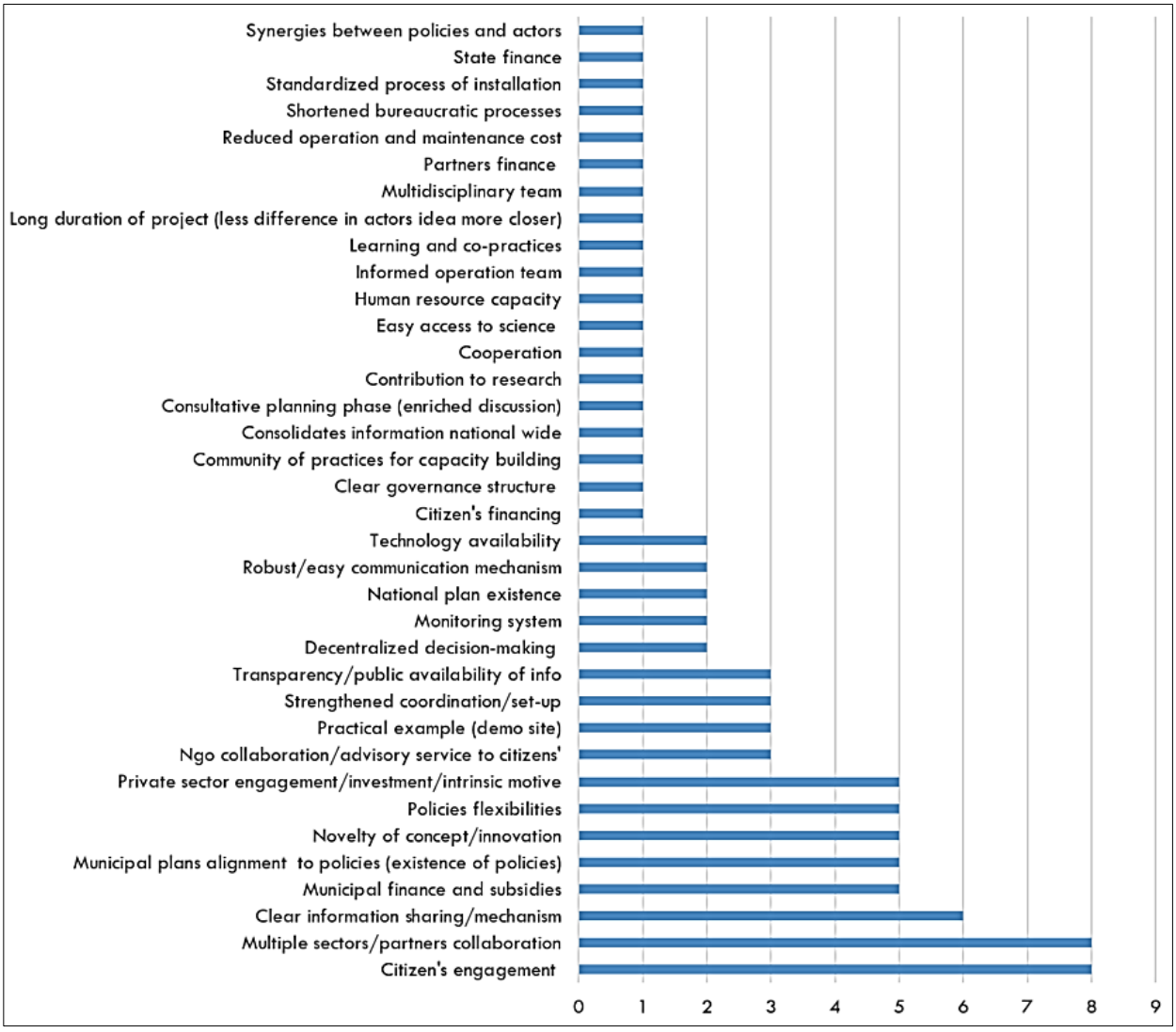
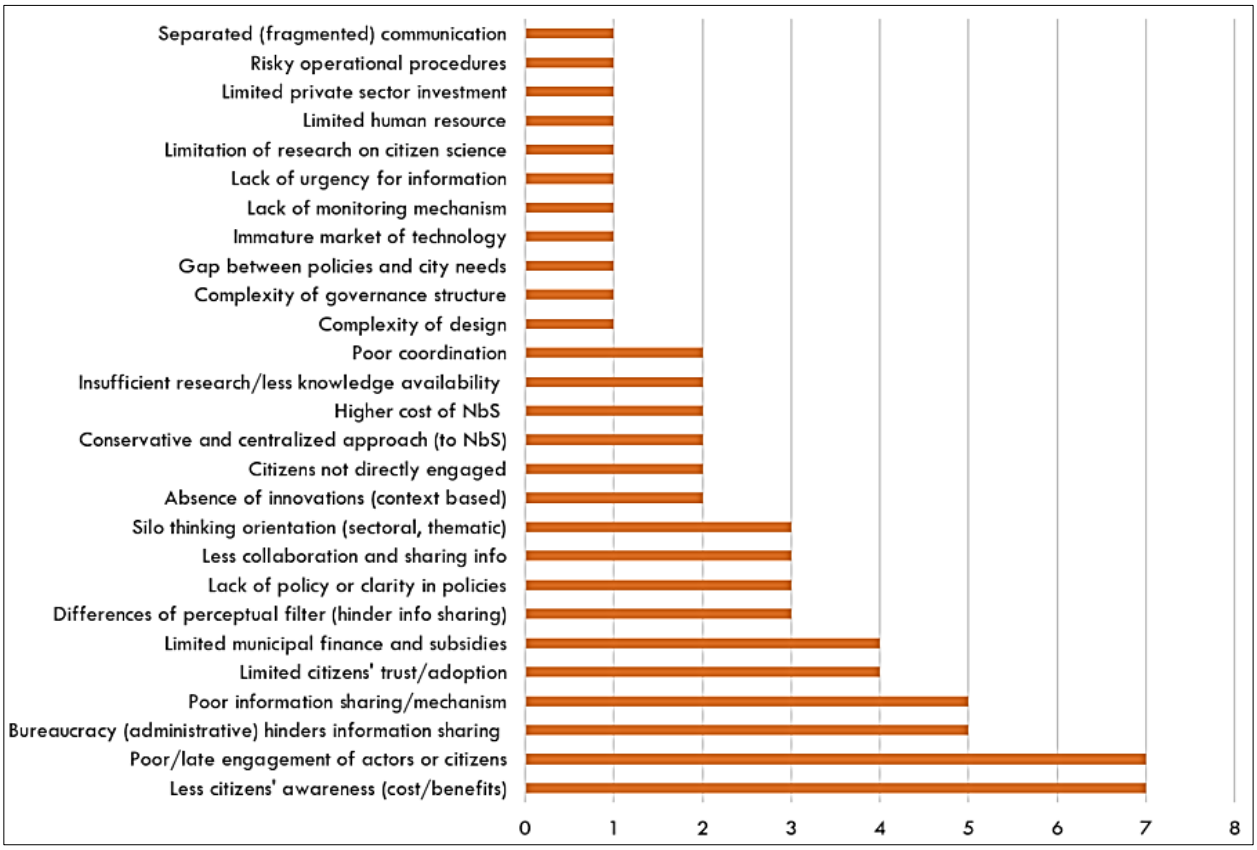


Figure 31: Failure factors for absorption of NBS at the city level



4.5. Pathways for Reinforcing the Implementation of NbS

Pathways have been developed based on the key findings of the research for strengthening the implementation of NbS. According to the conceptual framework, the pathways fall into four categories: policy and institutional, knowledge and information, governance, and economics.

4.5.1. Policy and Institutional Pathway

Global policies heavily influence policy development in the EU. NbS is rooted in several key EU policies. A review of 21 EU policies in this paper found that 86% explicitly used NbS approaches, while 9% implicitly used NbS. The EU Green Deal 2019 as an umbrella roadmap represents one of the key documents at the EU level that specifically mentions NbS and influences multiple legislations, policies, roadmaps, and strategies for absorbing the NbS concept.

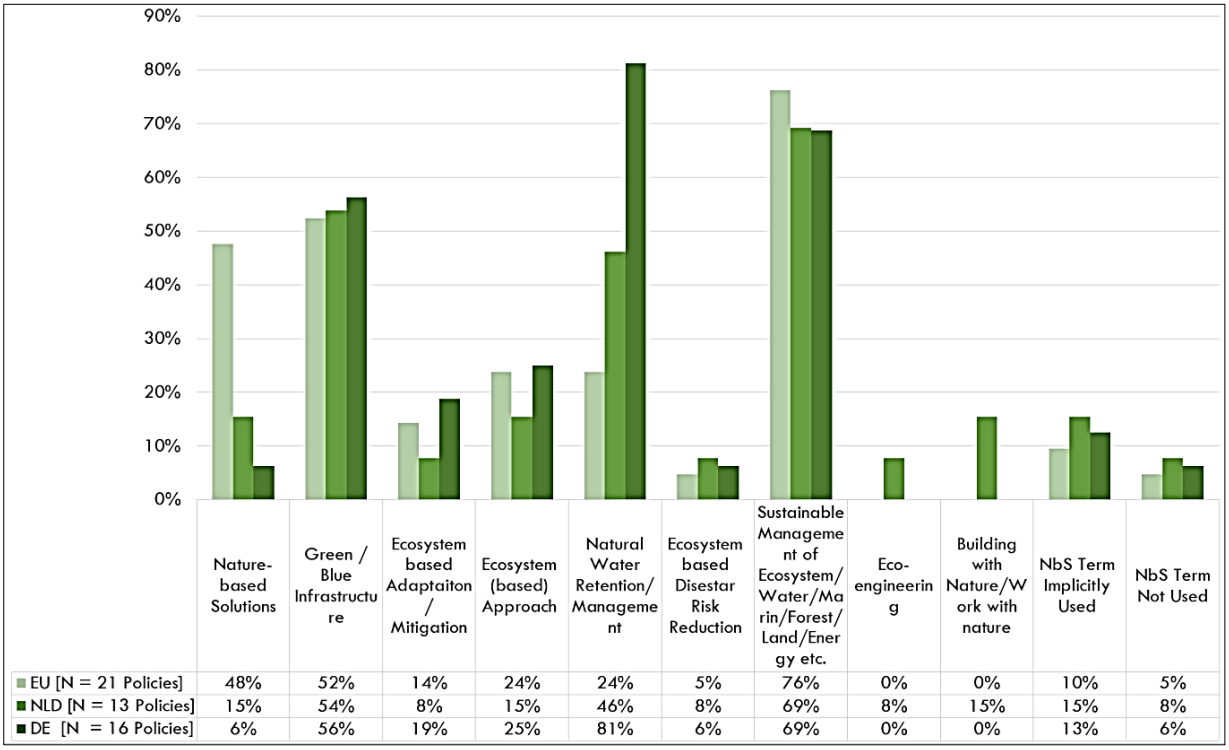
In accordance with the Treaty of Functioning of the EU, the EU climate law recognizes climate as a transboundary issue. This law emphasizes that the EU will be emission-neutral by 2050. EU Climate Law 2021 is one of the pillars of EU law based on the Paris Agreement to limit global temperature increases to 1.5 degrees. It has explicitly referred to the concept of NbS for the benefit of climate change mitigation, adaptation, and biodiversity protection.

