FACTORS INFLUENCING THE IMPLEMENTATION OF NATURE-BASED SOLUTIONS IN DUTCH CITIES

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MSc Thesis

TU Delft

"The greatest threat to our planet is the belief that someone else will save it." (Acciona, n.d.)

by

Robert Swan

Factors influencing the implementation of Nature-Based Solutions in Dutch cities

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Acknowledgements

Before you lies my thesis that I wrote over the past several months to graduate from my Master of Science in Complex Systems Engineering and Management at Delft University of Technology. With this thesis, my university experience comes to an end with a topic dear to me. I have always been interested in addressing sustainability challenges, and during my minor in Architecture I discovered a passion for designing urban spaces. Nature-Based Solutions combine both of these interests.

With climate change impacting all life on Earth and biodiversity declining at unprecedented rates, these interconnected crises must be addressed. Nature-Based Solutions offer cost-effective and resource-efficient approaches that are inspired and supported by nature, capable of delivering a wide range of social, economic, and environmental benefits simultaneously. Despite this potential, their implementation remains limited. This research therefore explored which barriers and drivers influence the implementation of NBS in Dutch cities, as well as formulated strategies and measures that can help with successfully realizing future Nature-Based Solutions projects. However, these results could not have been achieved without the help of others.

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I hope you enjoy reading and get inspired!

Julia Klapwijk

Delft, November 2025

Executive Summary

Problem statement

Cities worldwide are increasingly confronted with the impacts of climate change and an unparalleled decline in biodiversity. This has led to a growing interest in the use of Nature-Based Solutions (NBS), which are multi-purpose solutions, inspired and supported by nature, that aim to address societal challenges by protecting, sustainably managing, and restoring natural and modified ecosystems. Due to their multifaceted character, they are able to adapt to local needs and can simultaneously provide a range of social, environmental, and economic benefits. Although their potential and need have been acknowledged, their implementation in Dutch cities remains limited due to a deficient understanding of the factors that influence their adoption as well as the absence of guidance on how to overcome barriers, harness drivers, or implement strategies and measures that can support NBS uptake. Therefore, this research aims to address this knowledge gap by answering the following question:

"What are the factors influencing the implementation of NBS in Dutch cities, and how can these factors be integrated into a guiding implementation framework to support the adoption of NBS?"

Methodology

To answer this question, the design science research approach was employed. First, a review of grey and academic literature was conducted to analyze existing NBS frameworks used during the planning and implementation phases to derive insights into the characteristics such frameworks should possess. A second review identified the barriers and drivers influencing NBS adoption, the strategies and measures that can address these factors or generally facilitate implementation, and the principles that support sound practice. Based on these findings, hypotheses were formulated and explored through ten semi-structured interviews with experts, including both academics and practitioners. These interviews examined whether the factors identified in the literature also arise in practice within Dutch cities and helped contextualize their influence. Interviewees further provided requirements for the framework, complementing the literature-based findings. The interview data were analyzed using thematic analysis. Drawing on all collected insights, the Seeds of Change Framework was developed by synthesizing and visualizing the findings, resulting in a guiding implementation framework to support stakeholders in adopting NBS. Finally, the framework was applied to several illustrative cases to demonstrate its practical relevance and added value in facilitating NBS implementation.

Results – Framework requirements

Certain **characteristics** were identified to be recurrent in NBS frameworks. Most frameworks specify the framework's type, nature, purpose, value, during which phase(s) of the urban planning process the framework should be used, and what the intended use and target user group are. For the framework's application, some recommended a specific governance approach that can be followed. Content-wise, an important element found is the distinction between context, process/activities, and outcomes. For a barriers and drivers approach, organizing them into themes and assigning a relevance level to each factor can provide clarity and overview. Frameworks that included strategies or measures formulated these in the imperative form to communicate action while avoiding the assignment of responsibilities to specific parties. In addition, the text incorporated in the frameworks is formulated concisely. All frameworks are accompanied by supplementary material, often including expert commentary and real-life cases, to support practitioners in their application. Overall, the frameworks strived to achieve a balance between text and visual elements. Interviewees mentioned relatively similar elements. They underscored the importance of stating for whom the framework is intended and selecting a format

that fits with these users by reasoning from a Theory of Change. Moreover, usability in terms of word choice, size, and required attention span was highlighted, implicating that sentences should be kept concise and that jargon should be avoided. It was also noted that summarizing the findings first could help keep the content manageable and maintain the reader's focus on the most important elements, while more in-depth explanations could be provided in subsequent sections. The importance of including visual elements, such as flow charts, to complement text was also stressed. Lastly, many participants pointed out that the use of examples and references is helpful.

Results – Influencing factors

Both literature and experts indicated that the influencing factors can typically be classified across the themes of social and cultural, governance, informational and technological, physical and ecological, financial, political, and legal. The following factors were considered important by interviewees.

- Within the **social and cultural** domain, awareness and understanding, acceptance and support, and interests and priorities vary among citizens and can be addressed by employing several strategies, including informing citizens about NBS and their benefits, framing NBS in ways that align with citizens' values and priorities, stimulating citizen-led initiatives, and letting citizens participate in multiple forms, ranging from incorporating citizens' perspectives to co-creation and active involvement in maintenance. Drivers within this domain include the ability of NBS to enhance citizens' quality of life and to foster a sense of place and ownership.
- When it comes to **governance**, limited collaboration between departments, organizations, and sectors hinders NBS adoption. To foster multi-stakeholder collaboration, the use of co-creation and communication tools, the establishment of construction or thematic groups, and the strategic linking of NBS to urban agendas can be of help. Moreover, assigning responsibility to stakeholders, through multi-level governance structures, national or municipal leadership, or citizen-led stewardship, is vital. While formal networks can serve as platforms for connecting practitioners, exchanging knowledge, and facilitating cooperation on NBS projects, informal personal relationships also play a critical role in driving collaboration.
- For the **informational and technological** aspects, key factors include data availability, expressibility, measurability, and predictability, as well as the presence of appropriate tools. Although data on NBS is becoming increasingly available, several barriers persist: lack of open access to data, the absence of a data overview, the challenge of expressing certain variables quantitatively or monetarily, difficulties in identifying the right tool for specific purposes, and the fact that existing tools often only offer a snapshot of NBS outcomes. To address this, several strategies can be employed, such as developing a comprehensive data overview, using averages or proxies in calculations, combining qualitative and quantitative methods, creating an overview of available tools, and employing scenario modeling to explore long-term effects. Moreover, Urban Living Labs can help with knowledge generation and data collection and catalogs with example NBS projects can help practitioners learn about the possibilities.
- Within the **physical and ecological** system, the benefits delivered by NBS, including increased air quality, enhanced biodiversity, and reduced flood risk, serve as key drivers for their adoption. Moreover, the inherent adaptability and multifunctionality of NBS further promote their implementation. However, the general lack of space within cities, limited availability of suitable locations, existing systems in place, and maintenance requirements form hindrances. To address these barriers, strategies like assigning multiple functions to NBS, optimizing soil use, implementing hybrid solutions, and using zero maintenance species can be of help.

- Within the **financial** realm, the (maintenance) costs is an important factor. While some argue that the costs are higher, others point out that the percentual difference is minimal, especially given the increase in property value. Making a strong business case is also experienced as challenging: while NBS provide an array of benefits, they are difficult to express in monetary value and are often enjoyed by others than those who bear the costs. Next to this, financial flows within governments are often separated for each department. Combining departmental financing streams, establishing co-financing models, using subsidies, and comparing the costs of NBS with grey solutions, are strategies that can aid in addressing these factors.
- For the **political** theme, the existence of political interest in and prioritization of NBS is vital for its adoption. Participants indicated that NBS are currently not often on the priority list of politicians. To create a supportive political landscape and reduce vulnerability to political cycles, a helpful strategy would be to embed NBS in long-term planning frameworks. Equally important is the presence of supportive and coherent policies for NBS, of which both the Netherlands and the EU have some in place. Despite this, interviewees felt that the current set can be expanded and that cities can take inspiration from each other's policies.
- Lastly, factors within the **legal** landscape are of influence. Land ownership can act as a barrier, as governments have limited say over what private property owners should implement, and quite a large area of the city is privately owned. Another important factor is the regulations in place, of which some currently make NBS implementation difficult or impossible. However, there are also several supportive regulations in force in the EU and various Dutch cities, of which the latter can serve as measures that can be copied in other cities: implementing a no loss or biodiversity net gain regulation, creating a NBS point system, mandating the inclusion of greenery/water storage, or mandating pavement removal.

Results – Seeds of Change Framework

The insights from literature and experts are synthesized in the Seeds of Change Framework, which is a guiding implementation framework that enables users to systematically identify the barriers and drivers that influence their NBS projects, as well as select the strategies and measures that can be applied to address these factors or to generally stimulate implementation. In addition, it highlights the principles that should be followed to ensure sound practice. The primary application of the framework is prospective, guiding decision-making and design during the planning and implementation phases of NBS projects, but it can also be applied retrospectively to evaluate what went well, identify areas for improvement, and draw lessons for future projects. The framework consists of three chapters. The first chapter introduces the framework by explaining NBS, the necessity of the framework, what it does, who can use it, what it looks like, and how it can be used. This is followed by the second chapter that contains tables for identifying barriers and drivers, selecting strategies and measures, and becoming aware of principles. The first table lists influencing factors for which stakeholders must identify whether they function as a barrier, driver, or both. Next, the framework asks stakeholders to assess the relevance of each factor. The following column refers to numbered strategies and measures that can be selected to address each factor. Separate tables list the strategies and measures as well as the principles, each with a unique number. The third chapter provides one-line definitions for each factor, along with expert comments and illustrative cases for selected factors. The illustrative cases are realized NBS projects that show how the content of the framework can be found in practice.

Contributions to literature

The thesis contributes to literature by providing a comprehensive understanding of the barriers and drivers that affect NBS implementation in Dutch urban contexts, the strategies and measures that can

be applied to address these factors or generally support implementation, and the principles that can be followed to ensure sound adoption. It is novel in that it focuses on NBS specifically, considers the Dutch urban context, identifies all factor types within a single study, and treats all of them with equal importance. In doing so, the research also contributes to explaining the existing implementation gap. Moreover, testing hypotheses on these factors revealed which of the factors identified in literature play a part in practice within Dutch cities. It also showed that some factors previously assumed to be barriers can in fact act as drivers, or even both, and vice versa. The nuances in experts' responses as well as the (subtle) differences in perspectives among participants, further confirmed that factors are highly context-dependent. Finally, the study contributes to the landscape of NBS frameworks that can be used during the planning and implementation phases of projects. By incorporating all factors into a single tool, the thesis provides an implementation framework that can guide stakeholders toward more widespread and successful NBS implementation.

Recommendations for practice

For stakeholders involved in the planning and implementation of NBS projects, it is recommended that they become aware of the most critical factors. Each stakeholder group should act on this knowledge in ways that align with their specific roles, responsibilities, and capacities, addressing the factors they are best positioned to influence. Regarding the use of the Seeds of Change Framework, it is advised that all involved stakeholders apply the framework at the start of the project to create a shared understanding of the influencing factors. As application of the framework is limited by the knowledge and experience of its users, they should collect and analyze data to verify their assumptions about potential barriers and drivers. Before applying the framework to current NBS projects, stakeholders are encouraged to first use it retrospectively on a completed project in which they were involved to gain hands-on experience with the framework as well as to practice critical reflection.

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List of Abbreviations

BGI	Blue and Green Infrastructure(s)
CoSEM	Complex Systems Engineering and Management
DSR	Design Science Research
EC	European Commission
EIA	Environmental Impact Assessment
ESG	Environmental, Social, and Governance
EU	European Union
ES	Ecosystem Service(s)
GHG	Greenhouse Gas
GI	Green Infrastructure(s)
IUCN	International Union for Conservation of Nature
LID	Low Impact Development
NBS	Nature-Based Solution(s)
NGO	Non-Governmental Organization
PPP	Public-Private Partnership
SDGs	Sustainable Development Goals
UHI	Urban Heat Island
ULL	Urban Living Lab
UN	United Nations
WSUD	Water Sensitive Urban Design

1. Introduction

1.1 Cities progressively faced with challenges

Cities are increasingly grappling with environmental challenges, with two of the most significant issues being climate change and a loss of biological diversity (United Nations, n.d.-a; Generation Climate Europe, 2024). With projections suggesting that the population share that lives in urban areas will increase up to 66% by mid of this century, this urban expansion will further draw on natural resources, which will have severe effects on ecosystems and their services (Kabisch et al., 2017).