Regarding the policies of the Netherlands, the Climate Law of the Netherlands emphasized the issue of energy and GHG emission reductions, with no explicit or implicit focus on NBS-relevant approaches. Similarly, the Netherlands' National Climate Adaptation Strategy – 2016 and Environment and Planning Act have only some indirect references to NbS-related concepts. In the study, it was found that the NbS term was used directly in 15% of policies (only in 2 of 13 Dutch policies) during the last few years, and among the significant NbS-related terms used in the Netherlands policies are "sustainable management of the ecosystem, energy, or water, etc." in 69% (9 out of 13), followed by "green/blue infrastructure" in 53% (7 out of 13 cases), and "natural water retention/management" in 46% (6 out of 13).

In the case of Germany, The Circular Economy Act (2012) hasn't mentioned any direct or indirect reference relevant to the terms of NbS. The Federal Climate Change Act and City Vision Leipzig 2050 have only implicit indications of NbS. Moving on to the content of the policies reviewed, it was found that out of 16 policies only one policy (6 percent) which is the draft national water strategy, developed in 2021, has directly used the term NbS. The majority of 81% (13 out of 16) of policy documents noted “natural water retention/management” as explicit relation to the NbS concept. This is followed by "sustainable management" of ecosystems/water/energy/forest in 67% (11 out of 16) policies, and “green/blue infrastructure” in 56% (9 out of 16) policy documents.

Compared EU-level policies, such as the European Climate Change Law, the new EU Adaptation Action Plan, the EU Circular Economy Action Plan, and the EU Zero Pollution Action Plan all explicitly mention the term NbS itself. As a result, 48% of EU policies directly use the NbS term, 19 out of 21 EU policies have multiple explicit NbS practices, 2 out of 21 EU policies have an implicit focus on NbS, and only one policy (4.7%) does not mention NbS.

Figure 32: A comparative review of the use of NbS-related terms in the EU, Dutch and German policy documents



	Nature-based Solutions	Green / Blue Infrastructure	Ecosystem based Adaptaiton / Mitigation	Ecosystem (based) Approach	Natural Water Retention/ Management	Ecosystem based Disestar Risk Reduction	Sustainable Management of Ecosystem/ Water/Marin/Forest/ Land/Energy etc.	Eco-engineering	Building with Nature/Work with nature	NbS Term Implicitly Used	NbS Term Not Used
EU [N = 21 Policies]	48%	52%	14%	24%	24%	5%	76%	0%	0%	10%	5%
NLD [N = 13 Policies]	15%	54%	8%	15%	46%	8%	69%	8%	15%	15%	8%
DE [N = 16 Policies]	6%	56%	19%	25%	81%	6%	69%	0%	0%	13%	6%

Consequently, there is a need for further integration of the NbS approach into the national and decentral policy documents. According to the Study, the existence of the relevant policies or NbS proofing of policies for the design, initiation, and implementation of NbS practices is supporting political comment and improving governance over NbS practices and would give actors the flexibility they need to inspire nature and contribute to renaturing cities.

4.5.2. Knowledge and Information Pathway

Based on the review of the four cases, it is critical for the municipality to establish an open information sharing system from the beginning/conceptualization phase. Such a system supports the operationalization of an MLG that minimizes silo thinking, enables better knowledge sharing across themes and agencies, and results in co-production and innovation. However, sharing information was challenging and affected by organizational systems, processes, and individual perceptions. Wiseman et al. (2012) also asserted that networks shape the identities and form of institutions, which occurs at multiple levels and boundaries of analysis of a firm or industry. Organizational performance benefits from the networks for mobilizing access to resources and information. The density of social networking plays a critical role in reducing or increasing information asymmetry as well as pressure on agents and principals to limit their opportunistic behaviours (Wiseman et al., 2012). Therefore, a network with a meaningful mechanism of sharing information with the actors and citizens will enhance the intake and contribution of actors in NbS.

A list of key success and failure factors in this study are presented in Table 18 in order to contribute to strengthening knowledge pathways for absorbing NBS in cities.

Table 18: Key factors to consider in the knowledge and information pathway

Success factors	**FRQ**	**Failure factors**	**FRQ**
Clear Information sharing / mechanism	6	Less citizens' awareness (cost/benefits)	7
Novelty of concept / innovation	5	Poor information sharing / mechanism	5
Practical example (demo site)	3	Differences of perceptual filter (hinder info sharing)	3
Transparency / public availability of info	3	Absence of innovations (context based)	2
Existing of a clear monitoring system	2	Insufficient research / less knowledge Availability	2
Robust/easy communication mechanism	2		

4.5.3. Governance Pathway

Power relations present our ability to shape our world and the types of relationships in the governance structure (Wiseman et al., 2012). Firms and agents may be forced to act under the interests of the stakeholder who has the power to impose it (Wiseman et al., 2012). Based on the four cases, the results indicate that collaboration and engagement of actors across sectors and levels are the fundamental success factors. This would be determined by aligning the project's goals with the policies. At the municipal level, the flexibility of policy allows plans, designs, and decisions to be conceptualized smoothly. It was equally evident that policy flexibility was contributing to innovation. Flexibility in policies can also be viewed in terms of acceptance of risk, and openness toward nature-friendly practices is considered viable support for NbS-related decisions at the city

level. However, the critical failure factors for governance were poor engagement of actors and citizens (e.g., the private sector and businesses), low awareness and trust of citizens, and lack of policies and connection between the short and long-term policies. While Kabisch et al. (2016) stress that the key barriers related to NbS in urban areas are fear of unknowns, disconnection between short-term objectives and long-term goals, disconnectedness between short- and long-term actions, and paradigm of growth and sectoral silos.

Based on the findings of the four cases, it was determined that policies establishment and promotion of adoptive governance for NbS can consider Table 19 key governance factors of success and failure.

Table 19: Key factors to consider in the governance pathway

Success factors	**FRQ**	**Failure factors**	**FRQ**
Multiple sectors/partners collaboration	8	Poor /late engagement of actors or citizens	7
Increased citizen's engagement	8	Bureaucracy (administrative) hinders information sharing	5
Policies flexibilities	5	Limited citizens' trust / adoption	4
Municipal plans alignment to policies and existence of policies	5	Lack of policy or clarity in policies	3
NGO collaboration / advisory	3	Less collaboration and sharing info	3
Strengthened coordination / set-up	3	Silo thinking orientation (sectoral, thematic)	3
Technology availability	2	Poor coordination	2
Decentralized decision-making	2	Citizens not directly engaged	2
Existence national/city plan	2	Conservative and centralized approach of institutions toward (to NbS)	2

4.5.4. Economics Pathway

The common success factor between cases was the relatively significant investment role of the government or municipality in the NbS projects. Because there has been limited private investment in NbS. However, the failure factor was the limited contributions of citizens, builders, or businesses in financing rather than the municipality. Wamsler et al. (2020) argue that the main strategies to overcome this barrier involve the private sector and academic institutions to learn and share knowledge. Moreover, they emphasize that strategic citizen involvement is needed to increase awareness. This would also increase the potential for investment in the private sector.

Table 20 summarizes the key factors of success and failure of the four cases in terms of economics to be considered for promoting economic pathways for strengthening NbS implementation.

Table 20: Key factors to consider in the economic pathway

Success factors	**FRQ**	**Failure factors**	**FRQ**
Municipal finance and subsidies	5	Limited municipal finance and subsidies	4
Private sector engagement / investment / intrinsic motive	5	Higher cost of NbS	2

In summary, four pathways have been suggested in this thesis: policy and institutional, knowledge and information, governance and economics. It is suggested that policies be NbS-proofed by aligning actions, practices, and implementation at multiple levels. This thesis illustrated the importance of the information sharing mechanism among actors; and further emphasis on raising citizens' awareness, as well as the novelty or innovation of the NBS concept. Multi-sectoral and multilevel governance requires collaboration between sectors and actors, assured citizen engagement, alignment of plans to policies and long-term goals, and flexible policies. The role of subsidies, private sector finance, and engagement in strengthening NbS implementation at the city level is crucial in the economic pathway.

CHAPTER 5: CONCLUSIONS AND DISCUSSION

The purpose of this chapter is to provide concise answers to the research questions based on the findings of this thesis. This chapter also aims to reflect on this research method, its limitations, and future research directions. Answers will be provided sequentially to the sub-questions on each main question and then concluding with the main research question's answer.

5.1. NbS Entry into the EU Policy Agenda

To answer the sub-question "1.1. How did the concept of NbS get agency within the EU?" Based on a historical analysis of 21 EU-level policies, it appears that NbS was initially derived from the EIA Directive (1985), the first legally bounded and mandatory policy document at the EU level that implicitly referred to NbS through screening the impact of projects and interventions on natural and semi-natural areas. Accordingly, for taking care of protected areas and water bodies, the Habitat Directive (1992) was the second policy document in the EU that implicitly stressed over application of the NbS. The WFD (2000) was the first policy document that explicitly addressed NbS at the EU level. Global policies influence EU policies, and NbS has its roots in several global conventions and policies, including UNFCCC, UNCBD, Habitat III, and SFDRR (2015-2030). Adaptation to climate change and disaster risk reduction have been explicitly addressed via NbS concepts, while the SDGs, UNCCD, and Ramsar conventions implicitly utilize NbS terms.

Furthermore, the Paris Agreement 2015 played a significant role in developing trans-national and national strategies related to the limitation of global warming and climate change resilience (adaptation and mitigation) which influenced EU-level and member states' policies for adaptation of the NbS practices as moderators for adaptation to climate change. Hence, NbS has infected multiple societal sectors' policies of the EU, and this research has categorized it under four areas: environment and climate; agriculture, water and soil; habitat, biodiversity and forest; and growth and regional development. From the review of 21 EU policies across the societal sectors, there was 86% indication for the explicit use of NbS, 9% of the policies have used NbS approaches implicitly, and only 5% did not use the NbS concept.

In addition, the EU Green Deal (2019) established a roadmap for EU-level policies with a high focus on NbS and its related concepts, influencing several EU legislations, policies, roadmaps, and strategies. As part of the EU agenda for emissions neutrality and climate adaptation by 2050, the New EU climate law of 2021 also emphasized NBS. In line with the EU policies; therefore, 77% of Dutch policies have explicitly adopted NbS, and 15% have implicitly absorbed NbS. Accordingly, 81% of German policies explicitly absorbed NbS. It is worth mentioning that the term NbS directly has been used in the EU policies after 2015, while in the Dutch and German national and decentral policies, the NbS term was used more commonly in the policies after 2020.

To answer the sub-question "*1.2.* What role of NbS is envisioned in multilevel decision-making (governance) across Europe?" According to the European Commission, the major societal challenge for Europe has been identified in 12 categories based on the SDGs. From 1985 to 2000, NbS played a significant role in EU policies for water management and health and well-being, followed by addressing natural climate hazards and biodiversity. From 2001 to 2015, NbS was visible in policies for climate resilience, social justice/social cohesion, along with the previous

trending roles. Since 2016, NbS role has significantly increased in enhancing climate resilience as a top priority, and new economic opportunities and green jobs are followed as the second priority. To sum up, overall, the top roles envisioned for NbS in the EU policies are in water management in 17 out of 21 policies, followed by biodiversity conservation in 16 out of 21 policies, and climate resilience (adaptation and mitigation) in 15 out of 21 policies, health and well-being in 15 out of 21 policies, and new economic opportunities and green job in 14 out of 21 policies.