Climate change has led to an increase in the probability of occurrence and magnitude of extreme weather events, more health risks, a loss of species, and decreasing water availability and crop yield (United Nations, n.d.-a). With climate change heavily impacting cities and their basic services, housing, infrastructure, health, and human livelihoods, cities need to play a key role in climate mitigation and adaptation measures (United Nations, n.d.-b; European Commission, n.d.-a; United Nations, 2024b). These measures are required for achieving the climate targets outlined in the Paris Agreement (United Nations, n.d.-c; United Nations, 2024a).

The second problem cities are concerned with is a strong decline in biodiversity. The main driver for this is a loss of natural habitats due to further urbanization (United Nations Environment Programme, 2020). Nevertheless, decreasing biodiversity is also a consequence of climate change. Currently, the rate of biodiversity loss is approaching numbers that can only be found during a trickle of cataclysmic events in the fossil record. A well-functioning ecosystem depends on biodiversity to deliver its various services, including the provision of fresh water, clean air, food security, fuel sources, and natural medicines as well as the regulation of diseases, crop pests, and the quality of air, water and soil (World Health Organization, 2025). With biodiversity loss accelerating at an unprecedented rate, these vital services are threatened and public health risks are exacerbated, particularly in cities (Connop, 2016).

1.2 Nature-Based Solutions as promising measures

A potential solution for addressing these challenges is Nature-Based Solutions (NBS), which are multi-purpose solutions aimed at addressing societal challenges by protecting, sustainably managing, and restoring natural and modified ecosystems (International Union for Conservation of Nature, n.d.-a). The solutions are supported and inspired by nature, allowing them to bring more, and more diverse, nature and natural topographies and processes into cities (European Union, n.d.). Due to their multifaceted character, they are able to adapt to local needs and can provide a range of social, environmental, and economic benefits. Thereby, they help build resilience while being resource-efficient and cost-effective. An impression of the key benefits that these solutions can deliver in cities is shown in Figure 1. Their ability to provide multiple benefits also denotes that urban NBS have many beneficiaries, including residents, governments, public sector institutions, utility, energy, and transport companies, property and landowners, local businesses, and real estate developers (United Nations Environment Programme Copenhagen Climate Centre, 2024). There are many types of NBS, which can be adopted in cities at different spatial scales (Castellar et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024). Examples at the building level include green roofs and walls. Along streets and water bodies, measures such as street trees and bioswales can be applied. At the city scale, urban parks and forests can be implemented.

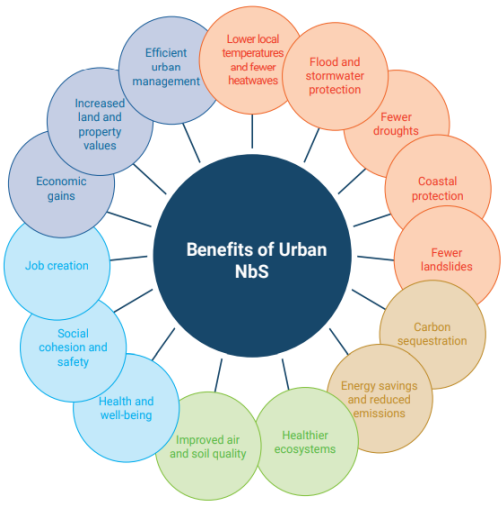

Figure 1 Benefits of NBS in cities (United Nations Environment Programme Copenhagen Climate Centre, 2024)

To express the potential of NBS with statistics, the measures can contribute to 30% of the global required mitigation, remove at least 5 gigaton of CO_2 equivalents per year, and reduce the intensity of climate hazard by 26% (International Union for Conservation of Nature, n.d.-b). When it comes to biodiversity, an average increase of 67% in local species richness is associated with NBS (Key et al., 2022). Moreover, investing in NBS could create up to 32 million new jobs and can lower the economic cost of climate change and biodiversity loss substantially, which is of importance as the global economic impact of these trends within the next years is expected to amount to 38 trillion dollars and 10 trillion dollars a year respectively (International Labour Organization et al., 2024; International Federation of Red Cross and Red Crescent Societies & World Wide Fund for Nature, 2022; Hart, 2024; World Health Organization, 2025).

1.3 Research context

The geographical focus is on Dutch cities due to both their need for and interest in NBS. To begin with, the Netherlands' low elevation levels and densely populated cities require climate measures to decrease, prevent, and prepare for the probability and impact of extreme weather events. With 59% of land surface being prone to flooding and being inhabited by almost 70% of the population, including 26% of land that lies below sea level, flooding is considered one of the worst disasters that can hit the country in terms of consequences (Netherlands Environmental Assessment Agency, n.d.). In addition, many Dutch cities are subject to the Urban Heat Island (UHI) effect, meaning that they experience significantly higher temperatures than surrounding rural areas due to the prevalence of man-made materials that absorb and retain heat, as well as increased anthropogenic heat production resulting from intensified urbanization (Steeneveld et al., 2011; Mohajerani et al., 2017). This phenomenon is amplified by the Netherlands being the fifth most densely populated country in the world (Ritchie & Mathieu, 2019). Figure 2 and 3 illustrate these statements by showing the flood-prone areas and the summer-average daily maximum UHI map. Moreover, the Netherlands is one of the world's leaders in biodiversity loss, mainly caused by land use changes and high nitrogen pollution in the country (Soons et al., 2022). As many species have been lost and remaining populations of species are exceedingly small, restoration of plant and animal populations, including their living conditions, is crucial.

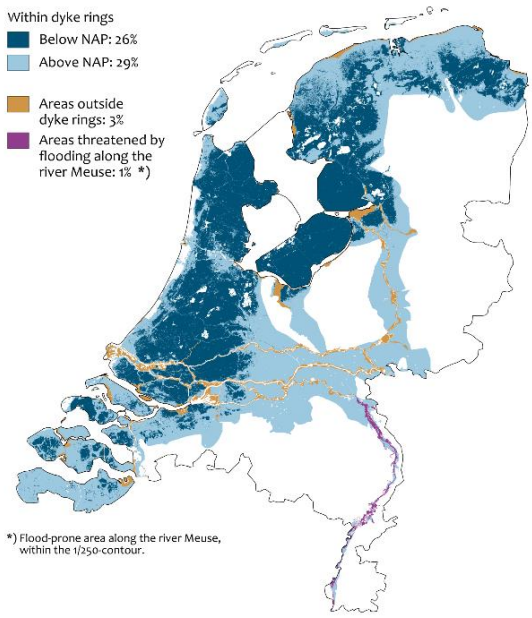

Figure 2 Flood map (PBL Netherlands Environmental Assessment Agency, n.d.)

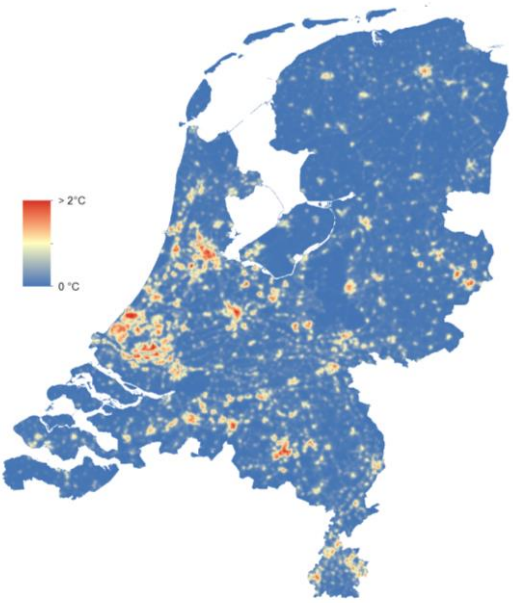

Figure 3 UHI map (Lauwaet et al., 2018)

Earlier, the global potential of NBS was revealed, but the measures also drastically contribute to solving various environmental challenges, including the ones stated above, in the Netherlands (De Knegt et al., 2024). A recent modeling study demonstrated that adoption of NBS on the national scale can have a significant impact on the quality of water bodies (+34 %), sustainability of agriculture (+24 %), protection and restoration of biodiversity (+22 %), quality of the living environment (+13 %), climate change (+10 %), and the energy transition (+2 %). It was also discovered that the measures can help achieve various sectoral policy targets at global, EU, and national levels.

This sense of urgency to take action and the potential of NBS have been recognized by the Dutch government, who desires for the Netherlands to become a global leader in NBS (International Union for Conservation of Nature, 2023). This has resulted in the establishment of a national knowledge and innovation program titled NL2120, which is a consortium consisting of several companies, knowledge institutes, and governments in which resources and expertise regarding NBS are pooled (Government of the Netherlands, n.d.). The program's purpose is investing in research in combination with gaining experience in various projects to discover how NBS work, how innovative revenue models can be formed for them, and how a societal transition process towards these measures can take place.

1.4 Research objective

However, despite growing recognition of their potential, the implementation of NBS in Dutch cities remains limited due to various barriers (PBL Netherlands Environmental Assessment Agency, 2023). These barriers range from technical challenges and insufficient financial investment to governance obstacles and limited citizen engagement (Dorst et al., 2022). To accelerate NBS adoption, it is essential to have an understanding of the barriers and drivers that influence NBS implementation in the Dutch urban context to be able to develop strategies and measures that can help with overcoming the barriers and leveraging the drivers. However, successful employment of NBS also depends on the presence of structured frameworks that can help facilitate the realization of NBS (Wickenberg et al., 2021; Voskamp et al., 2021). Such tools can aid practitioners in designing and streamlining their NBS projects, for instance by identifying suitable NBS or enabling collaborative processes (International Union for Conservation of Nature, 2020a). Without this guidance, stakeholders risk NBS being

inconsistently applied, failing to deliver their full potential, or not being implemented at all. Therefore, the objective of this study is to identify and contextualize the barriers and drivers that influence NBS adoption in Dutch cities as well as to discover strategies and measures that can be implemented to address these factors. In addition, the research aims to integrate these insights into a framework designed to support stakeholders in the planning and implementation of NBS projects in Dutch cities.

1.5 Outline of the research

The thesis is structured as follows. Chapter 2 delves into the current state of science regarding NBS, the factors that influence their implementation, and the frameworks that stakeholders can utilize during the urban planning process of NBS. This review revealed several knowledge gaps that have led to the formulation of the main research question. Next is Chapter 3, outlining the research approach that will be followed, the sub-questions that are required for developing an answer to the main research question, and the methods that will be employed for each sub-question. Subsequent chapters discuss the results of each sub-question. Chapter 4 analyzes existing NBS planning and implementation frameworks to identify requirements that the framework to be developed must fulfill. While Chapter 5 presents the literature review on influencing factors, Chapter 6 discusses which of these factors were considered important by experts in the Dutch urban context. This is followed by Chapter 7, in which the framework is developed by synthesizing and visualizing the results. It also shows the practical application of the framework by means of illustrative cases. The results are discussed in Chapter 8, after which the study's limitations are explained and suggestions for further research are provided. The thesis concludes with Chapter 9 by answering the research questions, stating the contributions to literature, and presenting recommendations for several stakeholder groups.

2. Literature review

This chapter presents insights from literature on NBS. Section 2.1 explains the search and selection process that was followed to conduct this review. Section 2.2 reviews the academic knowledge base, starting with what NBS entail and their potential benefits and concerns, followed by the factors that influence their adoption, and concludes with the frameworks that can be consulted during their urban planning process. Subsequently, Section 2.3 identifies the research gaps that this thesis aims to address as well as formulates the main research question that guides the research process. Then, Section 2.4 examines the academic and societal contributions of the research. Section 2.5 concludes by explaining how this study is related to the Complex Systems Engineering and Management (CoSEM) program.

2.1 Search and selection process

To initiate the research, a literature review was conducted using the Scopus database, focused on articles regarding NBS for urban climate adaptation and mitigation and biodiversity enhancement, the factors that influence the implementation of these measures, and the frameworks that steer this implementation. The following search strings were employed for Section 2.1 to 2.3, respectively:

- Nature-Based AND Solution OR NBS OR natural AND solution AND urban AND climate AND resilience OR urban AND climate AND adaptation OR urban AND climate AND mitigation OR urban AND biodiversity OR benefit OR advantage OR service OR cost OR disadvantage
- Nature-Based AND Solution OR NBS OR natural AND solution AND urban AND climate AND resilience OR urban AND climate AND adaptation OR urban AND climate AND mitigation OR urban AND biodiversity AND implementation OR barrier OR challenge OR difficulty OR driver OR enabler OR opportunity OR lesson OR strategy OR measure OR policy
- Nature-Based AND Solution OR NBS OR natural AND solution AND implementation AND framework OR guideline OR tool

The articles were selected based on their availability as open access and their publication in English. Moreover, to ensure this literature review reflects state-of-the-art research, only articles, reviews, and books published from 2016 onward were included in the initial selection. In addition, snowballing was utilized to expand the collection of sources, which involved reviewing key articles to find additional, foundational studies.