The role envisioned in the Dutch policies is: water management 92% (12 out of 13 policies), with equal significance for health and well-being, and 84% (11 out of 13 policies) for climate resilience (adaptation and mitigation). Looking to the Climate Adaptation in Dutch Delta (2011), the National Water Plan (2015) and the Vision for Climate Adaptation Utrecht for 2050 (2021), and Investing in Utrecht (2022-2016) have a stronger focus on water issues as well. While in Germany, the role of climate resilience (adaptation and mitigation) and water management has received the equally most attention (87.5%) in 14 of 16 policies, the second most frequently cited role is health and well-being in 81% of policies. Compared with EU-level policies, it appears that there is greater coherence in the expectations of roles between EU, Dutch and German policies since water management is among the top priorities, and climate resilience is among the second highest. However, the results of this thesis present a difference in area of the role envisioned for NbS to address the societal challenges, compared to a study conducted by Davis et al. (2018) supported by the NATURVATION. Davis et al. (2018) reviewed 23 EU-level policy documents which 7 out of 23 was EU funding programs/mechanism documents. According to Davis et al. (2018), the central role of NbS for was specified to the green space, habitat and biodiversity (first rank), followed by climate action for adaptation, resilience and mitigation (2nd rank), and environmental quality (3rd rank). Based on Davis et al. (2018), the use of NbS-related terms in EU-level policies was ranked as sustainable management (first rank), followed by natural water retention (2nd rank), which is similar to this thesis findings regarding the NbS-related terms used.

However, this thesis reviewed 21 EU-policy documents from 1985 – 2021 and 29 Dutch and German policies. The categorization in the Davis et al. (2018) study is different since green space is counted in combination with biodiversity, while in this thesis, the topic of green space and biodiversity has been reviewed partway based on the categorizations of the societal challenges by the EC (Dumitru & Wendling, 2021b).

Now to address the main research question "How did NbS enter the policy agenda of the EU?" The study revealed that EU policies had been infected to the NbS based on several global conventions and policies, including UNFCCC, UNCBD, Habitat III, and SFDRR (2015-2030) that explicitly noted NbS, and UN Conference 2012 held in Rio about Sustainable Development, SDGs, UNCCD, and Ramsar conventions implicitly utilize NbS terms. This NbS entry to the EU policy agenda was to respond to societal challenges such as water management, climate resilience and adaptation, biodiversity, health and well-being, and economic growth.

5.2. Governance of NBS at the City Level

To answer the sub-question "2.1. To what extent are NbS absorbed in urban space and societal sectors?" Municipalities are the primary agency behind NbS projects. As part of municipal strategies and visions for climate change adaptation, NbS-interested units within municipalities included water, energy, climate, and nature conservation. Municipalities coordinate horizontally with infrastructure, housing, and spatial planning experts and agencies to provide advice and

capacity. In most cases, city-level decisions were influenced by decisions made by the city council, such as adopting strategies for reducing pollution and developing green economies and the influence of political parties in this regard. Moreover, in some cases, the private sector also influences NbS initiatives. For example, the Utrecht Bio-Washing Machine project implementation was also influenced by companies such as NS and Rabobank as beneficiaries of the heat. For the green roof and green wall initiatives (case 2 and case 3) in both cities, environmental NGOs also contributed to driving and spreading the idea and implementing the practices along with the municipalities. In terms of societal challenges, urban climate adaptation, water, biodiversity, flood defence, and pollution reduction were the main focuses of the selected cases in this study.

To answer the sub-question "2.2. What factors explain the success and failure of adopting NbS?" Based on the frequency of repetition of factors for both cities, three of the most critical factors for adopting NbS are citizen engagement (physically and financially), enhanced collaboration among actors across levels and sectors, and an effective mechanism for disseminating information to ensure the actors are well informed. The main failure factors are the low awareness of citizens regarding the cost and benefits of the NbS; and poor engagement of actors and citizens. The second place goes to bureaucracy, poor communication of information, and lack of information sharing. The research finding is aligned with Frey and Ramirez (2019) that municipalities' effectiveness in adapting to climate change rests on their ability to engage local communities and citizens and have smooth interactions with multilevel policies for their adaptation activities, and enable cities to be agents of change and take into account the agency of the city. The finding is also supported by Brande (2014), who stated that the most common challenges ahead of effective MLG are gaps in information, capacity, financial/funding, and policy. Wamsler et al. (2020) also asserted to involve the private sector, academic institutions, and citizens to overcome this barrier.

Now to answer the main question, "2. How supportive for NbS are decision-making processes at the level of cities?" It was found that municipalities have excellent political commitment, which can be seen in the existing municipal climate change adaptation and NbS policies and strategies. Lower awareness, poor information sharing, fewer existing financial instruments and technical capacity limitations hinder the municipality's image. Subsidies were recognized as a means of strengthening performance. Moreover, the limited financial and technical engagement of the private sector and citizens is one of the significant challenges to scaling NbS practices. Nevertheless, capacity and awareness building are needed to increase the potential for absorption of NbS at the scale and across sectors. NbS planning is influenced by national and European policies, subsidies, and incentives. In NbS practices, decentralization and horizontal collaboration have been recognized as institutional advantages. At the same time, the city-level decision is impacted by multiple factors such as short-term plans and long-term policies' alignment, city council decisions, and political parties' influences on the environmental and climate strategy.

5.3. Pathways for Reinforcing NbS Implementation

To respond to the main question, "3. What are the possible pathways to effectively reinforce the implementation of NbS?" This thesis offers four key pathways following the conceptual framework.

From a policy and institutional perspective, there is a need for further integration of the NbS approach into the national and decentral policy documents. According to this study, the existence of the relevant policies or NbS proofing of policies for the design, initiation, and

implementation of NbS practices supports political commitment at the city level, and improving governance of NbS practices, and would give actors the flexibility they need to inspire nature and contribute to renaturing cities.

From a knowledge and information perspective, it is critical for the agency (e.g., municipality) to establish an open information sharing system from the beginning/conceptualization phase. The development of an open information sharing system supports the operationalization of multilevel and cross-sectoral governance that minimizes silo thinking, enables better knowledge sharing across themes and agencies, and results in co-production and innovation. However, sharing information was challenging and affected by organizational systems, processes, and individual perceptions.

From a governance perspective, the results indicate that collaboration and engagement of actors across sectors and levels are the fundamental success factors. This would be determined by aligning the project's goals with the policies. At the municipal level, policy flexibility allows plans, designs, and decisions to be conceptualized smoothly. It was equally evident that policy flexibility was contributing to innovation. Flexibility in policies can also be viewed in terms of acceptance of risk, and openness toward nature-friendly practices is considered viable support for NbS-related decisions at the city level. However, the critical failure factors for governance were poor engagement of actors and citizens (e.g., the private sector and businesses), low awareness and trust of citizens, and lack of policies.

From an economic perspective, the private sector's investment and the citizens' contribution seem critical for moving forward. However, the state or municipalities are currently playing a significant role in investment in the NbS project. This is because there has been limited private investment in NbS. However, the failure factor was the limited contributions of citizens, builders, or businesses in financing rather than the municipality.

5.4. Future Research

This thesis had its own constrain and limitations. It was restricted to a specific academic semester, and the researcher was unfamiliar with the context. Further, arranging interviews with the experts and finding the right person took more time. Furthermore, some of the decentral policies were in national languages; I translated them for analysis using Google Translate. Moreover, interviews were conducted online. Application of MLG theory is found crucial in exploring the complexity of interactions across the levels; however, the agency theory helped to explore the policies relations and agency problems. Nevertheless, its use in the public domain is less visible in academic literature. Considering the above notes, I suggest an in-depth study and further exploration of the four pathways presented in this research to cross-check with similar research, generate and evaluate the options, to design a roadmap to strengthen the NbS institutionalization effectively.

References

1) Act, T., Conservation, N., Management, L., Nature, F., Act, C., Gazette, F. L., Nature, F., Act, C., & Gazette, F. L. (2010). Act [n] on Nature Conservation and Landscape Management. Encyclopedic Dictionary of Landscape and Urban Planning, 2009(51), 7–7. https://doi.org/10.1007/978-3-540-76435-9_118
2) Bauer, A., & Steurer, R. (2014). Geoforum Multi-level governance of climate change adaptation through regional partnerships in Canada and England. Geoforum, 51, 121–129. https://doi.org/10.1016/j.geoforum.2013.10.006
3) Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. NursingPlus Open, 2, 8–14. https://doi.org/10.1016/j.npls.2016.01.001
4) Biesenthal, C., & Wilden, R. (2014). ScienceDirect Multi-level project governance : Trends and opportunities. JPMA, 32(8), 1291–1308. https://doi.org/10.1016/j.ijproman.2014.06.005
5) Blom-Hansen, J. (2005). Principals, agents, and the implementation of EU cohesion policy. Journal of European Public Policy, 12(4), 624–648. https://doi.org/10.1080/13501760500160136
6) BMU. (2012). Adaptation Action Plan of the German Strategy for Adaptation to Climate Change adopted by the German Federal Cabinet on 31st August 2011. August. http://www.bmub.bund.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/aktionsplan_anpassung_klimawandel_en_bf.pdf
7) BMUB. (2015). Grün in der Stadt – Für eine lebenswerte Zukunft, Grünbuch Stadtgrün. 96.
8) Brande, V. den. (2014). Multilevel Governance and Partnership. October.
9) Braun, D., & Guston, D. H. (2003). Principal-agent theory and research policy: An introduction. Science and Public Policy, 30(5), 302–308. https://doi.org/10.3152/147154303781780290
10) Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit (BMU). (2007). NATIONALE STRATEGIE ZUR BIOLOGISCHEN VIELFALT.
11) Bundestag, & Bundesrat. (2012). Act - Reorganising the Law on Closed Cycle Management and Waste. February.
12) Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., Maginnis, S., Maynard, S., Nelson, C. R., Renaud, F. G., Welling, R., & Walters, G. (2019). Core principles for successfully implementing and upscaling Nature-based Solutions. Environmental Science & Policy, 98, 20–29. https://doi.org/https://doi.org/10.1016/j.envsci.2019.04.014
13) Davies, C., Chen, W. Y., Sanesi, G., & Lafortezza, R. (2021). The European Union roadmap for implementing nature-based solutions: A review. Environmental Science and Policy, 121(July 2020), 49–67. https://doi.org/10.1016/j.envsci.2021.03.018
14) Davis, M., Abhold, K., Mederake, L., & Knoblauch, D. (2018). Nature-Based Solutions in European and National Policy Frameworks. May, 52. https://naturvation.eu/result/nature-based-solutions-european-and-national-policy-frameworks
15) Delreux, T., & Adriaensen, J. (2019). Principal–Agent Analysis and the European Union. Oxford Research Encyclopedia of Politics, November. https://doi.org/10.1093/acrefore/9780190228637.013.1048
16) Delta Programme | Coast. (2013). Compass for the Coast | National Coastal Strategy. 1–153.
17) Dumitru, A., & Wendling, L. (2021a). Evaluating the impact of nature-based solutions: Appendix of methods. https://doi.org/10.2777/11361
18) Dumitru, A., & Wendling, L. (2021b). SOLUTIONS A Handbook for Practitioners. https://doi.org/10.2777/244577

19) Dunlop, C. A., & James, O. (2007). Principal-agent modelling and learning: The European commission, experts and agricultural hormone growth promoters. Public Policy and Administration, 22(4), 403–422. https://doi.org/10.1177/0952076707081585
20) EC. (2021). New EU Forest Strategy for 2030. European Commission, 5–24. https://eur-lex.europa.eu/resource.html?uri=cellar:0d918e07-e610-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF
21) EEA. (2021). Nature-based solutions in Europe (Issue 01). https://www.eea.europa.eu/publications/nature-based-solutions-in-europe
22) Egusquiza, A., Cortese, M., & Perfido, D. (2019). Mapping of innovative governance models to overcome barriers for nature based urban regeneration. IOP Conference Series: Earth and Environmental Science, 323(1). https://doi.org/10.1088/1755-1315/323/1/012081
23) Eisenhardt, K. (1989). Agency Theory: An Assessment and Review. Academy of Management Review, 14(1), 57–74.
24) EU. (2020). City Vision Leipzig 2050. 864242.
25) European Commission. (1992). Council Directive 92/43/ECC, on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Union, 94(1259), 40–52.
26) European Commission. (2012). Blue Growth opportunities for marine and maritime sustainable growth. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions,
27) European Commission. (2013a). Green Infrastructure (GI) — Enhancing Europe's Natural Capital. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions,
28) European Commission. (2013b). Green Infrastructure: Policy Guides, European Parliament resolution of 12 December 2013 on Green Infrastructure – Enhancing Europe's Natural Capital (2013/2663(RSP)).
29) European Commission. (2016). Urban agenda for the EU. Urban Agenda, 47. http://ec.europa.eu/regional_policy/sources/policy/themes/urban-development/agenda/pact-of-amsterdam.pdf%0Ahttp://urbanagendaforthe.eu/
30) European Commission. (2017). Urban development - Regional Policy - European Commission. http://ec.europa.eu/regional_policy/en/policy/themes/urban-development/
31) European Commission. (2018). A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the envir. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels.
32) European Commission. (2019a). Nature-based solutions | European Commission. In European Commission. https://ec-europa-eu.ezproxy2.utwente.nl/info/research-and-innovation/research-area/environment/nature-based-solutions_en
33) European Commission. (2019b). The European Green Deal. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions,. http://eur-lex.europa.eu/resource.html?uri=cellar:208111e4-414e-4da5-94c1-852f1c74f351.0004.02/DOC_1&format=PDF
34) European Commission. (2020). A new Circular Economy Action Plan For a cleaner and more competitive Europe. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.
35) European Commission. (2021a). Pathway to a healthy planet for all. EU Action Plan: "Towards Zero Pollution for Air, Water and Soil." European Union Communication, COM(2021), 400final.

36) European Commission. (2021b). EU Biodiversity Strategy for 2030: Bringing nature back into our lives.
37) European Commission. (2021c). EU Climate Adaptation Strategy. Brussels, 24.2.2021 COM(2021) 82 Final. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0082&from=EN
38) European Commission. (2021d). EU Soil Strategy for 2030 Reaping the benefits of healthy soils for people, food, nature and climate, Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions,. EU Official Journal.
39) European Commission. (2021e). European Climate Law. Official Journal of the European Union, 2021(June), 17. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119
40) European Parliament and the Council of the European Union. (2014). DIRECTIVE 2014/52/EU OF The European Parliament and of The Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment. Official Journal of the European Union, 128–129. https://doi.org/10.1017/s1466046600002350
41) European Parliament and the Council of the European Union. (2021). Regulation (Eu) 2021/2115 of the European Parliament and of the Council. Official Journal of the European Union, 2021(November), 435/1-435/186.
42) European Union. (n.d.). Nature-based solutions research policy | European Commission. In Official Website of the European Union. https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-based-solutions/research-policy_en
43) European Union. (2007). Directive 2007/60/EC of the European Counil and European Parliment of 23 October 2007 on the assessment and management of flood risks. Official Journal of the European Union, 2455, 27–34. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007L0060&from=EN
44) European Union. (2008). Directive 2008/56/EC of the European parliament and of the Council of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Official Journal of the European Union.
45) European Union. (2009). DIRECTIVE 2009/147/EC OF The European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. Official Journal of the European Union. https://doi.org/10.1111/1467-9388.00079
46) European Union. (2020). Farm to Fork Strategy. DG SANTE/Unit 'Food Information and Composition, Food Waste'',' DG SANTE/Unit 'Food Inf. Compos. food waste'',' 23. https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf
47) Eyink, H., & Heck, B. (2018). White Paper : Green Spaces in the City.
48) Faivre, N., Fritz, M., Freitas, T., de Boissezon, B., & Vandewoestijne, S. (2017). Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges. Environmental Research, 159(August 2017), 509–518. https://doi.org/10.1016/j.envres.2017.08.032
49) Federal Agency for Nature Conservation. (2017). Federal Green Infrastructure Concept. 68. https://www.bfn.de/fileadmin/BfN/planung/bkgi/Dokumente/BKGI_Broschuere_englisch.pdf
50) Federal Ministry of Justice and Consumer Protection, & Federal Office of Justice. (2019). Federal Climate Change Act. 1–10. http://www.gesetze-im-internet.de/englisch_ksg/englisch_ksg.pdf
51) Frey, K., & Ramírez, D. R. C. (2019). Multi-level network governance of disaster risks: the case

of the Metropolitan Region of the Aburra Valley (Medellin, Colombia). Journal of Environmental Planning and Management, 62(3), 424–445. https://doi.org/10.1080/09640568.2018.1470968
52) Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. Environmental Innovation and Societal Transitions, 1(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002
53) Gemeente Utrecht. (2021). Utrecht Dichtbij: de tien-minutenstad. Ruimtelijke Strategie Utrecht 2040. https://utrecht.bestuurlijkeinformatie.nl/Agenda/Document/dedcc939-ae80-46dc-a5b4-c980f12c082b?documentId=d8d154f1-628e-4ece-9442-72f0ac8c1263
54) German Federal Government. (2008). German Strategy for Adaptation to Climate Change. December.
55) German Federal Ministry of Transport, B., & Affairs, and U. (2006). Concepts and Strategies for Spatial Development in Germany. June.
56) Gustavsson, E., Elander, I., & Lundmark, M. (2009). Multilevel Governance , Networking Cities , and the Geography of Climate- Change Mitigation : Two Swedish Examples Multilevel governance , networking cities , and the geography of climate-change mitigation : two Swedish examples À. February. https://doi.org/10.1068/c07109j
57) Hawxwell, T., Mok, S., Mačiulytė, E., Sautter, J., & Dobrokhotova, E. (2019). Municipal Governance for Nature- Based Solutions. August, 60.
58) IPCC. (2022). Working Group III — IPCC, Intergovernmental Panel on Climate Change,. https://www.ipcc.ch/working-group/wg3/
59) IUCN. (2016). What are Nature-based Solutions? In Nature-based solutions to address global societal challenges. https://portals.iucn.org/library/sites/library/files/documents/2016-036.pdf
60) Jänicke, M. (2017). the Model and its Current State. 121, 108–121. https://doi.org/10.1002/eet.1747
61) Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., & Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society, 21(2). https://doi.org/10.5751/ES-08373-210239
62) Kassim, H., & Menon, A. (2003). The principal-agent approach and the study of the European union: Promise unfulfilled? Journal of European Public Policy, 10(1), 121–139. https://doi.org/10.1080/1350176032000046976
63) Katrin, L., Castán, V., & Huang, P. (2019). Revisiting multi-level governance theory : Politics and innovation in the urban climate transition in Rizhao , China. Political Geography, 70(January), 14–23. https://doi.org/10.1016/j.polgeo.2019.01.002
64) Kees Diepeveen. (2022). Visie Klimaatadaptatie Utrecht. https://utrecht.bestuurlijkeinformatie.nl/Agenda/Document/ebb7f1bd-9bf4-4352-81e0-5427789933d1?documentId=8d32abf9-1f7f-4b2c-a60d-fa7008a85e77&agendaItemId=d20aa079-76be-47c9-b6eb-8aead379abff
65) Klein, R., Huq, S., Denton, F., Downing, T., Richels, R., & Robinson, J. (2007). Inter-relationships between adaptation and mitigation. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution OfWorking Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 745–777.
66) Leonardi, G. (2010). Adaptation to climate change. In Environmental Medicine (pp. 521–530). https://doi.org/10.4324/9781351297967-18
67) Marquardt, J. (2017). Conceptualizing power in multi-level climate governance. Journal of Cleaner Production, 154, 167–175. https://doi.org/10.1016/j.jclepro.2017.03.176

68) Mendes, R., Fidélis, T., Roebeling, P., & Teles, F. (2020). The institutionalization of nature-based solutions-a discourse analysis of emergent literature. Resources, 9(1). https://doi.org/10.3390/resources9010006
69) Ministerie van Infrastructuur en Waterstaat Ministerie van Landbouw, N. en V. M. van B. Z. en K. (2021). Nationaal Deltaprogramma 2022. www.deltaprogramma.nl
70) Ministry of Infrastructure and Environment. (2014). (Unoffical) Translation of the Environment and Planning Act. June 2014, 104. https://www.helpdeskwater.nl/publish/pages/132185/the_dutch_water_act_in_brief.pdf
71) Ministry of Infrastructure and the Environment. (2016). National Climate Adaptation Strategy 2016 (NAS), Adapting with ambition. Ministry of Infrastructure and the Environment, 49.
72) Ministry of Infrastructure and the Environment Ministry. (2015). National Water Plan 2016-2021.
73) Municipality of Utrecht. (2017). Omgevingsvisie Beurskwartier en Lombokplein: naar een groter centrum. december.
74) Naturvation. (2021). Urban Nature Atlas. In Nature-based solutions: Green roofs. Projects. https://una.city/front-search/ecological_domains_tid/29?search_api_fulltext=&page=0
75) Netherlands Ministry of Economic Affairs. (2019). National Climate Agreement. June, 247. https://www.klimaatakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands
76) NMU. (2022). Nature and Environment Federation Utrecht: Green climate-active city.
77) of Environment, M., & Water. (2021). National {Water} {Strategy}. Mintery of Water and Irrigation. https://www.mewa.gov.sa/en/Ministry/Agencies/TheWaterAgency/Topics/Pages/Strategy.aspx
78) PBL. (2011). Climate Adaptation in the Dutch Delta. Strategic options for a climate-proof development of the Netherlands. PBL Netherlands Environmental Assessment Agency. www.pbl.nl/en
79) Rasoolimanesh, S. M., Badarulzaman, N., & Jaafar, M. (2011). Achievement to Sustainable urban Development using City Development Strategies (CDS): A Comparison between Cities Alliance and the World Bank definitions. Journal of Sustainable Development, 4(5). https://doi.org/10.5539/jsd.v4n5p151
80) Shapiro, S. P. (2005). Agency theory. Annual Review of Sociology, 31, 263–284. https://doi.org/10.1146/annurev.soc.31.041304.122159
81) Shoshanna, S. (1999). Qualitative Methods: What Are They and Why Use Them? In Health Services Research (Vol. 34, Issue 5, pp. 1101–1117).
82) Staatsblad Jaargang van het Koninkrijk der Nederlanden. (2019). KlimaatWet(Climate Act). Staatsblad 651, 2–5.
83) Stadt Leipzig. (2016). Klimawandel. Anpassungsstrategien für Leipzig. 36.
84) Stadt Leipzig. (2018). Integriertes Stadtentwicklungskonzept Leipzig 2030. 2030.
85) Sun, B., & Baker, M. (2021). Multilevel governance framework for low-carbon development in urban China : A case study of Hongqiao Business District , Shanghai. Cities, 119(July), 103405. https://doi.org/10.1016/j.cities.2021.103405
86) Tallberg, J. (2002). Delegation to supranational institutions: Why, how, and with what consequences? West European Politics, 25(1), 23–46. https://doi.org/10.1080/713601584
87) The European Parliament and the Council of the European Union. (2000). Establishing a framework for Community action in the field of water policy, DIRECTIVE 2000/60/EC of The European Parliament and of The Council. Official Journal of the European Communities.
88) The Federal Minister for the Environment Nature Conservation and Nuclear Safety. (2002). Promulgation of the Amended Version of the Federal Water Act of 19 August 2002. Federal