2.2 Academic knowledge base

2.2.1 Nature-Based Solutions

2.2.1.1 Discourse on definitions

The concept of NBS was first introduced in 2008 and up until now many definitions, varying in the scope and types of interventions that can be classified as NBS, have been put forward (Castelo et al., 2023; Sowińska-Świerkosz & García, 2022). The European Commission (EC) considers 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” (Almenar et al., 2021). Another commonly used definition has been put forward by the International Union for Conservation of Nature (IUCN), who view NBS as “actions to protect, sustainably manage, and restore natural and modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” (Cohen-Shacham et al., 2019).

Although these definitions are frequently quoted, the academic discourse on NBS definitions is wider, with scholars often providing their own perspective in their research on what they consider NBS. While some academics, like Haase et al. (2017) and Short et al. (2019), keep their formulation relatively close to the organizational definitions, others take a different route. Some of them highlight the governance aspect of employing NBS, including Frantzeskaki (2019), who acknowledges NBS as "being powered by nature and restoring natural flows in cities, creating novel ecosystems that require multi-actor collaborations for their design and sustainability". There are also scholars that highlight the challenges NBS tackle, such as Padma et al. (2022), who define NBS as "innovative solutions, which are inspired from nature, and applied to contemporary societal problems such as climate change, overtourism, poverty alleviation, and so on". A final example of an approach that can be taken is the description of Langergraber et al. (2020), who state that NBS can "provide a range of ecosystem services beneficial for the urban biosphere such as regulation of micro-climates, flood prevention, water treatment, food provision, and more".

2.2.1.2 Origin of varying definitions

However, all of these definitions are viewed as somewhat general and blurry, leaving NBS as an open concept and hampering its mainstreaming into urban planning (Kabisch et al., 2016; Dorst et al., 2019). This ambiguity is the result of three reasons (Sowińska-Świerkosz & García, 2022). To begin with, experts from multiple scientific fields work with NBS and think about it from their discipline's point of view. Moreover, there is a tendency to mix related actions, like Ecosystem-Based Approaches, and Green Infrastructures (GI), with NBS (Dorst et al., 2019; Nesshöver et al., 2017). Because of this, many authors have proposed NBS as an umbrella concept under which the aforementioned terms fall (Corgo et al., 2024; Almenar, 2021). Although the approaches share common characteristics, each concept has its own nuanced definition and a specific focus. In the case of NBS, the added value resides in their ability to provide multiple benefits as well as in their integrative, systemic approach (Nesshöver et al., 2017). Assigning these traits to NBS prevents the concept from becoming another 'green communication tool', as a mere re-labelling of business as usual would harm the understanding and effective use of both NBS and other concepts (Kabisch et al., 2017). Lastly, there has been a delay in establishing frameworks, standards, and guidelines for NBS adoption (Sowińska-Świerkosz & García, 2022). Due to the noteworthy lack of criteria, especially prior to 2020, numerous actions that were branded as NBS would today be regarded as complementary or related to NBS as they do not fulfil all the requisite criteria to be true NBS.

2.2.1.3 Towards one definition

Because of this, it is important to formulate a clear NBS definition for this thesis. After analyzing 20 descriptions, Sowińska-Świerkosz and García (2022) found that the actions can be identified by four elements: (1) being inspired and powered by nature, (2) addressing societal challenges and/or resolving problems, (3) providing multiple benefits, including biodiversity gain, and (4) being highly effective and economically efficient. As the definitions provided by the EC and IUCN are the most referenced, they are combined with these four elements to formulate a NBS definition that will be used throughout this thesis:

Box 1 NBS definition

Nature-Based Solutions are actions inspired and powered by nature to protect, sustainably manage, and restore natural and modified ecosystems within cities, landscapes and seascapes. The actions aid in addressing societal challenges and resolving problems in an effective, cost efficient, and adaptive manner, while simultaneously providing environmental, social, and economic benefits, including biodiversity enhancement.

With regard to defining NBS, another important aspect to touch upon is the difference between NBS and hybrid NBS, also requiring an explanation of grey solutions. Grey approaches are engineering infrastructures, mainly composed of concrete and steel, such as tunnels of the drainage system and dikes, which thus have a limited role in ecosystem functions (Xu et al., 2019; Kabisch et al., 2017). They are often not able to tackle the root causes of risk and can therefore increase the vulnerability of cities in the long-term. On the contrary, green and blue approaches, under which NBS can be categorized, consider biophysical aspects and ecosystems and their services. The approaches rely on existing or restored ecosystem functions and water bodies, of which wetland restoration and urban trees are examples. Hybrid NBS are a blend of biological-physical and engineering structures: while based on ecosystem functions, they are accompanied by engineered infrastructures. Some researchers consider these approaches the most effective strategy for reducing risk to hazards in the urban context (Kabisch et al., 2017; Xu et al., 2019). Moreover, they may provide the optimal impact taking into account environmental footprint, land requirements, and cost expenditures, but this can vary depending on the hazards and risk management level (Fink, 2016). Instances of hybrid approaches are bioswales, porous pavement, and green roofs (Kabisch et al., 2017; Luque & Arpon, 2024). In line with the chosen definition of NBS for this thesis, both hybrid NBS and 'regular NBS' are considered in this research.

2.2.1.4 Potential benefits and concerns

NBS are equipped to address multiple societal challenges simultaneously: climate change mitigation and adaptation, disaster risk reduction, economic and social development, human health, food security, water security, and reversing environmental degradation and biodiversity loss (Dunlop et al., 2024). Even though studies have been disproportionately skewed towards the climate and biodiversity crises, research focused on the other challenges has become more prominent in recent years. NBS attend to these issues by providing several benefits, including conservation of biodiversity, adapting to and mitigating the impacts of climate change, improving human health and well-being, increasing place attractiveness, and stimulating green economies and jobs (Raymond et al., 2017).

Nevertheless, NBS implementation also comes with some concerns, especially regarding equality and gentrification. While NBS often claim to address issues of social cohesion, socio-spatial inequalities, and unequal distributions of goods and burdens, there is little known about how they affect the health and wellbeing, livelihood, and living conditions in the mid and longer term of the urban poor (Haase et al., 2017). According to Woroniecki et al. (2020), an unequal distribution of NBS can exacerbate current inequalities, particularly in urban areas where disparities in access to green spaces are pronounced. Moreover, NBS can increase the property costs in the neighborhood in which they are implemented, with social displacement as a consequence. Another concern is that NBS may fall short of societal expectations due to limitations in their design, boundary conditions, or their target-driven application (Krauze & Wagner, 2019). This means that although NBS are multifunctional in essence, they require prioritization of certain Ecosystem Services (ES) over others to be able to sustain themselves, nature, and society, which could result in the public being unjustly disappointed in NBS.

2.2.2 Barriers, drivers, strategies, and measures

2.2.2.1 Research in the ecological domain

Even though these aspects influence the uptake of NBS, there is a wider list of factors, both barriers and drivers, that play a part in the roll out of these measures in cities. As NBS adoption still remains limited, it is important to analyze which barriers and drivers are present in a specific context as well as how they can be addressed. A multitude of studies have been performed to discover these factors, however, many of them are focused on the broader concept of climate adaptation and mitigation as NBS have not been gaining momentum until recently. One example is the study performed by Reckien et al. (2015), in which 200 cities across Europe have been analyzed to explore the barriers and drivers

to the development of urban climate change plans. It was found that factors like membership of climate networks and adaptive capacity can act as drivers, while factors such as unemployment rate and proximity to the coast can be seen as barriers. A similar study has been done by Lehmann et al. (2015), who analyzed the barriers and drivers for adaptation planning in cities from the viewpoint of municipal decisionmakers. They proposed a two-tier framework: the first-tier variables are resources, information, and incentives, which are each considered as a function of a set of second-tier variables, including the natural and socio-economic environment, the institutional environment, and the actor-specific characteristics of the decisionmaker. The framework was tested on cities in Latin America and Germany. More recently, Thaler et al. (2019) performed a study in which the drivers and barriers of adaptation strategies arising from flood and avalanche hazards were researched. Within this regard, the focus was on societal transformation by community-based initiatives. The influencing factors were derived for Austria, France, and Ireland.

However, there are also scholars who have focused their research efforts on the Dutch urban context. An example is Biesbroek et al. (2011), who looked into the barriers to climate change adaptation policies and practices by conducting a survey among experts involved in Dutch climate change adaptation projects. The results highlighted that conflicting timescales was considered the most important cluster of barriers and that other highly ranked barriers included unclear division of tasks and responsibilities, uncertain societal costs and future benefits, and conflicting interests. Uittenbroek et al. (2013) took a different approach and developed a conceptual model to understand the barriers and drivers that influence the mainstreaming of climate adaptation, as well as to explore strategies for overcoming the barriers and creating opportunities. The framework was applied to two Dutch case studies. Their model considers various categories of barriers and opportunities, including social, financial, technical, and organizational, for several policy stages. While the focus of this study was mainly on the factors that hamper or facilitate the adoption of climate adaptation measures, Dai et al. (2018) looked at three Dutch cities to discover which strategies municipalities employed to successfully integrate climate-adaptive building into urban water management and to derive valuable lessons for future projects. They did this by analyzing the cities' governance approaches on ten dimensions, including stakeholders involvement, engineering practices, and financial arrangements.

Furthermore, research on barriers and drivers has also been done on concepts related to NBS. Kim et al. (2017) focused their research on barriers and incentives of applying Low Impact Development (LID) practices in urban development by conducting a survey among stakeholders involved in the Energy Corridor District area in Houston. The results showed that decisionmakers considered the lack of incentives of applying LID practices and the lack of knowledge as major barriers. Therefore, education programs, financial incentives, and innovations in policy systems were considered to be successful to support the adoption of LID practices. Another concept for which this type of research has taken place is Water Sensitive Urban Design (WSUD), which has been studied in the context of South Australia by Sharma et al. (2016). Through employing a variety of research methods, they tried to unravel the drivers and impediments of the adoption of WSUD approaches. The identified enablers ranged from a need for improved management of stormwater flows to a desire to reduce water consumption. Some of the barriers that were found were the current policy framework in place for WSUD in South Australia, the limited capacity for the implementation and management of WSUD approaches, and the lack of understanding of the required maintenance tasks and costs for WSUD components. A similar study was conducted by Dhakal and Chevalier (2017), who focused on discovering barriers and formulating strategies for adopting a GI to manage urban stormwater by analyzing projects in 10 US cities and assessing the relevant policies. The findings showed that most barriers stem from socio-institutional arrangement and cognitive limitations. The suggested policies included conducting public education and awareness programs and changing governance structures.

2.2.2.2 Research in the NBS domain

Although the concepts discussed in the previous section are related to NBS, the unique characteristics of NBS mean that the factors identified in studies on those concepts do not directly apply. As this difference has been recognized by many scholars, the amount of studies done on the factors that influence NBS adoption has significantly increased in recent years. One example is the study by Sarabi et al. (2019), who identified key enablers and barriers to NBS implementation in urban settings by means of a systematic literature review. Some of the main barriers found were path dependency and institutional fragmentation, while some of the main enablers were knowledge sharing mechanisms and technologies and effective monitoring and valuation systems. A similar study was performed by Perrault (2022), who reviewed literature to identify thirteen key barriers of NBS adoption, including limited professional expertise and resources as well as public knowledge, performance and contextual uncertainty, a fear of negative consequences and operational unknowns, and insufficient interactions between key players. Another example of research that solely focuses on barriers is the study by Sarabi et al. (2020), who identified key barriers to NBS uptake in European cities and their relationships through a literature review, expert interviews, and a questionnaire. After discovering fifteen barriers, they identified interdependencies among the barriers and classified them into categories. Political, institutional, and knowledge-related barriers turned out to be the most dominant. A year later Sarabi et al. (2021) sought to identify the barriers of adopting Urban Living Labs (ULLs), which can be used as safe environments to test and co-create, for implementing NBS by means of stakeholder workshops and interviews in Finland, the Netherlands, and Italy. There are several similarities between this study and the previous, but also differences like the key role of collaboration across policy domains and scales as well as the important role that knowledge brokers and intermediaries play in adopting ULLs.