Law Gazette I Page 3167.
89) UNFCCC. (2020). What do adaptation to climate change and climate resilience mean? | UNFCCC (pp. 1–5). https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean
90) urban-development @ europa.eu. (n.d.). https://europa.eu/capacity4dev/topics/urban-development
91) Urban-Planning @ Www.Britannica.Com. (n.d.). https://www.britannica.com/topic/urban-planning
92) Utrecht, C. (2022). kiezen voor gelijke kansen , betaalbaar wonen en klimaat.
93) Utrecht Province. (2020). Programma Klimaatadaptatie 2020-2023. 1–35. https://www.provincie-utrecht.nl/sites/default/files/2020-05/Programma Klimaatadaptatie 2020-2023 provincie Utrecht mei 2020.pdf
94) van der Heijden, J., Patterson, J., Juhola, S., & Wolfram, M. (2019). Special section: advancing the role of cities in climate governance–promise, limits, politics. Journal of Environmental Planning and Management, 62(3), 365–373. https://doi.org/10.1080/09640568.2018.1513832
95) Wamsler, C., Wickenberg, B., Hanson, H., Alkan Olsson, J., Stålhammar, S., Björn, H., Falck, H., Gerell, D., Oskarsson, T., Simonsson, E., Torffvit, F., & Zelmerlow, F. (2020). Environmental and climate policy integration: Targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation. Journal of Cleaner Production, 247. https://doi.org/10.1016/j.jclepro.2019.119154
96) Wiseman, R. M., Cuevas-Rodríguez, G., & Gomez-Mejia, L. R. (2012). Towards a social theory of agency. Journal of Management Studies, 49(1), 202–222. https://doi.org/10.1111/j.1467-6486.2011.01016.x

Appendices

Appendix 1: Definition of Concepts

Def 1: Societal Challenges and Sector Selection

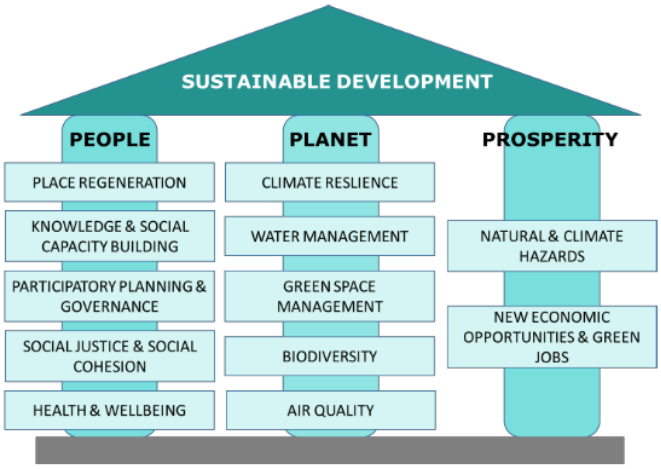
According to the IUCN (2016), the societal challenges have been specified based on the SDGs that are mainly to achieve: water security (SDG 6); food security (SDG 2) but also interconnected with all SDGs; human health (SDG 3, 11, 13); Disaster risk reduction (SDG 11, 13 but also contributing to SDG 1, 2, 3 6, 15); addressing climate change based on the UNFCCC agreements below 2C (SDG 13), and conserving of the natural capital and our planetary boundaries, which is also presented in the figure Figure 33:

Figure 33: IUCN societal challenges

Source: IUCN (2016: 12)

According to the European Commission, the major societal challenge for Europe has been identified in 12 categories based on the SDGs. These are consisting of "Climate Resilience, Water Management, Natural and Climate Hazards, Green Space Management, Biodiversity, Air Quality, Place Regeneration, Knowledge and Social Capacity Building for Sustainable Urban Transformation, Participatory Planning and Governance, Social Justice and Social Cohesion, Health and Well-being, New Economic Opportunities and Green Jobs" (Dumitru & Wendling, 2021b).

Figure 34: A conceptual map of the societal challenges based on the EU



Source: Dumitru & Wendling (2021b; 118).

Due to the geographical location of the research and assessment of the NbS between the Netherlands and Germany, I have used the definition of the European Union in this study. Both IUCN and EU definitions are similar. In my research, I would specifically focus on "climate change adaptation" and I would narrow it down to the urban area at the municipality level.

Def 2: Urban Planning and Development

In Europe, cities are perceived to be the source for addressing some of the key challenges of our world, such as economic, environmental, and social issues. Focusing on the urban areas and cities in Europe, it becomes clear that two-thirds of the population lives in urban areas, where they are using over 80% of energy, contributing to 85% of GDP. On the other hand, these places are under persistent socio-economic and ecological pressures such as poverty, unemployment, etc. (European Commission, 2017).

According to EU "Urban development covers infrastructure for education, health, justice, solid waste, markets, street pavements and cultural heritage protection. These constructions usually form part of specific sector programmes, including capacity building measures. Special attention is also paid to slums of large cities. Rehabilitation and reconstruction comprises in particular social infrastructure following natural disasters or conflicts" (*Europa.Eu*, n.d.).

The goals of urban planning are more focused on engineering and social and political concerns related to designing and regulating space based on the physical, economic, and social aspects of the urban area. Urban planning refers to the development of open land and the revitalization of existing urban areas based on the establishment of goals, and the gathering of technical data and information to generate design and information, in consultation with the public. (Www.Britannica.Com, n.d.).

Rasoolimanesh et al., (2011), argued that we need to differentiate between two terms 1) urban sustainability or sustainable cities and 2) sustainable urban development or sustainable urbanization. In urban sustainability, both renewable and non-renewable resources are utilized effectively, the natural environment is protected, economic growth is enabled, and the basic needs of community members are met (Rasoolimanesh et al., 2011). A sustainable city is also one that owns the resources for its development and is free of environmental issues (Rasoolimanesh et al., 2011). According to Rasoolimanesh et al. (2011), sustainable urban development involves a dynamic process in which the city responds properly to environmental, economic, social, and governance challenges in order to achieve sustainability and create a balance between the economic, environmental, and social pillars.

EU is focusing on the concept of "integrated sustainable urban development". EU definition of integrated sustainable urban development stresses that city life is composed of multiple aspects interdependent upon each other such as the environment, economics, and socio-cultural issues, and urban development can only be accomplished through a holistic and integrated approach. Furthermore, measures related to physical urban renewal must take into account education, economic development, social inclusion, environmental protection, economic development activity, digital transformation, and the creation of jobs, which necessitates partnerships among citizens, civil organizations, industries, and various levels of government (European Commission, 2017). The EU's urban agenda seeks to enhance the quality of life in urban areas. It also seeks to utilize the growth

potential of cities, promote cooperation between cities, and address societal challenges in a responsible manner (European Commission, 2017).

Def 3: Climate Change Adaptation

According to the UNFCCC (2020) "Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change" (UNFCCC, 2020).

The EU definition of climate change adaptation is "taking action to prepare for and adjust to both the current effects of climate change and the predicted impacts in the future" (Leonardi, 2010).

UNFCCC (2020) encourages countries to develop their own adaptation solutions and actions, and implement them to confront the current and future threats of climate change. Adaptation can take place in many ways and there is no one-size-fits-all solution (UNFCCC, 2020). Additionally, the adaptation process requires active engagement at various levels, scales, and sectors (UNFCCC, 2020).

Def 4: Climate Change Mitigation

A mitigation measure involves reducing or improving the sinks of greenhouse gases through anthropogenic interventions (Klein et al., 2007). Climate mitigation can be applied across all sectors and activities since greenhouse gases can come from a variety of sources such as forms of land management, energy, transport, buildings, industry, waste management, agriculture, forestry, and etc. (IPCC, 2022)

Def 5: Levels and Sectors

The levels, in this research are derived from MLG partners in the EU context. The focus will be on agencies/institutions/administrations that are involved with urban climate change adaptation - this will include: the global level, the EU level, the state member level, the decentralized level (regions, provinces), the local level (municipalities), and at the community level (citizens)

The sectors, sectorally in this research, the primary focus is climate change adaptation and urban development (municipalities); however, climate adaptation in urban is also cross-cut with the social, economic, and environmental sectors, such as infrastructure, transportation, energy, water, disaster and risk, agriculture, industries, tourism, etc.

Therefore, multi-stakeholders consisting of the public, business, citizens, and academia would be engaged in a multilevel and multi-sectoral process of decision making.