Although these studies provide overviews of the factors that influence NBS adoption, they mainly contain aggregated results that have been collected across literature or interviews and workshops with stakeholders from multiple countries. As implementing NBS is highly context-dependent, it can be argued that a better approach would be to analyze the barriers and drivers that are present in each country. This was proven by a comparative case study performed by Dorst et al. (2022), who analyzed the barriers that influence urban NBS implementation, as well as the structural conditions that shape these barriers, in multiple countries by means of expert interviews. Despite several barriers being observed across multiple cases, the nature of the barriers differs for each country. To illustrate this, limited citizen engagement is caused by low environmental awareness in Spain, while for the Dutch context NIMBY-ism is considered the culprit. Therefore, Dorst et al. (2022) suggests “moving beyond ‘silver bullet’-type approaches to addressing NBS mainstreaming barriers, towards systemic but context-sensitive responses, tailored to specific urban infrastructure regime”. Duffaut et al. (2022) took this approach and interviewed professionals working on implementing NBS in French cities to identify the barriers and levers that play a role in that context. Interviewees felt that the main barriers were a lack of knowledge, political will, financial resources, and regulations. As levers, they proposed the development of transdisciplinary research disciplines and on-field collaboration between all NBS stakeholders in cities, the adoption of funds for NBS and their regulatory implication, the execution of demonstrative examples of urban NBS, and education efforts. There are also scholars that specify their research even further by also focusing on specific NBS. One example of this is the study of Han and Kuhlicke (2021), who analyzed the barriers and drivers of implementing NBS for flood risks in South Korea by conducting expert interviews. Interviewees saw the direct monetary benefits, the cost-effectiveness, and the capacity to cope with flood risks as influential factors for the public and decisionmakers to opt for NBS. Peculiar barriers that were found were the lack of sufficient systems to integrate NBS in practice and the ideologicalization of NBS policy.

Next to discovering the barriers and drivers for each country, it is also important to come up with strategies and measures that are able to address them. It can be noted that in the previous two paragraphs the discussed studies paid minimal attention to this aspect, but there are scholars who did put this matter on the forefront. Faivre et al. (2017) provided an overview of the actions the EC has taken to increase the use of NBS in European cities and what additional actions are planned at the European Union (EU) level to promote NBS. The EU suggests building the evidence base, collecting experience and knowledge to develop a repository of best-practice examples, and creating a NBS community as well as public awareness. While these recommendations are based on many examples, there are also academics who have drawn lessons from single NBS projects. One instance is the study executed by Dartée et al. (2023) on the Urban Waterbuffer in Rotterdam, for which they analyzed the barriers and drivers that played a role in the project to provide seven lessons for adopting NBS for urban water management in the Dutch context. Some of these lessons were that the co-benefits of NBS need to be monitored, the current planning regulations and policymaking need to be changed, and the multi-functionality of NBS needs to be highlighted. Other studies have investigated the potential of a single solution in addressing barriers and/or drivers. Chappin et al. (2024) tried to unravel how networks can address various barriers, in the agriculture and construction sectors specifically, by conducting focus group meetings and interviews. It was found that broad network functions like knowledge sharing are able to address multiple barriers simultaneously, while targeted network functions like lobbying efforts are aimed at alleviating specific barriers. A similar study has been performed by Veraart et al. (2024), who looked at how spatial information can aid in removing barriers and fostering enablers of NBS adoption for food production and water resource management in Ghana and the Netherlands. The results showed struggles in making the future spatially explicit due to spatial information not being available for all relevant factors. Involvement of stakeholders in the process of creating this information was considered valuable in improving its adequacy.

2.2.3 Frameworks

An urban planning process typically concerns four different phases: strategic planning, implementing, maintaining and managing, and evaluating (Wickenberg et al., 2021). For each phase, various NBS frameworks with different foci have been developed. However, many frameworks can be used during multiple phases of the urban planning cycle.

2.2.3.1 Strategic planning

The first phase within the cycle refers to the evaluation, modeling, and employment of comparative approaches to inform strategic planning and policymaking. One example of a planning framework is the stakeholder-centered framework of ES trade-offs, shedding light on the stakeholders that are involved in urban planning trade-offs, which ES trade-offs are recurrent in spatial planning, what drives these trade-offs, and how stakeholders respond to them (Turkelboom et al., 2018). While this framework is focused on the decision regarding which ES should be prioritized when selecting NBS, Calliari et al. (2019) developed a trade-off framework that focuses on the choice between NBS and grey solutions by capturing the benefits and costs of the ES NBS can provide. There are also frameworks focused on the planning phase of specific NBS, for example on WSUD or urban farming (Kuller et al., 2019; Säumel et al., 2019). Whereas the former facilitates a geo-information science-based multi-criteria decision analysis to inform the placement of NBS, the latter deepens the socio-cultural and socio-economic dimensions of NBS by introducing a conceptual framework for so-called Edible City Solutions. Next to this, there are planning frameworks with a modeling nature, such as the spatial framework developed by Bellamy et al. (2017), which is based on habitat suitability models and health deprivation data to identify win-win opportunity areas that are most in need of NBS to support pollinator habitats as well societal health and well-being.

2.2.3.2 Implementing

While there are quite a few studies dedicated to developing frameworks for the planning phase, the amount of frameworks that address the implementation stage is quite limited according to Wickenberg et al. (2021). They analyzed seven implementation frameworks, of which half are also focused on strategic planning. The majority of the frameworks are conceptual or definitional in nature, such as the study executed by Cohen-Shacham et al. (2019). They compared the eight NBS principles that have been proposed by the IUCN to the principles stated in other ES-based frameworks to inform review and revision of the frameworks. An example of a conceptual framework is the one developed by Albert et al. (2019), which focuses on the actions that need to be taken in the domains of landscape planning and governance research to realize NBS. Connop et al. (2016) suggested another conceptual framework, which juxtaposes the potential benefits of urban GI against barriers of implementation to present foci for research and innovation. However, this framework is limited by solely containing six barriers that have been discovered during discussions with local authority planners. The need for a more in-depth focus on barriers from different perspectives was noticed by Deely et al. (2020), who developed a Barrier Identification Framework for implementing BGI. While this framework is more elaborate in the amount of barriers incorporated, it is established by conducting a literature review as the only research method, thereby aggregating the barriers and ignoring their context-sensitivity. The framework also does not include drivers or strategies and measures to address the barriers and drivers. However, several frameworks that offer guidance for NBS adoption exist. Van der Jagt et al. (2019) provide guidance for the co-creation of urban GI by engaging a broad range of stakeholders, whereas Raymond et al. (2017) propose a framework for implementing the co-benefits of NBS in urban areas.

2.2.3.3 Maintaining and managing

The third stage of the planning cycle is concerned with maintenance and management, which focuses on strategies and tools for managing ecosystems, natural resources, and infrastructures (Wickenberg et al., 2021). One instance is the analytical framework provided by Diduck et al. (2020), which explores how maintaining private urban gardens contributes to bridging the gap between the normative and cognitive connection between people and nature. Thereby, the study suggests that creating learning-focused private gardens can contribute to the enhancement of biodiversity and the delivery of NBS. An example of a conceptual management framework is the one developed by Accastello et al. (2019), which focuses on integrating NBS into risk management strategies. The framework is meant to be applied to contexts subject to natural hazards, particularly mountainous areas. A framework with a more quantitative output has been proposed by Seifollahi-Aghmiuni (2019), who developed a scoring framework to investigate whether and how wetland ecosystems and implemented management plans influence the Sustainable Development Goals (SDGs) and their targets. Application of the framework highlights synergies to be considered in wetland management and environmental governance.

2.2.3.4 Evaluating

It can be seen that the scoring framework also leans towards the evaluation phase of urban planning, which can be characterized by the assessment of implemented solutions (Wickenberg et al., 2021). Another example of a framework that can be used during both the management and evaluation stage is the Adaptive Gradients framework put forward by Hamin et al. (2018), consisting of eight gradients that can be used to evaluate NBS projects designed to increase coastal resilience. The framework is accompanied by a seven step iterative refinement process that researchers and practitioners should follow after project implementation, which is thus more focused on the management aspect. Another instance of such a framework is the assessment framework developed by Caroppi et al. (2024), which can be used to analyze the performance of NBS for reducing hydro-meteorological risks. The tool requires stakeholders to help select and apply key performance indicators for the (co-)benefits and

costs associated with an implemented NBS project. While these evaluation frameworks are focused on specific NBS, there also exist frameworks that are concerned with the assessment of NBS projects in general. One example is the framework brought forward by Chairat and Gheewala (2024), who have provided both an assessment framework for quantifying the performance of NBS interventions and a step-by-step guideline for evaluating NBS. The framework contains an ES assessment, a life cycle assessment, and a cost-benefit analysis.

2.3 Knowledge gaps and main research question

Despite a significant growth in the amount of research on NBS, the literature review has revealed that several knowledge gaps remain. While extensive studies have examined the barriers and drivers that influence the implementation of climate adaptation and mitigation measures, as well as the adoption of concepts related to NBS, NBS possess unique characteristics that distinguish their implementation challenges and opportunities. Although the body of research focused on discovering these factors for NBS has increased, those studies are geographically concentrated on locations other than Dutch cities. As NBS are highly context-dependent, there remains a clear gap in understanding the barriers and drivers that influence NBS implementation in Dutch cities.

Moreover, many scholars focus their research endeavors on identifying either only barriers or drivers and barriers. From the studies that contain strategies and measures, the focus is often on drawing lessons from existing projects, instead of formulating approaches that can tackle the core of NBS implementation in a certain context: barriers and drivers. While some scholars do use the factors that influence NBS implementation as a starting point for proposing strategies and measures, most only look at the factors that influenced the implementation of a single project or investigate the potential of a single (type of) solution for specific NBS. This while it is most valuable to recommend a plethora of strategies and measures based on barriers and drivers experienced by stakeholders involved in various urban NBS projects in the Netherlands. Furthermore, the approaches recommended in these studies are mainly based on barriers and not necessarily on drivers, while addressing these is equally important for the roll out of NBS. In addition, many studies examining the factors that influence NBS adoption tend to focus on either one factor or a combination of two, with relatively few addressing all elements: barriers, drivers, and strategies/measures. In the limited research that does consider all three, strategies and measures are often not given the same emphasis and are typically less detailed compared to the identification of barriers and drivers. Therefore, there is research required that puts all factors equally on the forefront and bases the formulation of strategies and measures on the drivers and barriers that have been found in the context being studied.

Lastly, many NBS frameworks are not concerned with the implementation stage, and to a lesser extent the planning stage, of NBS projects, despite these being crucial phases in the urban planning cycle. Most planning frameworks primarily focus on site or measure selection. However, making informed and meaningful decisions in these areas, and successfully completing the planning phase, requires an understanding of the barriers and drivers that influence NBS implementation, as well as insight into which strategies and measures can effectively address them or generally support the realization of NBS. A similar argument can be made for the implementation stage, as the likelihood of implementing a NBS project and its success depend on a continuous identification and addressment of the factors that impede and drive the adoption of NBS. Yet, among the limited number of NBS frameworks for the implementation phase, only a few explicitly address these influencing factors. However, these are all conceptual frameworks and only contain barriers and/or drivers, without providing strategies and measures that can address them. This while stakeholders involved in the planning and implementation of NBS need guidance and actionable insights on how to (successfully) realize their projects and how they can address the factors that impede or stimulate NBS adoption. Currently, there is not a guiding

implementation framework that enables stakeholders to systematically identify the barriers and drivers influencing their NBS projects and to select strategies and measures that address these factors or otherwise facilitate successful project realization.

In conclusion, there is need for a study that addresses these knowledge gaps. This leads to the formulation of the central research question of this thesis:

Box 2 Main research question

> *What are the factors influencing the implementation of NBS in Dutch cities, and how can these factors be integrated into a guiding implementation framework to support the adoption of NBS?*

2.4 Research relevance

2.4.1 Academic relevance

This research fills a significant gap in existing literature by offering insights into the barriers and drivers that influence NBS implementation in Dutch cities, as well as the strategies and measures that can help overcome the identified barriers, leverage the found drivers, or enable successful NBS implementation in general. By discovering these factors in a single study by means of expert interviews, a context-sensitive understanding of NBS adoption in Dutch cities will be generated. Moreover, the development of a guiding implementation framework that contains these results adds to the current landscape of NBS frameworks. There are limited NBS frameworks available that are designed for the planning and implementation phases of NBS projects and, within this small selection, there is a lack of frameworks that provide practitioners with clear actions to support NBS adoption. A framework that enables them to systematically identify the barriers and drivers influencing their NBS projects and to select strategies and measures to address them can help fill this gap. By delivering these results, the thesis touches upon the research domains of implementation science, sustainability transitions, and urban planning for NBS, contributing to the existing theories of these fields of study.

2.4.2 Societal relevance

Despite the potential of NBS and the need to implement them, their adoption in Dutch cities remains limited. The results of this thesis can assist stakeholders in identifying the barriers and drivers that play a role in the implementation of their NBS projects and can provide concrete actions to address these factors as well as enable the successful realization of projects in general. This will contribute to the further roll out of NBS in the Netherlands and the creation of climate resilient and biodiverse cities. Although the research will be grounded in and focused on the Dutch context, the results could be useful for cities in other countries as well. Urban areas worldwide are grappling with similar issues related to climate change and biodiversity loss and require measures, like NBS, aimed at sustainable and climate-proof use of land and water systems. The insights that will be generated from this study can serve as valuable reference points for practitioners in other nations. By adapting the framework that is developed in this research to their own context, other countries can also stimulate, improve, and accelerate the implementation of NBS in their cities.

2.5 Relation to CoSEM program

Complex Systems Engineering and Management (CoSEM) involves navigating innovations in complex socio-technical environments and the interactions that take place within such systems. NBS in Dutch cities encapsulate a multifaceted system, in which the solutions themselves need to be studied next to matters such as the governance structures, technological aspects, and social-cultural context that influence their adoption. Analyzing the barriers and drivers that influence NBS implementation deepens comprehension of the system. Combining these insights with strategies and measures that

can address them and contribute to successful realization of NBS projects, as well as integrating them in a guiding implementation framework, helps stakeholders with implementing and upscaling NBS in Dutch cities. In doing so, the research aligns with the interdisciplinary lens that is mandated by the CoSEM program. Insights from engineering, social sciences, governance studies, and urban planning are merged by employment of various research methods that are pivotal to CoSEM. This approach requires a holistic perspective that resonates with the program's ethos. The results of the thesis contribute to the climate resilience and biodiversity of Dutch cities, research areas that are frequently addressed in the program's energy track that has been followed by the researcher.

3. Methodology

This chapter outlines the thesis' methodology. Section 3.1 argues for selecting the design science research approach as the most suitable for answering the research questions. Then, Section 3.2 formulates the sub-questions, explains their aim, and relates them to the phases of the selected research approach. This is followed by Section 3.3, which describes the research methods that are used to answer each sub-question.

3.1 Design science research

The design science research (DSR) approach was employed throughout this thesis to answer the main research question, since it is a problem-solving paradigm that focuses on the creation of artifacts, being constructs, models, methods, and instantiations, to address real-world problems (Brocke et al., 2020). Given that the aim of the study is to develop an artifact, namely a guiding implementation framework based on the factors that influence NBS adoption, DSR offers a structured yet flexible methodology that aligns closely with this goal. Integrated systems thinking is required to formulate the framework, since NBS implementation touches upon the domains of finance, ecology, politics, social sciences, governance, and engineering. The interdisciplinary nature of the DSR approach allows for the creation of a holistic framework that balances this variety in requirements (Johannesson & Perjons, 2014). It enables researchers to iteratively design, test, and refine the framework based on empirical evidence and stakeholder input, thereby ensuring both scientific rigor and practical relevance (Jacob et al., 2021). This aligns with the study as both literature and expert perspectives have been used to inform the framework development, which will be explained in more detail later in this chapter. Moreover, as the DSR approach encourages engagement with the context in which the framework will be applied and allows for the development of tools, in this case a framework, to solve real-world issues, it provides a strong foundation for bridging theory and practice in an impactful manner (Hevner et al., 2004).

The DSR approach usually includes six different research activities: (1) explicate problem, (2) identify requirements, (3) design and develop artifact, (4) demonstrate artifact, (5) evaluate artifact, and (6) communicate artifact (Brocke et al., 2020; Pfeffers et al., 2007). The first phase is required to precisely formulate the problem and to justify its significance for practice (Johannesson & Perjons, 2014). The next activity, identification of requirements, outlines a solution to the explicated problem and elicits requirements, which will be defined for functionality, structure, and environment, that this artifact must meet. This is followed by the design and develop phase, meaning the creation of the artifact that addresses the explicated problem and fulfills the defined requirements. The design of an artifact concerns the determination of its structure and functionality. The purpose of artifact demonstration is to use the developed artifact in an illustrative or real-life case to prove its feasibility, while the aim of the evaluation phase is to determine how well the artifact is able to fulfill the requirements and to what extent it can solve the problem at hand. The final phase is the communication of all aspects regarding the problem and the designed artifact to the relevant stakeholders.

Nevertheless, many design science studies do not undertake all six activities of the approach in depth (Johannesson & Perjons, 2014). Considering the time and resource constraints of this thesis, the fifth phase will not be included in this research. Due to this and the fact that this is a Master's thesis, the sixth phase will not take place either. This means that the typical process iteration of the approach will not be followed. Instead, the study will solely follow the approach's nominal process sequence. The various phases of the DSR approach are outlined in Figure 4, which also shows the research activities this thesis will focus on. In Section 3.2 these phases are linked to the chapters and sub-questions of this study to further justify the choice for the design science research approach and is it explained with which version of the DSR methodology the research aligns most.

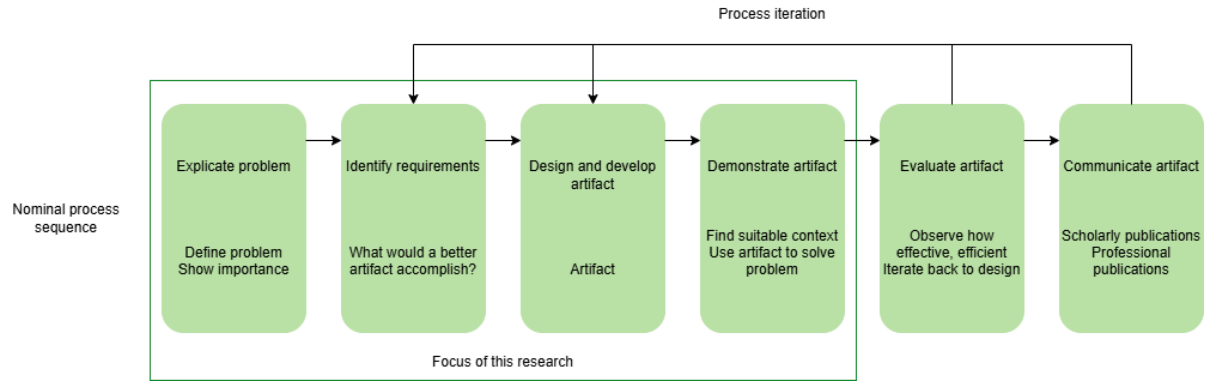

Figure 4 Design science research approach (adapted from Pfeffers et al. (2007))

The figure below will be used throughout this thesis to illustrate the progress of the DSR approach and to indicate the phase to which each chapter and sub-question belong. In these figures, the light green color indicates the phases that have been completed, the dark green color represents the phase currently being addressed in the chapter, and the grey color denotes the phases that still need to be completed. Figure 5 shows the progress made so far: the first phase has been completed, as the problem was explicated in the first two chapters – the Introduction and Literature review.

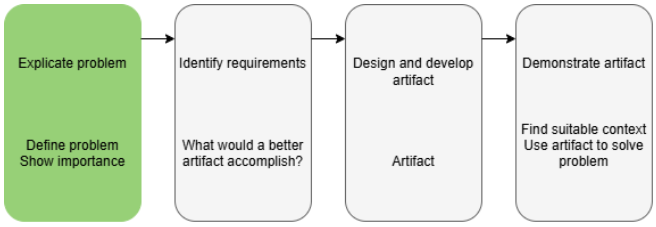

Figure 5 Progress DSR approach - Explicate problem

3.2 Sub-questions

3.2.1 Aim of the sub-questions

Based on the main research question and the DSR approach, the following sub-questions have been formulated to guide the research process:

1) What characteristics should a NBS framework designed for use during the planning and implementation phases possess?

In order to develop a guiding implementation framework that can be used during the planning and implementation phases of NBS projects, it is essential to understand which common characteristics existing NBS frameworks embody. This knowledge informs the development of a well-founded and practical framework. Identifying the requirements for the artifact is a crucial step within the DSR approach, as it ensures that the design is grounded in both theory and practical considerations.

2) Which barriers and drivers influencing the implementation of NBS are identified in literature, and which are perceived by experts within Dutch cities?
3) Which strategies, measures, and principles to support successful implementation of NBS are identified in literature, and which are proposed by experts for Dutch cities?

These questions together provide an answer to the first part of the main research question, since the factors that influence NBS implementation can be categorized as barriers, drivers, strategies or measures. Notable is that the discovery of principles is also included in question 3. This inclusion stems from both the literature review on frameworks and influencing factors performed in Chapter 4 and 5,

as well as the expert interviews of Chapter 6, which underscored the significance of principles as a factor type. However, principles do not directly contribute to increased implementation in the same way that strategies and measures do, but rather ensure sound and more successful NBS adoption. Therefore, while the primary focus remains on strategies and measures, principles are considered when emphasized in literature or by experts. These questions are part of the 'identify requirements' phase of the DSR methodology. Whereas the first question provided the characteristics the framework must encompass, the answers to these questions deliver the content the framework must contain.

4) What is a suitable framework for these experts to consider when planning and implementing NBS, and how can this framework be used in practice?

This question provides an answer to the second part of the main research question. By including the content of question 2 and 3 and structuring and visualizing it according to the characteristics identified in question 1, the results of the research become clearer and more accessible to experts in the field. The developed framework not only synthesizes the insights into a coherent format, but also adds value beyond the presentation of the standalone results. It enables stakeholders to effectively interpret and apply the findings in real-world contexts. As a result, this increases the usability and practical relevance of the research. This question also allows for testing the real-world applicability of the framework as well as shows how stakeholders can use the framework on existing and future NBS projects, thereby revealing the framework's practical value. The first part of this question addresses the 'design and develop artifact' phase, and the second part addresses the 'demonstrate artifact' phase of the DSR methodology.

3.2.2 Relation to DSR approach

These sub-questions correspond to the various phases of the DSR methodology. The introduction and literature review of this research conclude the first phase of the approach, since the problem has been shortly explicated in those chapters. While sub-question 1 through 3 identify the requirements the framework must meet and provide an answer to the first part of the main research question, sub-question 4 is concerned with developing and demonstrating the framework, thereby answering the second part of the main research question.

The flexibility of the DSR approach also enables researchers to selectively emphasize specific activities within the overall process (Johannesson & Perjons, 2014). Typically, one or two phases are explored in depth, while others are treated more lightly or be omitted altogether. Based on the varying focal points, five types of DSR can be distinguished, of which the 'Requirements- and Development-Focused Design Science Research Approach' is most appropriate for this research. As illustrated in the previous paragraph and in Figure 4, the thesis places a strong emphasis on the definition of requirements and the development of the artifact, a focus that aligns with the most frequently applied DSR variant. Even though this approach usually does not involve the 'problem explication' phase, the study addresses this component within the introduction and literature review chapters, without assigning a dedicated sub-question to it. The identification of requirements and design of the artifact are the most important aspects of this research and will be performed in a rigorous way. In line with this DSR variant, either a lightweight demonstration or evaluation of the artifact must be performed to show its viability.

3.3 Research methods

The sub-questions will be answered by employing various research methods, which will be discussed together with the data sources and tools that are required to execute these methods.

3.3.1 Literature review on frameworks

To answer sub-question 1, a comprehensive review of academic and grey literature was carried out. This review focused on identifying and analyzing frameworks that can be used during the planning and implementation phases of NBS projects. The goal was to gain insights into the essential characteristics such frameworks should possess. The review process consisted of three steps: (i) collecting relevant publications, (ii) analyzing the content and characteristics of each framework, and (iii) deriving a set of requirements or key considerations for the development of the framework within this research, based on recurring elements identified across the reviewed sources.

(i) Since the literature review in Chapter 2 also considered NBS planning and implementation frameworks, these frameworks were used as starting point for this review. By employing the snowballing method, additional papers were found on the topic. Moreover, to provide an elaborate overview of the discourse on frameworks, sources of grey literature were reviewed as well. To identify relevant publications, search terms combined 'Nature-Based Solutions' with either 'planning framework' or 'implementation framework'. Scopus was used as a search engine for finding academic literature, while Google was used for identifying grey sources. Given the knowledge gap regarding frameworks that consider the barriers, drivers, strategies, and measures that influence NBS implementation, the review also considered frameworks that focused on providing guidelines or principles, as this is similar to strategies and measures in a way, for successfully realizing NBS projects. In total 10 frameworks have been reviewed: 6 were developed within academic publications, 2 were presented in grey literature, and 2 were featured in academic and grey sources.

(ii) The next step involved an analysis of each framework and its accompanying explanation. Attention was paid to the framework its content and the key characteristics the framework possesses. For the content the focus was on several aspects, such as the framework's purpose and scope as well as how its core components were structured. Even though the content of the framework developed in this thesis is based on interview findings, examining the content of existing frameworks provided valuable insight into how other researchers scoped their work, balanced visual versus textual information, and built a coherent narrative around their framework. Secondly, important characteristics of the frameworks were identified, such as allowing users to assign a relevance level to factors or including examples to show stakeholders how the framework should be used. The key characteristics that are most relevant for the development of the framework in this thesis are highlighted in the individual framework analyses. The analysis of the content served as background knowledge for the researcher and facilitated a more informed evaluation of the characteristics. A detailed assessment of each framework is presented in Appendix A.