Appendix 2: Description of Selected Case Projects in Utrecht and Leipzig

Case name	Case Summary
Case 1: Utrecht – Bio-washing Machine	This NbS project aims to get multiple benefits from an aqua-thermal heat storage system by pumping water from the first aquifer and at the same time performing natural bioremediation of polluted water as if it were a washing machine. In this project, several parties had a role, such as Utrecht Municipality, Rabobank, and Dutch Railways Agency (NS), where Bioclare was responsible for biodegradation; Bodem+/RWS and Deltaras were also involved in supporting the municipality in its design and implementation. Contamination should not be moved from a zone under soil policy, so this project employed a risk-based concept to prevent contamination from being moved while producing heat and conducting natural attenuation to reduce contamination. The project also contributed to the energy transition.
Case 2: Utrecht Sustainable Roofs	Based on the idea of utilizing the roof for multiple functions like water collection (blue roofs), greenery (green roofs), energy production (yellow roofs), and living space (red roofs), the project idea was adopted from Rotterdam city, where in Utrecht this idea was suggested by NMU to the Utrecht Municipality and Province. Sustainable roofs envision a green and eco-friendly environment. This is done through the provision of advice, plans, and calculations via a neighborhood initiative by the NMU. Utrecht Municipality is also providing subsidies for houses to spread and expand the concept. As a result of this project, citizens will be provided with a more liveable and biodiversity-rich city. Resilience and climate adaptation will be supported in the city by contributing to water harvesting, heat wave reduction, biodiversity improvement, and energy transition. The housing companies are not particularly interested in this kind of initiative due to the cost. However, this will increase the price of houses as well.
Case 3: Leipzig Keletterfix Green wall	According to the interview, the project was come up in collaboration with the municipality of Leipzig and Okolowe Environmental NGO, and it was started in 2015. Okolowo was to work on public relations with Leipzig City, implement green facets, and connect with citizens to increase greenery, facets, or green walls. This would eventually protect the environment and save nature. According to experts, there have been few studies on the climatic impact of green walls, but the effect of green roofs is different considering the conditions. Walls can affect temperature to some extent, but they require management, irrigation, etc. Further, Leipzig City offers subsidies for green roofs in the range of 10- 20-25 percent. But for the facets, this is not the case, only the NGO provides advice and plans for the property owners.
Case4: Leipzig Lebendige Luppe	This restoration project was initiated in the Lebendige Luppe flood plain area for flood defense, but also to improve the urban climate. The project has a wide range of effects on the city's economy and ecosystem in the city. For instance, this project is a soft factor that impacts the housing price in the surrounding area. Besides, its greenery and forests had an impact on the cooling of the city and provisioning of fresh air, retaining water, enhancing biodiversity, and contributing to recreation in the city and its residents' well-being. This project is a collaboration between the Leipzig and Schkeuditz Municipalities, Leipzig University, UFZ research institute, and NABU Sachsen Environmental Organization. It has 75% financial support from the Saxony State Ministry of Environment.

Appendix 3: Potential List of the Indicators for Exploring NbS Entry into EU Policy

SN	Indicators	Measures
1	How did the concept of NbS get agency within European institutions?	
1.1	Name of policy instrument	
1.2	Date of enforcement	
1.3	Date of revision (if applicable)	
1.4	Why did the policy idea emerge? (The aim, objective, and targets related to NbS)	
	Based on the policy, who is leading the design, financing, and implementation of NbS?	A- Public Administration (ministries, municipalities etc) B- Public-private C- Public-NGOs D- Private sector E- Citizens / communities
1.5	What led to the request for the task?	**A-** Member States Request /National Governments **B-** SDG Response **C-** EU parliament
1.6.	What kind of policy instrument is it?	**A-** Strategy **B-** Policy **C-** Directive **D-** Program, or finance instrument, etc.
1.7.	What legal status does it have?	**A- Mandatory**: legally binding, Rigid implementation **B- Voluntary**: legally binding, encourage for action, flexible **C- Statement**: legally binding, no action required **D- Not legally binding**
2.	What role of NbS is envisioned in multilevel decision-making (governance) across Europe?	
2.1	What geographic coverage does the policy instrument have?	**A-** EU level **B-** Netherlands **C-** Germany **D-** Utrecht **E-** Leipzig
2.2	What role is expected to be fulfilled by NbS? or what societal challenges are expected to be addressed? *Adopted from (Dumitru & Wendling, 2021b) and considering the SDGs adopted from (IUCN, 2016)*	**A-** Climate Resilience/Adaptation/Mitigation **B-** Water Management **C-** Natural and Climate Hazards **D-** Green Space Management **E-** Biodiversity **F-** Air Quality **G-** Place Regeneration **H-** Knowledge and Social Capacity Building for Sustainable Urban **I-** Transformation (sustainable consumption and production) **J-** Participatory Planning and Governance **K-** Social Justice and Social Cohesion **L-** Health and Well-being **M-** New Economic Opportunities and Green Jobs
2.3	Is the policy instrument focused on urban/city inclusion?	**A-** More attention to urban **B-** General **C-** Not focused on urban
2.4	Has the term NbS been used clearly in the policies? In what way? *Adapted from (Davis et al., 2018a; pg. 43 &44)*	**A- Explicitly**: the term used directly or as of the following; a. NbS, b. Green/blue/NbS infrastructure, c. Ecosystem-based approach (adaptation, mitigation); d. Sustainable ecosystem or (water or ecosystem or forest or natural resource) management; e. Natural water retention; f. Eco-engineering/ecological engineering; g. building with nature/working with nature;

		B- **Implicitly**: the term has not been used directly but some of the NbS interventions/concepts are referenced or applied. a. Green building e.g. green roofs, green walls, balcony green etc. b. Urban green area connected to gray infrastructure c. Parks and semi natural areas, urban green areas d. Allotment and community garden and horticulture e. Green indoor area f. Blue areas e.g. lake, water pond, river, stream, canal, sea coast, wetland, march, delta, bog, fen, etc. g. Green areas for water management, sustainable urban drainage, swales filter strips, rain gardens, h. Derelict areas i. Other areas **C-** **Ignored**: Not focused on NbS
2.5	What sector mix is highlighted by the policy instrument? (multiple options)	**A-** Urban development / Spatial planning **B-** Water and soil **C-** Energy **D-** Industry **E-** Agriculture **F-** Construction **G-** Transport **H-** Tourism **I-** All economic sectors
2.6	What is the NbS activity Mix? *Adopted from (IUCN, 2016)*	**A-** New area creation **B-** Management and maintenance of existing areas **C-** Restoration and protection **D-** No Clear
2.7	Has there been a focus on cross-sectoral alignment in policy?	**A-** Yes **B-** No
2.8	Is the policy focused on information and knowledge exchange?	**A-** Yes **B-** No
2.9	The authority to monitor/audit/oversee is delegated to whom?	**A-** EU level agency **B-** State level **C-** Federal/Provincial/Municipality level **D-** Community level **E-** Not Clear
2.10	Is the communication and reporting mechanism for the policy outcome clear? If so, to whom?	**A-** Yes **B-** No
Summary / Remarks:		

Appendix 4: Questionnaire for Interviews

Disclosure:
Dear expert, thank you for participating in this research for the Master's program (MEEM) of the University of Twente. By participating in this interview, you agree to the recording of this interview, your answers will be analysed and used in the research. The recording will be deleted within six months. Your name will be anonymized, but your position will be indicated in a generic term, not quoting your description to a level that makes it possible to link this to you. If you have any questions, please feel free to reach us via email: m.r.qazizada@student.utwente.nl

Brief research introduction:
Nature-based solutions (NbS) can play an important role in increasing resilience against climate change while addressing urban challenges. The thesis project is titled "Governance of nature-based solutions for societal challenges: lessons from Utrecht and Leipzig to reinforce implementation". The research tries to enlighten how NbS entered the agenda at various levels reaching from EU to implementation at city level in sectors and space. Second the research tries to envision ways to further strengthen the implementation of NbS across levels, and within urban planning and decision-making, eventually contributing to renaturing and adaptation to climate change. In this research two European cities are compared – Utrecht and Leipzig.

The main research questions are:

1. How did NbS enter the policy agenda of the EU?
   1.1. How did the concept of NbS get agency within the EU?
   1.2. What role of NbS is envisioned in multilevel decision-making (governance) across Europe?

2. How supportive for NbS are decision-making processes at the level of cities?
   2.1. To what extent are NbS absorbed in urban space and societal sectors?
   2.2. What factors explain the success and failure of adopting NbS?

3. What are the possible pathways to effectively reinforce the implementation of NbS?

Therefore, to answer a partial of the above key questions – specifically the question 2 and 3, we appreciate the opportunity to interview you based on the interview questions listed below:

Part 1: Introduction:
1. Could you provide us what was your role was?
2. How long were you involved?

Part 2: Personal and Social interest for NbS:
3. How was the idea for this NbS project born?
4. How green, or climatically adaptive, and resilient did you envision comparing the area was before?
5. In what ways has the project benefitted or not benefitted the citizens and actors involved in the project?
6. What is your personal perspective upon NbS in cities?

Part 3: Assessment of the NbS absorption at the Utrecht municipal level:
7. How would you rate the political commitment to NbS implementation in Utrecht city?

Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)

8. What institutional arrangements such as rules, policies, strategies, process and instrument are in place that enhances NbS design, planning and implementation?
    a. To what extent does this enhance decision-making towards NbS?
9. Do you have any examples of long-term goals for NbS proofing of the municipality's plans and actions in accordance with the provincial, national and EU level policies?
    a. If yes, please explain?
    b. If no, could you elaborate on the reason.
10. Which agency(ies) or sector(s) was the leading force behind the design, implementation, and funding of the urban climate adaptation and NBS projects at the municipal level? (and why)
11. Can you be more specific upon institutional barriers and opportunities at the municipality level regarding the project?
12. Are these institutional barriers and opportunities project specific or do you think these apply to NbS in general in urban decision-making?

Part 4: Pre-selected lenses upon success and failure factors for adopting/implementing NbS:

A) Knowledge and information:

13. How do you rate information sharing among the actors?
    Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)
14. Do you think all the levels and actors have the same amount of information about the project, plans and policies?
    a. If No, why? And when do the actors de-share information?
15. How would you rate the innovation and creativity in the design and implementation of the project?
    Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)
16. Can the implementation of your project be characterized by an innovation and creativity, any experience or examples to elaborate?
17. Do you find it easy to get access to science, information and technology that suit the project?
    Yes - No
    a. How can the science and technology be enhanced locally for similar project in future?
18. How well did citizens (beneficiaries) know the costs and benefits of the NbS project to trust?
    Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)
    a. how to promote the citizens' awareness and engagement?

B) Governance:

19. How do you rate the alignment of short-term activities and plans with the long-term policies at the municipality level?
    Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)
    a. What can be done to foster alignment between short-term project objectives and long-term goals and policies?
20. Who were the key sectors and actors involved in this project?
21. How do you rate coordination between sectors and across levels for NbS Project?
    Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)
22. Does sectoral thinking (silos) dominate city planning for adaptation to climate change?
23. Is there any mechanism for the levels such as citizens to municipality, provincial or federal and public to private sector, to collaborate and coordinate in relation to NbS projects?
    Yes - No,
    (please explain in both situation? Any example of co-creating practices?)
24. How flexible are the actor's and sector's policies, plans, and decisions for integrating NbS into their operations (giving NbS room to grow)?

Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)

a. Is there a way to improve this, please explain?

25. How do you rate the complexity of governance structures to reach to a decision at the municipality level for NbS project?

Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)

a. What are your suggestions for improvement?

26. How do you rate the citizen's engagement (technically and financially) in the NbS project?

Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)

a. Is there a way to promote the citizens' involvement and trust in the decision-making process (cost and benefits)?

C) Economic

27. Where does the money for NbS activities come from?

a. How to improve fundraising capacity at the municipality level?

28. Which key risks do you perceive hindering the collaboration, decision-making, and implementation of NbS activities, and specifically the project?

a. How can these risks be mitigated?

29. How do you rate the transparency of actors with each other in decision-making, sharing information and reporting?

Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% -100%)

a. what are your observations for improvement?

30. How do you rate the motive of private sector investment in your NbS project?

Very Poor (0% - 25%) - Poor (26%- 49%) - Good (51 % - 75%) - Excellent (76% - 100%)

a. And, how to promote the private sector/citizen investment and ownership?

31. Has the project been audited and monitored? Yes/No

a. How sectors /actors have been involved in the audit process?