(iii) The final step involved synthesizing the findings from each framework analysis to derive requirements for the framework development in this thesis. This was achieved by examining the highlighted elements across the analyses, thereby identifying recurring features that could inform the desired characteristics of this thesis' framework. The commonly emphasized elements are further elaborated upon in Chapter 4.

3.3.2 Literature review on barriers, drivers, strategies, measures, and principles

To gain an initial understanding of the barriers, drivers, strategies, measures, and principles that might be applicable to the Dutch urban context, a structured narrative review of academic and grey literature was performed. This analysis equipped the researcher with the necessary background knowledge to conduct meaningful interviews, which is the primary research method used to address sub-question 2

and 3. Moreover, this approach allowed for a comparison between factors identified in literature and those that emerge specifically within the Dutch urban context. The review process consisted of four steps: (i) collecting relevant publications, (ii) identifying and categorizing the factors mentioned in these sources, (iii) clustering similar factors together, and (iv) analyzing the surrounding context in the publications to provide clear explanations for each cluster.

(i) As the literature review performed in Chapter 2 also covered publications focused on influencing factors, these studies were used as starting point for this review. By employing the snowballing method, additional papers were found on the topic. Moreover, to provide an elaborate overview of the discourse on these factors, several sources of grey literature were reviewed as well. To identify relevant grey and academic publications, search terms combined 'Nature-Based Solutions' with the key factors: barriers, drivers, strategies, or measures. Scopus was used as a search engine for finding academic literature, while Google was used for identifying grey sources. Given the knowledge gap regarding the factors that influence NBS adoption in Dutch cities, the review also includes literature on NBS implemented outside the Netherlands and/or in rural areas. In total 30 sources have been reviewed, of which 16 sources of grey literature and 14 academic publications.

(ii) This step involved a reading of each source to identify the barriers, drivers, strategies, measures, and principles discussed. A note needs to be made here that most studies did not discuss all factor types, meaning that strategies and measures could not necessarily be linked to the barriers and drivers that have been found. To certify that the factors were categorized correctly, definitions of each of the factor types have been formulated:

Box 3 Factor types definitions

Barriers are factors that hinder, delay, or prevent NBS implementation.
Example: lack of data

Drivers are factors or conditions that enable or encourage NBS implementation.
Example: political will

Strategies are broad plans that help overcome barriers, build on drivers, or stimulate NBS implementation more generally.
Example: stimulate collaboration between stakeholders

Measures are actions, tools, or interventions that help overcome barriers, build on drivers, or stimulate NBS implementation more generally.
Example: implement a biodiversity net gain regulation

Principles are guiding ideas that help make NBS implementation more successful.
Example: adapt NBS to the local context

Distinguishing drivers and strategies can be difficult as both enable NBS implementation. Drivers can be seen as existing circumstances that create a favorable environment for NBS adoption. They can be internal or external motivators that naturally push implementation forward and can therefore be seen as the 'why' behind the momentum. On the other hand, strategies are intentionally designed mechanisms to leverage drivers or to overcome barriers. They can be seen as the 'how', the tools used to support the 'why' or to tackle the hindrances. Similarly, distinguishing strategies, measures, and principles can be tricky. While strategies can be seen as broad approaches to address barriers and drivers, or to

generally enable NBS adoption, measures are more detailed in their formulation, thus can often fall under strategies, while contributing to the same goal. Principles, on the other hand, do not necessarily stimulate NBS adoption, but ensure sound practice, thereby improving the quality of NBS projects. Nevertheless, since the main objective of the review is to provide an overview of the influencing factors, strategies, measures, and principles are initially grouped together in this step for the sake of simplicity. This grouping is justifiable as all three can be regarded as approaches that are deliberately implemented or followed to facilitate (successful) NBS adoption. Since strategies and measures are similar in nature, they will remain grouped in subsequent stages. Principles, on the other hand, are different in nature and thus will be discussed separately in subsequent stages.

To create structured overviews for each category, the factors were organized across seven themes: (1) social and cultural, (2) governance, (3) informational and technological, (4) physical and ecological, (5) financial, (6) political, and (7) legal. These themes emerged inductively during the initial review of a few sources. Each factor was assigned to a theme by analyzing the context in which it was discussed. Although some factors transcend a singular theme, the most fitting theme was selected based on the context provided in the source.

The social and cultural domain discusses matters like public perception of NBS and citizens' quality of life. Governance refers to institutional structures, stakeholder collaboration, and decision-making processes. The informational and technological theme is concerned with the availability of data on and tools for the performance of NBS as well as personnel that has the required knowledge and skills to participate in NBS projects. The physical and ecological system refers to factors like the climate change and biodiversity crises, space constraints, and the existing grey solutions. Aspects such as the availability of financial incentives, existence of a business case, and bankability of projects are all covered in the financial realm. The political theme addresses both politics and policy, including political will, priority of NBS on the political agenda, and presence of supportive policies. The legal landscape is concerned with the existence of supportive regulatory schemes. Overviews of the factors, organized by factor type, are included in Appendix B.5 through B.7.

(iii) In order to reduce complexity and keep the amount of factors manageable, similar factors were grouped into clusters of barriers, drivers, and strategies/measures/principles. For example, the barriers '(Perceived) high (upfront) costs,' 'High transaction costs for small-scale projects,' 'Ongoing maintenance costs are challenging due to their magnitude and unpredictability,' and 'Uncertainty surrounding costs' were combined into a single, more comprehensive barrier titled '(Perceived) high and uncertain costs of NBS'. This clustering process reduced the number of barriers, drivers, and strategies/measures/principles from 131 to 60, 115 to 56, and 157 to 72, respectively. Overviews of the clustered factors, organized by theme, can be found in Appendix B.4.

(iv) The final step of the review process involved analyzing the context in which each factor was discussed in the literature, in order to develop clear explanations for each cluster. The sources contributing to each cluster were examined to produce a description of what the clustered factor entails, and are presented in Chapter 5 and Appendix B.1 through B.3.

3.3.3 Semi-structured interviews

The literature review process was followed by semi-structured interviews with experts, in which their perspective was asked on the factors that influence NBS implementation in Dutch cities. The results of these interviews provided answers to sub-question 2 and 3. The choice for semi-structured interviews was based on the fact that a semi-structured approach can provide a balance between consistency and flexibility. Preparing a set of guiding questions ensures consistency across interviews, while allowing the researcher to follow up on interesting responses. This enables a deeper exploration of insights and clarification of complex ideas as they come up. Moreover, it encourages participants to speak in their own terms, rather than being steered by direct questions that might lead to socially desirable answers. The interview process consisted of six steps: (i) considering the interviews' ethical aspects, (ii) selecting the themes and factors the interviews should be centered around, (iii) establishing the interview protocol, (iv) identifying and approaching experts with the appropriate knowledge and experience, and scheduling the interviews, (v) conducting mock interviews, and (vi) carrying out the expert interviews.

(i) As this research method involves human research subjects, it is important to adhere to ethical principles to protect the dignity, rights, and welfare of the research participants. To ensure the upholding of ethical standards, an ethics checklist, informed consent form, and data management plan were reviewed and approved by the TU Delft ethics committee. The researcher conducted the research in adherence to the statements made in these documents. Before the interviews took place, participants were asked to review and sign the informed consent form. A template of this form can be found in Appendix C.2.

(ii) Since it would require many interviews to discuss and validate all factors, it was decided to focus the interviews on a few themes and factors. Four themes were chosen: social and cultural, governance, informational and technological, and physical and ecological. These themes were selected since it would be more difficult to find experts, with the necessary time and knowledge, who can speak in depth about the financial, political, and legal factors. For each theme, a few clustered barriers, drivers, and strategies/measures from literature were chosen as hypotheses to test during the interviews (1) whether they play a role in the Dutch urban context and (2) what the context surrounding the factors is.

When deciding which barriers and drivers to test during the interviews, efforts were made to strike a balance between factors the researcher anticipated to be influential and those that might be less impactful. Similarly, a mix was sought between factors likely to be widely accepted by experts and those that could generate more diverse opinions. Drawing on the literature reviewed throughout this thesis, the researcher made informed decisions in selecting hypotheses. When available, corresponding strategies and measures were then selected as hypotheses to ensure coherence. However, as noted earlier, most strategies and measures were derived from publications distinct from those discussing the barriers and drivers. As a result, linkages between factors are not always present. Furthermore, several of these strategies and measures can be interpreted as broader enabling measures that generally enhance the likelihood of NBS implementation, rather than being tailored responses to particular barriers or drivers. It is also interesting to examine whether such approaches are perceived to be useful. This matter was also observed in the framework analyses, where it was seen that many frameworks include strategies in some way without referring to specific barriers and drivers. Therefore, it was also aimed to balance strategies and measures targeted at specific barriers and drivers with broader enabling measures. The hypotheses can be found in Chapter 6.

(iii) The third step was concerned with creating an interview protocol. Since the interviews followed a semi-structured format, the protocol was intentionally designed to be generic and flexible, serving as a guide while allowing room to adapt to each expert's specific expertise and responses. The interview protocol was divided into five components.

The first 5 minutes of the interview were used for brief introductions and explaining the research objectives and interview's purpose. In the following 5 minutes, the interviewees were asked about their own experience with NBS projects and/or research to help elicit early insights into NBS implementation. They were also asked to define NBS in their own words, as it became clear in Chapter 2 that there exists a wide discourse on this matter.

The core of the interview, lasting approximately 40 minutes, was about the factors that influence the implementation of NBS in Dutch cities. The discussion was guided by the hypotheses chosen in step (ii). However, to allow for more in-depth conversations, each interview was tailored to cover mainly three themes, most relevant to the expert's background, instead of all four themes. The reason for this is explained further in step (iv). Each theme was explored through a three-step process: (1) discussion of barriers and drivers, (2) identification of strategies and measures to overcome these barriers, leverage the drivers, or support the successful realization of NBS projects more broadly, and (3) space for experts to raise any additional factors related to the theme that had not yet been covered but were important to consider.

During the final part of the interview participants were first asked what they believe is most needed to scale up NBS in Dutch cities to indirectly uncover which factors they consider to be the most important. They were also asked which characteristics tools for practitioners should contain to be useful during the planning and implementation phases of NBS projects. The interviewees' insights together with the framework review provided an answer to sub-question 1 and informed the framework development in this thesis. Moreover, they were invited to share examples of NBS projects that offer lessons for future implementation, potentially serving as illustrative cases for the framework's demonstration. Lastly, the experts were given space for final questions, comments, or suggestions, and asked if they could recommend other professionals to interview.

To allow participants to prepare for the interview and familiarize themselves with the general topics of discussion, the interview protocol was shared with them in advance. However, the hypotheses included in the protocol were excluded from the version sent to interviewees to avoid influencing their responses. Slight variations were made to the protocols for academics and practitioners to better reflect their respective backgrounds. Both versions are provided in Appendix C.1.

(iv) The fourth step involved identifying and approaching experts and scheduling interviews with them. Potential interviewees were sampled according to a four-point approach that is common in interview-based research (Robinson, 2014). The first step is the definition of a sample universe, which can be delineated by establishing a set of inclusion or exclusion criteria that stipulate attributes that qualify or disqualify a case from the study. In this thesis, inclusion criteria were formulated. The more, and more specific, criteria are used for defining a sample universe, the more homogenous this universe will become. This is

preferred in certain studies to remain contextualized within a defined setting and generalization is made cautiously to, and not beyond, the localized sample universe. Therefore, the first criterion is that the interviewees need to be involved in research on NBS or in the actual planning and implementation phases of NBS projects in Dutch cities. However, within the sample some heterogeneity is coveted as well, for which can be argued that "commonality found across a diverse group of cases is more likely to be a widely generalizable phenomenon than a commonality found in a homogenous group of cases" (Robinson, 2014). Since academics and practitioners are both involved in NBS projects, thus have knowledge of the factors that influence NBS adoption in Dutch cities, including a degree of heterogeneity strengthens the evidence that findings are not limited to one stakeholder type. Academics have often conducted interviews, workshops, or projects with stakeholders, allowing them to reflect broader experiences with NBS implementation. Practitioners, on the other hand, are directly involved in the day-to-day processes and have built practical knowledge of the factors influencing NBS adoption. Therefore, including both types of stakeholders ensures a more comprehensive and balanced understanding of the dynamics at play.

The second step is determining the sample size, which is influenced by theoretical and practical considerations (Robinson, 2014). This depends partly on the aim of the interview research, which can be either nomothetic or idiographic. A nomothetic approach refers to the development of a general theory and typically requires a large sample size, whereas an idiographic aim seeks a sample size that is small enough for individual cases to have a locatable voice within the study and to conduct an intensive analysis of each case. This study falls somewhere in between: while the goal is to develop a framework that can be applied across Dutch cities, it is not intended to be universally generalizable beyond the national context. At the same time, the research aims to provide rich insights by closely examining the perspectives of individual experts. Given these goals and taking into account the limited time available for this research, a smaller and purposefully selected sample size is appropriate. For studies with an idiographic aim, a size between 3 and 16 participants is generally recommended. The sample size for this study was 10 participants.

The next step is determining how to select cases for inclusion in the sample, for which a distinction can be made between random and purposive sampling strategies (Robinson, 2014). Random sampling refers to selecting cases from a list containing all cases within the sample universe using a kind of random selection procedure. On the contrary, purposive sampling employs non-random strategies to ensure that certain categories of cases within a sample universe are represented in the final sample. This rationale is based on an a-priori theoretical understanding of the topic under study, that particular categories of individuals may have unique and important perspectives on the topic and that therefore their presence in the sample should be ensured. As aforementioned, both academics and practitioners have knowledge of the factors that influence NBS adoption in Dutch cities, which suggests that a purposive sampling strategy needs to be employed. Within this sampling approach various strategies exist, of which the cell sampling strategy is the best fit. This strategy is similar to stratified sampling, which requires the researcher to first select particular categories, in this case academics and practitioners, that are considered important to be included in the final sample. Next, the sample is stratified according to these pre-determined categories and a target number of participants is allocated to each category. However, since the current job position of some interviewees can involve both

conducting research on NBS and being actively involved in NBS projects, there is an overlap between the two categories. This overlap can be accommodated through cell sampling, making this the appropriate choice. As mentioned earlier, academics and practitioners are considered equally important to this study. Therefore, the aim was to achieve a balanced 50/50 split between both types. Participants whose professional roles encompass both academic and practical elements are counted toward both categories.

Then, participants can be sourced (Robinson, 2014). This stage of sampling requires ethical skills and sensitivity, which, as mentioned earlier, is guaranteed by completing an ethics application. As many experts can be found on websites of companies that work on NBS projects or research, as well as in literature that has been reviewed throughout this thesis, these sources were used as a starting point for identifying potential interviewees. In addition, a LinkedIn search and recommendations from members of the researcher's graduation committee resulted in finding additional participants. This resulted in a list of potential interviewees, from which experts whose knowledge aligned most closely with the selected themes and hypotheses were approached to inquire about their interest in contributing. In total, 18 potential participants were approached, of whom 14 expressed interest in participating. Ultimately, interviews were successfully scheduled with 10 experts within the desired timeframe, of which 5 academics, 3 practitioners, and 2 who work as academic and practitioner. The job role descriptions of the interviewees can be found in Appendix C.3. However, it is important to note that most experts have a longer-standing involvement with the topic than their current job titles might suggest. For example, some practitioners are occasionally involved in NBS research projects and most academics are regularly involved in actual NBS projects, without their job position indicating that they are involved in both academic and practical elements as is the case for the participants that are both advisors and researchers.

(v) The next step was to conduct mock interviews to test the setup and refine the interview questions. The duration of these interviews made it clear that covering all themes in each interview would likely be unfeasible, even though most experts are knowledgeable across all themes. As a result, each interview was tailored to include three themes that aligned most closely with the expert's background. Moreover, the mock interview revealed that the accuracy of the transcription significantly improved when the interview was conducted online, which led to the decision that all interviews would take place online. Moreover, it became clear that the language choice had little effect on how accurately the transcription software captured the conversation. Therefore, it was decided that all interviews would take place in the language preferred by the interviewee to facilitate more nuanced and spontaneous responses, which can enhance the quality and depth of the interview data.

(vi) The final step of the interview process involved conducting the interviews. Before each interview took place, the researcher looked into the NBS projects the expert had been involved in. Based on this, the three themes that were most closely related to the expertise of the interviewee were chosen to discuss during the interview. If time permitted, the participant was also asked about the theme not yet discussed. During the interview, key words were noted, and immediately afterward, a memo was written to capture the main insights shared by the interviewee. The interviews were semi-structured, meaning that the interview protocol was used as a guiding tool and that its questions and their order were not always strictly followed. Although the aim was to test hypotheses during the interview, questions around those hypotheses were asked to not steer the interviewees towards a

socially desirable answer. For example, for testing the hypothesis 'Silo mentality', experts were asked if they often collaborate with other stakeholders on NBS projects. In addition, it was tried to achieve a balance between asking questions related to the hypotheses and letting interviewees tell their own story, as they might better know what is relevant or have more knowledge about certain hypotheses than others. The interviews took place online between early July and early September. They were audio and video recorded and transcribed using Teams. Since Teams does not always transcribe speech accurately, each transcript was manually reviewed. When necessary, the recording was consulted to ensure an accurate representation of what was said. The details of the interviews can be found in Appendix C.3. The transcript was shared with the interviewees so they had the opportunity to rectify any information they had provided or add additional comments. This can be seen as a minor form of validation of the interview data.

3.3.4 Thematic analysis

A thematic analysis was conducted to identify, analyze, and report patterns, also called themes, within the interview data (Braun & Clarke, 2006). Two approaches can be distinguished within thematic analysis: inductive and deductive. An inductive approach derives themes from data without relying on pre-defined theoretical frameworks or analytic preconceptions of the scholar. A deductive approach is guided by existing theories, thereby providing a less rich description of the data overall, but a more detailed analysis of certain data aspects. Considering that the researcher's aim was to conduct semi-structured interviews that would be guided by hypotheses but would also leave room for experts to talk about the matters they consider to be important, a combination of both approaches was used. The data analysis process consisted of four steps: (i) reading and summarizing the interviews, (ii) establishing an initial coding scheme based on the hypotheses, (iii) conducting two coding rounds, and (iv) writing down the meaning of the codes supported by quotes.

(i) To familiarize with and become immersed in the data, each transcript was read again after manually reviewing it and the most important aspects were written down as bullet points. These points were combined with the key words and memos written during and after the interviews to form a summary consisting of six paragraphs. Each summary begins with the interviewee's definition of NBS. The following four paragraphs address the factors that influence NBS implementation in Dutch cities, organized according to the themes for which hypotheses were developed. The final paragraph outlines the characteristics the interviewees believe should be included in a framework designed to support stakeholders in NBS planning and implementation. The summaries can be found in Appendix C.4.

(ii) To establish an initial coding scheme, codes were formulated based on the interview protocol. To begin with, 21 themes, under which codes can be grouped, and four free codes were made. The 21 themes were developed by combining each of the seven themes identified in the literature review on influencing factors with the different types of factors they could entail: barriers/drivers, strategies/measures, or principles. The reason that barriers and drivers are grouped together during coding has to do with the fact that some factors can be both barriers and drivers depending on the specific context. For instance, in literature it was mentioned that there was often a lack of acceptance of NBS and that this hindered the implementation of the measures. However, there are also cities that are generally very accepting of NBS, meaning that acceptance can act as a driver in that case. Next to this, strategies and measures are combined as they are both interventions, although on different scales, that can help address barriers and drivers as well as stimulate NBS implementation in general. This while the aim of principles is more related to how the

success of implementation can be improved. Under these themes, the researcher tried to grasp the core of each hypothesis in a few words to formulate the codes. For example, the barrier 'Urban space is scarce and competed over' was coded as 'Space availability'. It can be noted that the codes were deliberately formulated in a neutral manner, so they could be applied in contexts where the factor was perceived either as barrier or driver. For the three themes for which no hypotheses were formulated, no codes were made during this phase. The four free codes, 'NBS definition', 'Most critical factors', 'Tool requirements', and 'Example projects', are related to the questions in the 'experience with NBS' and 'looking ahead' sections of the interview protocol.

(iii) The analysis of the interviews was done in ATLAS.ti, which is a qualitative data analysis software designed for the systematic organization, coding, and interpretation of data. This enables researchers to assign codes to segments of data and identify patterns across documents. The interview data was closely analyzed and quotes of interviewees were assigned to the formulated codes. Since experts also talked about factors other than the hypotheses, additional codes were created. As new interviews provided sharper insights into the factors, the formulation of the codes was adjusted to better reflect the interview data. In this process, some codes were merged, while others were split into multiple, more specific codes. This continuous improvement process was also applied to the codes established based on the hypotheses. After coding all interviews, a second round of coding was conducted to ensure consistency across the interviews and to refine the formulation of all codes. The coding scheme is shown in Appendix C.5.

(iv) After the second coding round took place the findings were written down in Chapter 6. The essence of each code was explained and quotes from the interviewees were used to support the descriptions. The summaries as well as the quotes were shared with the participants as an additional validation step.

3.3.5 Framework development and illustrative cases

Based on the requirements found in the previous sub-questions, a guiding implementation framework was developed and applied to several illustrative cases to answer sub-question four. This was done by synthesizing and visualizing the discovered factors while taking into account the characteristics that had been derived from existing frameworks and through the interviews. The programs Canva and draw.io were used to visualize the framework. In order to show the framework's content in practice and demonstrate its use and value, it was applied to several illustrative cases. An illustrative case provides a depiction of a particular situation to aid in understanding a concept, theory, or, in this case, framework. The use of such a real-world example can serve as an illustration of both the theoretical principles as well as the practical application of the framework. Where case studies typically aim for in-depth analyses, the purpose of an illustrative case is more explanatory of nature.

4. Results: Framework characteristics

This chapter discusses the results of the review of grey and academic literature on frameworks that can be used during the planning and implementation phases of NBS projects. It outlines the key characteristics of the reviewed frameworks, which serve as critical reference points to ensure theoretical robustness and practical relevance. The analyses of each of the reviewed frameworks can be found in Appendix A. In addition, this chapter summarizes the characteristics that interviewees identified as important when designing or using a guiding implementation framework. These insights collectively inform the development of the framework proposed in this thesis.

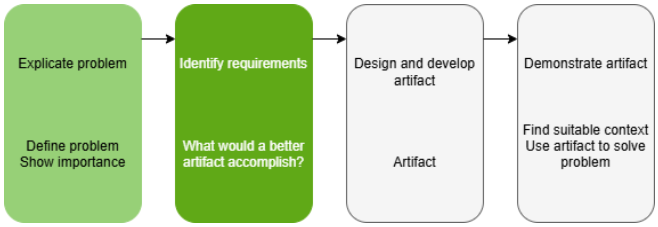

Figure 6 Progress DSR approach - Identify requirements 1

4.1 Requirements from literature

Most frameworks begin their supporting text by explaining the type of framework as well as clarifying its nature, purpose, and value, as exemplified by the IUCN Global Standard for NBS (International Union for Conservation of Nature, 2020b). Furthermore, the frameworks often specify during which phase(s) of the urban planning process the framework should be applied. This can concern a single phase, like in the NBS planning framework proposed by Albert et al. (2021), or multiple phases, as in the Connecting Nature Framework, which considers planning, implementation, and stewardship (Hölscher et al., n.d.). Most frameworks are designed to be applicable across different contexts and accessible to a broad audience. Another interesting element related to wide applicability can be found in the NBS planning and evaluation framework of De Lima (2022), which can be used prospectively and retrospectively. Additionally, both the intended use and target user group are typically defined at the outset of the framework, as demonstrated by the Green Cities Framework (Garcia-Blanco et al., 2022). For the framework application, some frameworks recommend a governance approach that can be followed, an element included in both the IUCN Global Standard for NBS and the NBS Barrier Identification Framework (International Union for Conservation of Nature, 2020b; Deely et al., 2020). This includes clarifying who is involved when and defining their respective roles and responsibilities.

Content-wise, an important element is the distinction between context (i.e., NBS definition, project(s) under consideration, and barriers and drivers influencing them), process/activities (i.e., strategies and measures that can be implemented to address barriers and drivers or to stimulate NBS adoption in general), and outcomes (i.e., increased NBS adoption). Such an approach is outlined in the framework proposed by proGIreg (2022). Closely related in content to the framework developed in this thesis is the Barrier Identification Framework, which demonstrates that organizing barriers and drivers into themes provides clarity and overview, although many of these factors transcend individual categories (Deely et al., 2020). Another characteristic is allowing users to assign a threat level to barriers, for which none, low, medium, or high can be selected. Since the framework in this thesis considers both barriers and drivers, this categorization can be adapted into a relevance level. All frameworks that include strategies or measures for improving or upscaling NBS implementation, such as the framework developed by Nesshöver et al. (2017), formulated these in the imperative form to communicate action while avoiding the assignment of responsibilities to specific parties, since this depends on the context. Additionally, the text included in the frameworks is formulated concisely. All frameworks are accompanied by either a guidebook or other supplementary material to support practitioners in their application. Frequently, expert comments and real-life cases are incorporated to illustrate the framework's content and demonstrate its use and value. Overall, the frameworks balanced text and

visual elements by including sufficient written explanation to ensure that users can understand the framework without immediately consulting additional information, while avoiding excessive text by integrating clear and engaging visuals.