Part 5: Closing:

32. Is there anything you would like to add or ask?
33. Would deem useful to share additional project materials and contacts for interview

Thank you for the interview

Appendix 5: List of Interviewees

Location	Case name	Interviewees	Organization	Relation to case project
Utrecht City	The Bio-washing Machine	Interviewee 1	Bodem+ WVL	Consultant/Expert contributed in concept, design and implementation
		Interviewee 2	Utrecht Municipality	Groundwater experts and responsible for the project
		Interviewee 3	Deltares	Hydrogeologist – contributed to project design and implementation
		Interviewee 4	Bioclear consulting company	Ex- Expert for design and biodegradation
Utrecht City	Sustainable Roofs project	Interviewee 5	Natuur en Milieufederatie Utrecht (NMU)	Climate adaptation related expert -
		Interviewee 6	Utrecht Province	Policy making for climate adaptation strategy and engaged in the project
		Interviewee 7	Utrecht Municipality	Responsible for the project
Leipzig City	Keletterfex – Green Wall Project	Interviewee 8	Okolowe	Responsible for the project
		Interviewee 9	Leipzig City (municipality)	Responsible for the climate change mitigation and adaptation - including greenery
		Interviewee 10	UFZ research institute	Researcher and PhD student. Responsible for research
		Interviewee 11	Leipzig City (municipality)	Responsible expert for office of green space and water
Leipzig City	Lebendige Luppe project	Interview 12	UFZ research institute	Researcher / scientist - involved in the project
		Interview 13	Leipzig City (municipality)	Responsible for planning and organizing of project

Appendix 6: Case Projects Identified and Selected for the Thesis

Table 21: Case selection based on criteria in Utrecht

No	Project title	Relevance to urban climate adaptation	start and end date	Governance type	Multi-actor finance
1	City Island Park Tour	Yes	2013 – ongoing	Government lead	Public finance
2	Food for Good	No	2013-ongoing	Non-governmental actors	Public and private
3	Green Park on Highway Tunnel	No	2011 – unknown	Govt. lead	Public fund
4	Greening the Historical Canal	No	2016-2019	Joint-governance	Public fund
5	Leidsche Rijn sustainable urban drainage system	Yes	1997-unknown	Joint-governance	EU and public
6	Máximapark	No	2007 -2013	Joint-governance	Multi-source
7	Roerplein Pocket Garden	Yes	2015-2019	Joint-governance	EU and public
8	Sustainable Neighbourhood Cherry Garden	No	2002-2003	Non-governmental actors	Public and private
9	The Bio Washing Machine	Yes	2009-2013	Government lead	EU, Public, private
10	The Garden Factory	No	2013-unknown	Non-governmental actors	Community / private

Table 22: Case selection based on criteria in Leipzig

No	Project title	Relevance to urban climate adaptation	start and end date	Co-governance	Multi-actor finance
1	Annalinde community garden, nursery and fruit orchard	No	2011-2016	Non-governmental actors	EU, public, private
2	BiodiverCity biodiversity initiatives in Leipzig	No	2016-2016	Non-governmental actors	unknown
3	Biotope Schladitz	No	1994-2012	Non-governmental actors	unknown
4	Citizen tree sponsorships programme	yes	2016-ongoing	Government lead	Public and private

5	Elster-Luppe wetland: Revitalization and renaturalization	yes	2012-ongoing	Joined governance	Public fund
6	Green Spaces in Leipzig's East Quarter	No	2012-ongoing	Joined governance	Multiple
7	Kletterfix Green Walls for Leipzig	yes	2015-ongoing	Joined governance	Public/NGOs
8	Neuseenland: Transformation of former lignite mining area	No	1994-ongoing	Joined governance	Public/corporate
9	Parkbogen Ost – Green belt project	No	2017-ongoing	Joined governance	EU/public
10	Resident park and community garden of Grünau district	No	2008-2008	Joined governance	Public and private
11	Urban Park Rabet	No	2004-2007	Government lead	EU/public fund

Appendix 7: Success and Failure Factors of NbS in Utrecht

Table 23: Knowledge and information factors in the adoption of NbS in Utrecht

Cases	Success factors	Failure factors
Case 1: The Utrecht Bio washing machine	a) Interviewees highlighted that establishing a mechanism for sharing information from the beginning stages, such as conceptualization of the project, is critical for agency to assure everyone (actors) is on the same page. Actors perceived a need at first, but later discovered the problem and fixed it (Interviewee 4). b) Interviewees suggested that having a robust communication and coordination mechanism would play a vital role in improved cross-thematic/sectoral understanding, and communicating information (Interviewee 1, 2). c) Based on the interviews, the collaboration of multiple sectors and actors across levels results in the generation of novel concepts, knowledge, and innovations in practices (Interviewee 4, 1).	a) According to the Interviewees, having separate/fragmented communication with each party (actor) consumes time, and prevents a common and clear understanding. Sharing of information at the initiation stage was perceived to be poor (Interviewee 4). b) A number of actors, including municipal structure, display silo thinking orientations that influence decisions and information sharing. For example, the environmental team of the municipality was requested to be involved in the project at a later stage (Interviewee 1). c) The more complex the design of an NbS project, the more agencies may perceive a gap in information. As some NbS interventions are more multi-disciplinary and technical, the complexity of encodings and barriers to communication and information sharing between actors can arise to result in not everyone being on the same page (Interviewee 1, 2, 4).
Case 2: Utrecht Sustainable roofs Project	a) The development of the national roof plan was a cooperative effort between the actors, such as scientists, developers, and municipalities, for the purpose of sharing information and alignment. (Interviewee, 7) b) A number of sustainable roof technologies are available in the market (Interviewee 5). c) The neighborhood initiatives provide practical examples and models for citizens to replicate (Interviewee 5). d) The concept of sustainable roofs is a novel idea, and it needs time and resources for expansion. Further, the practices are under learning (Interviewee 5, 7).	a) Differences in the perceptual filter of individuals representing agencies contribute to the variation of information/interpretations. So despite the transfer of information, the level of information varies between actors and levels (Interviewee 6). b) Existing solutions must become more sustainable, such as reducing the use of plastics. Therefore, innovation is imperative. Many green roofs are not compatible with the existing structure of the building (Interviewee 5). c) Less knowledge is available about sloppy roofs than flat roofs design and technologies (Interviewee 7). d) The market for related technologies is still young; more research is needed to make

		them adaptable to the ground (Interviewee 5). e) Citizen awareness of climate change is not sufficient, and engaging (interviewee 6, 7). f) The project is hindered by citizens' lack of information and urgency. Building contractors, businesses, and citizens awareness of NbS is needed for informed contributions (Interviewee 7). g) Citizens' trust in technology is not sufficient (Interviewee 7). h) The need for collaborative events for stakeholders to share information and developments was raised. Creating a network of municipalities/cities to share and learn was suggested, for sharing knowledge between municipalities/cities (Interviewee 5, 7).

Table 24: Governance factors in the adoption of NbS in Utrecht

Cases	Success factors	Failure factors
Case 1: The Utrecht Bio washing machine	a) The project goal was achieved and the project was rated highly aligned with the related climate policies (Interviewee 1, 2, 3, 4). b) Decentralized decision-making processes led to smooth decisions at the city/municipal levels, and shortened bureaucratic processes (Interviewee 1,) c) The policies' flexibilities are considered to be drivers. The flexible policies helped the project to be innovative and accommodate a risk-based approach (Interviewee 1, 2). d) The municipality was the owner and driver of the project. The governance structure was clear, and partners were engaged to provide expertise and advice (Interviewee 1, 2, 3, 4).	e) Late engagement of actors, not everyone engaged from the beginning (e.g. the environmental team engaged at the late stage) (Interviewee 1, 4). f) Poor coordination of actors e.g. at the initial phase leads to challenges in project design and implementation. Project coordination was rated poor. However, gradual improvement in coordination occurred through learning from lessons. Coordination is closely linked to knowledge and information sharing (interviewee 1, 4). g) Sectoral and thematic silos exist, preventing integrated cross-level and cross-sectoral activities (Interviewee 1, 2). h) The private sector and businesses' engagement was poor and not direct, but public relations informed them. Though they should have been somehow financially involved (negotiations with shopping centers and beneficiaries to reduce financial and operational risks were needed so that users feel responsible) (Interviewee 1, 2, 4).

Case 2: Utrecht Sustainable roofs Project	a) The national agenda is broad and flexible. The National policies give a vision of climate-neutral and climate-adaptive cities. Hence, Municipalities have the opportunity to make their contribution and align themselves. Alignment of plans to long-term policies is rated as satisfactory (Interviewee 6). b) The water board provides an umbrella policy and supports subsidies to cities, and the municipal policies are accordingly developed and more space specific and action-oriented (Interviewee 7). c) The municipality capacity and financial resources is pretended to be better rather other municipalities to provide more subsidies (Interviewee 6, 7). d) A National Roof Plan is available that creates synergies among multiple actors (interviewee 7). e) A municipal-specific policy need for green roofs is expressed for informed decisions. Hence, Utrecht Municipality is examining a policy for green roofs below 25 and installing solar roofs above 25. Agreements with builders are under negotiation to make the process more efficient (Interviewee 7). f) Forming a multidisciplinary team from different municipal units and disciplines to enhance coordination. Coordination among actors was rated favorably (Interviewee 7). g) The existing strategies are accorded to be soft and flexible (assist and inform) and promoting soft cooperation as well (Interviewee 7). h) Citizen engagement is average. The Municipality supported subsidies to increase the adoption of practices by citizens (Interviewee 5,6,7). i) Decentralization facilitated decision-making at the municipal level. Communication modes to the provincial and national levels are	a) Climate adaptation policies require more resources and budgets. The municipality, however, has insufficient technical (human) and financial resources considering a city like Utrecht (Interviewee 7). b) While the water board is responsible for overarching policies pertaining to climate change adaptation, the city administration realized that the policies did not reflect the challenges facing the city. A meaningful link must be made between policies and needs (Interviewee 7). c) The lack of a national policy for green roofs, similar to the solar energy policy for roofs to help achieve an energy-neutral plan, was noted (Interviewee 7). d) Lack of policy clarity on how the two practices of green roof and solar roof could proceed in parallel (Interviewee 7). e) Citizens, building owners, and builders need to be informed and capacitated about green roofs', and costs and benefits (Interviewee 5, 7). f) The need for a policy to enforce owners' (give them responsibility) for greening roofs was noted (Interviewee 7).

	clarified in the policies (Interviewee 6).	

Table 25: Economic factors in the adoption of NbS in Utrecht

Cases	Success factors	Failure factors
Case 1: The Utrecht Bio washing machine	a) The project was fully financed by the municipality (interviewee 1, 2, 3). b) EU role in developing advancing monitoring techniques. The projects developed a monitoring system to reduce operating costs (interviewee 1,3). c) The information is publicly available on the websites and the project presented transparency (interviewee 1, 2, 3, 4).	a) Since the project is being owned, financed, and implemented by the municipality, it could pose the risk of not having buy-in from the beneficiaries (less of citizens' engagement) (interviewee 1, 3).
Case 2: Utrecht Sustainable roofs Project	a) Building owners provide financing for more than 50% as well as maintenance of the project, and the municipality provides subsidies up to 50%. People are willing to pay for NbS (interviewee 5, 6, 7). b) Subsidies are boosting adoption rates and progress (interviewee 6, 7). c) Transparency between actors was rated good (interviewee 5, 7). d) The intrinsic motive of private companies is also a drive to contribute to NbS projects (interviewee 5, 7).	b) Economically, buildings may become costlier when investing in their roofs, however, a detailed cost-benefit assessment is required for various designs. Hence, private companies (builders) appear to be less willing to invest (interviewee 7). c) Due to being a new concept, it takes time to be absorbed by citizens (interviewee 5, 6, 7).

Appendix 8: Success and Failure Factors of NbS in Leipzig

Table 26: Knowledge and information factors in the adoption of NbS in Leipzig

Cases	Success factors	Failure factors
Case 3: Leipzig Kletterfix Green Wall	a) To share information and knowledge, and to rethink and arrange capacity, the municipality is forming activity groups (community of practice) that bring science, policy, and practice together as a conglomerate (Interviewee 11). b) The NGO role has been effective as a mediator for the transfer of information between actors and citizens (Interviewee 8, 11). c) A national organization consolidates information on green roofs (Interviewee 11). d) Green roofs and green wall installation are standard processes and technology and technology is available in the market (Interviewee 8, 10, 11). e) The interviewees rated the innovation aspect as acceptable. This is mainly because of the partnership with an environmental non-profit organization (Okolowe NGO) for providing information, advice, and planning to citizens (Interviewee 11). f) In comparison, policy-level officers have easy access to science, while local employees and citizens may find it less straightforward (Interviewee 11). g) An integrated (multilevel, multi-sector) approach enhances access to the sciences (Interviewee 8, 9, 11). h) The provision of a demonstration site and outlining of the project value could build the trust of citizens (Interviewee 8, 10, 11).	a) Bureaucracy hinders the process of exchange and transfer of information from one agency to another (Interviewee 8, 9, 10). b) The transfer of information can also be hampered by individual habits and perceptions (Interviewee 9). c) Poor transfer of information. Giving priority to one's own agency hinders the transfer of information (Interviewee 11). d) Context-based creativity and design is limited (Interviewee 10, 11). e) Research on citizen science is required to accelerate the transition and inform the people (Interviewee 11). f) unadequate citizen trust, which needed to be enhanced by outreaching the benefits versus costs of technology. Further, cost benefit assessment is inadequately transmitted to citizens (Interviewee 8).
Case 4: Leipzig Lebendige Luppe Floodplain Restoration	a) Everyone sees the project's / landscape success as a demonstration model (Interviewee 12). b) The municipality is responsible for coordinating and sharing information across levels (Interviewee 12).	a) As a result of different perspectives/lenses, actors make different judgments, which causes information to be absorbed differently (Interviewee 12). b) Saxony's water reservoir and river basin state agency follow

	c) The levels closest to the operations have more information. The sharing of information is rated positively (Interviewee 13). d) The concept of the flood plain is an innovation. Innovation is rated as acceptable (Interviewee 13). e) The collaboration of multiple actors such as universities, research agencies, NGOs, and municipalities led to innovative concepts and designs (Interviewee 12, 13). f) The project has been reviewed and contributed to multiple studies and research (Interviewee 12). g) Due to the involvement of universities and research agencies, and a strong network of scientists, access to science is easy (Interviewee 12, 13). h) Citizens are engaged in the project through public relations and the city council votes for the project (Interviewee 12). i) The public's trust in the project is high (Interviewee 12).	conservative, centralized approaches, not fully in line with NbS thinking (Interviewee 12). c) Citizens are not directly involved in the project (Interviewee 12, 13).

Table 27: Governance factors in the adoption of NbS in Leipzig

Cases	Success factors	Failure factors
Case 3: Leipzig Kletterfix Green Wall	a) Existing multiple policies that support the initiatives and the alignment of short-term actions with policies are rated as acceptable (Interviewee 8, 9, 11). b) Establishing a clear working or communication mechanism and meeting regularly to review progress, is suggested as a need (Interviewee 8). c) NGO involvement to engage citizens was effective in coordinating and communicating, so the coordination process was rated average (Interviewee 8, 11). d) However, the need for improved cross-sectoral coordination (e.g. with builders, public agencies, and private companies) was still present (Interviewee 8).	a) Lack of incentives/subsidies to encourage owners to adopt the green facade. The adaptability of the project due to the lack of subsidies is low (Interviewee 8). b) A clear monitoring mechanism and measures need to be in place, but city officials noted that the cost and benefit assessment must be completed first (to determine whether existing social maintenance is enough) (Interviewee 8). c) Hierarchical barriers exist within the city office and actors, which affect smooth collaboration and communications (Interviewee 8). d) Sectoral thinking is a barrier to communication and integration approaches. There are silos of performance. Such as water, green

	e) Policies have been flexible toward NbS and rated positively (Interviewee 9, 11). f) The engagement of those who benefited is excellent since they paid for all the costs, while most citizens did not benefit or are not interested (Interviewee 8, 11). g) Private sector involvement is mandatory in policy development (Interviewee 8, 9). h) Alongside public relations and communication, prestige is a driving force for adoption (Interviewee 10, 11).	space, traffic, etc. Each has its own priority (Interviewee 8). e) It is assumed that green walls affect the quality of a structure and may reduce housing prices (Interviewee 8, 11). f) A clear platform for proper coordination and decision-making was lacking to address problems (Interviewee 8). g) Some of the actors were not involved in the process from the beginning, such as the fire department which had its own objective in the late stages (Interviewee 8). h) Bureaucracy resulted in more complexity of governance structure, and this resulted in a decision to take a longer time (Interviewee 8). i) Citizens' engagement and trust are lower, and project progress is very slow (Interviewee 8, 11). j) Lack of subsidies for the green wall projects, and only those who are really motivated benefit from the project. The municipality was paying only the consulting cost to the NGO (Interviewee 8, 9, 11).
Case 4: Leipzig Lebendige Luppe Floodplain Restoration	a) The project is aligned with the flood plain development concept of the State of Saxony, the German water framework directive, and Natura 2000. Further, clarity of policy and plans has eased communications and coordination (Interviewee 13). b) Multiple agencies are involved in this project, including universities, research institutes, public agencies, and NGOs (Interviewee 12, 13). c) Coordination between actors was rated as acceptable (interviewee 12). d) The long-term duration of the project has led to a convergence of actors on the points and a focus on the problem (Interviewee 12). e) The planning system works when everybody agrees. A consultative	a) The administrative bureaucracy hinders the smooth coordination of decisions on NbS and has reduced the flexibility of structures (Interviewee 13). b) Coordination with the State Agency for Reservoirs and River Basins is a challenge, and the state agency is less flexible for NbS (Interviewee 12). c) Citizens are not directly engaged in the project; hence community participation is indirect (Interviewee 12, 13).

	decision-making process takes place to assure plan is based on evidence and rationale that minimizes silo thinking (Interviewee 12). f) Policies and actors' structures are flexible for the project since all actors need each other to succeed. However, it is argued that the flexibility of structures is related to individual behaviors as well (Interviewee 12, 13). g) Citizen feedback is sought through festivals, excursions, and voting for highly significant issues within the city (Interviewee 12, 13). h) The project has continued for over 15 years, therefore continuity is a factor of trust and success (Interviewee 12, 13).	

Table 28: Economic factors in the adoption of NbS in Leipzig

Cases	Success factors	Failure factors
Case 3: Leipzig Kletterfix Green Wall	a) Project services end with consulting. It is more dependent on citizens' investment in green facades (Interviewee 11) b) Building owners and the private sector engagement in scientific discussions and policies are useful for absorption and deeper understanding of ecological and economic benefits (Interviewee 11, 8)	k) The adoption rate is very slow (Interviewee 8) l) The lack of incentives/subsidies makes it less demanding, or there is no specific policy at the city level to provide subsidies to encourage the green wall (Interviewee 8, 11) m) Maintaining and watering green walls requires more budget. Lack of clear information about maintenance is another risk (Interviewee 8) n) Less attention of private investment and the owners and builders to invest (8, 9, 11) o) Limitation in sharing information that hinders transparency. Hence, the project requires proper review, reporting, and sharing of experiences for effective decision-making (Interviewee 8).
Case 4: Leipzig Lebendige Luppe Floodpl	a) 75% budget comes from the state government and 25% from city-level agencies/implementing partners (Interviewee 12, 13) b) Public participation and outreach, exposure, and exchange are tools	a) Some bureaucratic process hinders smoothen sharing of information (Interviewee 13)

ain Restoration	for increasing transparency (Interviewee 12) c) The municipality monitors the project and reports as necessary (Interviewee 13)	

Appendix 9: Factors of Success and Failure of NbS Absorption in Cities

No	Success Factors	FRQ	Failure Factors	FRQ
1	Citizen's Engagement	8	Less Citizens' Awareness (cost/benefits)	7
2	Multiple Sectors/Partners Collaboration	8	Poor /late Engagement of Actors or Citizens	7
3	Clear Information sharing / Mechanism	6	Bureaucracy (Administrative) hinders information sharing	5
4	Municipal Finance and Subsidies	5	Poor Information Sharing / Mechanism	5
5	Municipal Plans Alignment to Policies (existence of policies)	5	Limited Citizens' Trust / Adoption	4
6	Novelty of Concept / Innovation	5	Limited Municipal Finance and Subsidies	4
7	Policies Flexibilities	5	Differences of Perceptual Filter (hinder info sharing)	3
8	Private Sector Engagement / Investment / Intrinsic Motive	5	Lack of Policy or Clarity in Policies	3
9	NGO Collaboration / Advisory Service to Citizens'	3	Less Collaboration and sharing info	3
10	Practical Example (demo site)	3	Silo Thinking Orientation (Sectoral, Thematic)	3
11	Strengthened Coordination / set-up	3	Absence of Innovations (context based)	2
12	Transparency / Public Availability of Info	3	Citizens Not Directly Engaged	2
13	Decentralized Decision-Making	2	Conservative and Centralized Approach (to NbS)	2
14	Monitoring System	2	Higher Cost of NbS	2
15	National Plan Existence	2	Insufficient Research / Less Knowledge Availability	2
16	Robust/Easy Communication Mechanism	2	Poor Coordination	2
17	Technology Availability	2	Complexity of design	1
18	Citizen's Financing	1	Complexity of Governance Structure	1
19	Clear Governance Structure	1	Gap between Policies and City Needs	1
20	Community of Practices for Capacity Building	1	Immature Market of Technology	1
21	Consolidates Information National Wide	1	Lack of Monitoring Mechanism	1
22	Consultative Planning phase (Enriched Discussion)	1	Lack of Urgency for Information	1
23	Contribution to Researches	1	Limitation of Research on Citizen Science	1
24	Cooperation	1	Limited Human Resources	1
25	Easy access to science	1	Limited Private Sector Investment	1
26	Human Resource Capacity	1	Risky Operational Procedures	1

27	Informed Operation Team	1	Separated (Fragmented) Communication	1
28	Learning and Co-practices	1		
29	Long Duration of Project (Less difference in actors idea more closer)	1		
30	Multidisciplinary team	1		
31	Partners Finance	1		
32	Reduced Operation Cost	1		
33	Shortened Bureaucratic Processes	1		
34	Standardized Process of Installation	1		
35	State Finance	1		
36	Synergies between Policies and Actors	1		