4.2 Requirements from interviewees

Many interviewees underscored the importance of clearly stating for whom the framework is intended and selecting a format that fits with these users. Expert PA2 mentioned that it can be helpful to reason from a Theory of Change: "*Ultimately, you want your framework to enable people to make better-informed and better choices, make better decisions, and thereby implement Nature-Based Solutions more easily, better, more widely, and on a larger scale. So the key question here should be, who do I need to enable to do something different and what do they need to do that?*". A similar point was made by participant P3, who emphasized that the framework should be focused on the generations that can 'handle' it and that an appropriate format should be chosen for that target group.

Moreover, usability in terms of word choice, size, and required attention span was another important characteristic that was highlighted by interviewees. Expert P2 mentioned: *"I can say stick to KISS, Keep It Short and Simple. Short sentences. Avoid jargon. Keep it concise.*". Participant A5 also emphasized the importance of ensuring that the framework is user-friendly and effectively communicates its content. In addition, interviewee P3 noted that summarizing the findings could help keep the content manageable and maintain the reader's focus on the most important elements, while more in-depth explanations could be provided in subsequent sections.

Expert A3 also stressed that only small amounts of text should be included and that it is important to dedicate enough time to visualization of what is meant with the content of the framework. For this, the interviewee suggested the inclusion of visual elements, such as funnel diagrams and yes/no or flow charts, to complement text. In addition, many participants pointed out that the use of images as well as examples and references is helpful.

5. Results: Factors in literature

This chapter presents the factors influencing NBS adoption as identified in literature. A review on these factors was performed to (1) give an indication of the factors that might be applicable to the Dutch urban context, (2) provide the researcher with the necessary knowledge to conduct expert interviews, and (3) allow for a comparison between factors identified in the literature and those that emerge in practice within the Dutch urban context according to experts. As hypotheses were chosen within four themes, only these themes are discussed in this chapter. Each theme is addressed in a different section. For the discussions of the other three themes, Appendix B.1 through B.3 can be consulted.

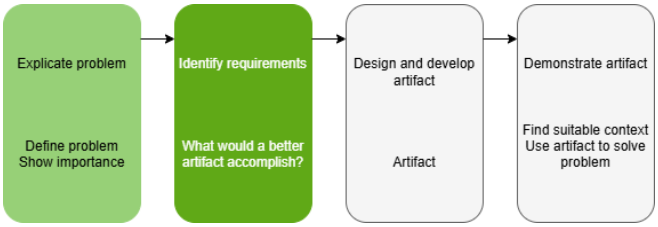

Figure 7 Progress DSR approach - Identify requirements 2

5.1 Social and cultural factors

5.1.1 Social and cultural barriers

To begin with, there is resistance towards risk, change, and the unknown among citizens, governments, and businesses alike (Sarabi et al., 2020; Kabisch et al., 2016; Tran et al., 2024; Castelo et al., 2023). Since municipalities are responsible for the safety and well-being of its citizens, urban planners prefer using measures with certain outcomes (Sarabi et al., 2020). As NBS have not yet received extensive assessments of their effectiveness, both operational and performance unknowns are associated with them (Kabisch et al., 2016). With urban planners being usually risk averse, these unknowns create a fear of failure in using NBS (Sarabi et al., 2020; Kabisch et al., 2016). Moreover, risk aversion also plays a part in the decision-making processes around NBS in the private sector, as they are concerned with possible financial losses when investing in NBS. This results in resistance to change and preference for grey solutions, a barrier that can also be found among citizens (Sarabi et al., 2020; Tran et al., 2024). According to them, NBS can create disruptions in routines and physical annoyances (Tran et al., 2024).

There is also a lack of public awareness, acceptance, and support (Sarabi et al., 2020; Kabisch et al., 2016; Leuven, 2025). The general public is not always aware of the existence of NBS and their benefits, with some citizens even believing that NBS are harmful and unwanted (Sarabi et al., 2020; Kabisch et al., 2016). In rare cases where there is public awareness of NBS, there is often no support from the local community in developing and maintaining NBS projects, while this is crucial for successful realization (Sarabi et al., 2020). Communities may also have other, often competing, priorities, such as livelihoods, leading to a lack of acceptance of NBS in their neighborhood (Leuven, 2025). A barrier associated with these aspects is the lack of community engagement in NBS projects (Leuven, 2025; Tran et al, 2024; Dorst et al., 2022). Citizen engagement is often experienced as difficult, contested, or insufficiently prioritized (Dorst et al., 2022). The reasons for this vary from limited experience with engaging citizens in urban development to limited funding availability to support these processes.

In addition, some citizens have the misperception that the benefits of NBS are uncertain, inconsistent or not worthwhile (Leuven, 2025; Triodos Investment Management, 2025; Tran et al., 2024; Castelo et al., 2023; Sarabi et al., 2020). Other citizens perceive NBS to be lacking in functional and economic value (Tran et al., 2024). A reason for these beliefs can be that humans do not always respect and properly attribute value to non-human nature (Castelo et al., 2023). Another cause can be the unreadiness of many citizens in accepting the economic valuation of NBS (Sarabi et al., 2022). For example, carbon credits are one of the cash flows of NBS, but the recent skepticism surrounding carbon markets due to past scandals involving low-quality carbon credits does not help with a positive perception (Triodos Investment Management, 2025). Furthermore, there has been criticism on putting

a price on the ES that NBS provide, as it risks commodifying them (Dorst et al., 2021; Triodos Investment Management, 2025). NBS themselves have also been criticized by citizens, as they perceive them to be a distraction from impactful action and another form of greenwashing (Castelo et al., 2023).

Finally, society's current paradigm and value frames hinder NBS adoption (Dorst et al., 2021; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020). As the current paradigm relies heavily on economic growth, consumerism, and cheap energy, a change in system seems unattainable (Castelo et al., 2023). Even in times of population decline, the amount of urban residential areas increases while the amount of urban green space decreases (Kabisch et al., 2016). This highlights that narrow value frames around economic efficiency of urban development can prevail over, or exclude, the social and ecological values that NBS can provide (Dorst et al., 2021). This prevalence can also be seen among owners of private real estate and land in cities, who often prioritize financial gain over sustainability benefits (Sarabi et al., 2020). The relevant underlying issue of these beliefs is the fact that Western civilization is built on the proposition that humans and nature are separate (Castelo et al., 2023).

5.1.2 Social and cultural drivers

NBS can distribute funds to, create employment opportunities for, and protect the livelihoods of vulnerable and Indigenous populations, people in marginal and economically disadvantaged regions, and people in regions vulnerable to climate change (United Nations Environment Programme, 2024; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Triodos Investment Management, 2025; Castelo et al., 2023; Frantzeskaki, 2019). NBS employment could increase by up to 32 million jobs through targeted investments (United Nations Environment Programme, 2024; Kopsieker et al., 2021). Moreover, NBS can help distribute funds to communities living in endangered ecosystems, thereby protecting livelihoods and addressing poverty alleviation (Triodos Investment Management, 2025; Castelo et al., 2023). When communities actively engage in NBS projects, it also empowers them in ways that go beyond income generation. One example is that NBS can help citizens with reclaiming public space and self-governance (Frantzeskaki, 2019).

Furthermore, NBS can improve mental health and reduce negative mental health outcomes (Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020). NBS implementation improves citizens' access to nature and can encourage them to be more physically active, which in turn can have a positive impact on mental health by reducing anxiety, loneliness, and depression (Kopsieker et al., 2021; Castelo et al., 2023). NBS can also improve concentration and reduce stress levels, thereby lowering the chance of developing stress-linked conditions (Kopsieker et al., 2021; Castelo et al., 2023). The measures do not only improve mental health itself, but also reduce negative mental health outcomes, such as psychosis, neurosis, dementia, and childhood behavioral disorders, as well as improve citizens' self-perceived mental health (Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024). Next to this, areas with NBS become more attractive to residents and visitors, meaning a positive effect on health from the point of scenery (Kopsieker et al., 2021; Castelo et al., 2023).

NBS can also positively impact physical health (United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Kopsieker et al., 2021). These benefits are documented in terms of blood pressure, cardiovascular diseases, obesity, diabetes, respiratory diseases, and air pollution removal (Castelo et al., 2023). If NBS stimulate citizens to be more physically active, they have a reduced risk of obesity and chronic diseases as well as an increased exposure to microorganisms that strengthen the immune system (Kopsieker et al., 2021). Similarly to mental health, NBS can strengthen physical health from the point of scenery and increase citizens' self-perceived physical health (Kopsieker et al., 2021; Castelo et al., 2023; United Nations Environment Programme Copenhagen Climate Centre, 2024).

Besides this, NBS can help address the inequality and public health crises by ensuring a fair distribution of health benefits from green areas as well as by fostering social interactions (Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023). In addition, NBS can reinforce cultural identities, enhance social cohesion, create green urban commons, and provide a sense of belonging (United Nations Environment Programme Copenhagen Climate Centre, 2024; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019). The measures can also help with preserving cultural and natural heritages and fostering acceptance and appreciation of diverse cultures (United Nations Environment Programme Copenhagen Climate Centre, 2024; Kabisch et al., 2016; Frantzeskaki, 2019). If citizens experience green urban areas, it provides them the chance to engage in open, unplanned social encounters when visiting, which in turn helps with accepting and appreciating cultural diversity (Frantzeskaki, 2019). NBS can also increase social stability and lower levels of violence, thereby decreasing crime rates (United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023).

Through providing these benefits, NBS are able to increase citizens' quality of life and life expectancy (United Nations Environment Programme Copenhagen Climate Centre, 2024; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016). For instance, the quality of children's lives in urban areas has been associated with the accessibility to outdoor green spaces (Castelo et al., 2023). Another example is the fact that NBS are able to improve the perceived thermal comfort beyond the temperature reduction. Furthermore, the presence of urban parks and green corridors has been linked to an increased life expectancy (United Nations Environment Programme Copenhagen Climate Centre, 2024).

The final drivers are concerned with a growing social and cultural support for NBS, which is rooted in shifting values, worldviews, and perceptions of sustainability as well as the human-nature relationship. To begin with, sustainability principles and values have been gaining traction among the public in urban development discourses and can translate into norms for action, thereby creating momentum for NBS (Dorst et al., 2021; Voskamp et al., 2021; Castelo et al., 2023). Moreover, NBS support systems change, a development that is required to address climate change and biodiversity loss (Castelo et al., 2023). Systems change can be seen as transformation of the status quo by altering underlying structures and their supporting mechanisms. Research has shown correlation between society participating in NBS projects and changing their behavior towards more sustainable choices.

Next to this, most Indigenous people view themselves and nature as a whole and therefore consider human survival to be dependent on nature (Castelo et al., 2023). These beliefs make such communities highly receptive to and supportive of NBS, thereby increasing the likelihood of them willing to be eager participants in the co-creation of NBS projects. Beyond strengthening human-nature relationships among Indigenous people, NBS can also help create socio-ecological connections by connecting the broader public to nature (Sarabi et al., 2020; Frantzeskaki, 2019).

Lastly, the alignment of NBS with economic growth is increasingly being recognized. Investing in NBS does not only deliver financial returns, but also offers reputational benefits for corporations (Triodos Investment Management, 2025). By supporting NBS projects that impact climate, biodiversity, and community, companies can position themselves as sustainability leaders. Furthermore, the discourse surrounding NBS reflects economic growth ideologies, meaning that NBS are increasingly framed or promoted in terms of their contribution to economic growth, thereby aligning NBS with economic narratives that are familiar and persuasive to the public (Dorst et al., 2021).

5.1.3 Social and cultural strategies/measures/principles

Local communities need to be informed about the value of NBS to raise awareness and to mobilize them (EPA Network & ENCA Network, 2020; Leuven, 2025; Dorst et al., 2021; Tran et al., 2024; Kabisch

et al., 2016; Sarabi et al., 2020). It is crucial that good examples of NBS are shared in an accessible way with key opinion formers within communities. One step further is ensuring that diverse communities, especially vulnerable, low-income, and Indigenous ones, are involved in NBS implementation (Tran et al., 2024; Castelo et al., 2023; Hölscher et al., 2023). This is critical for ensuring the short- and long-term success of NBS (Tran et al., 2024; Castelo et al., 2023). Moreover, Indigenous communities have vital knowledge of the local natural environment and should therefore play an active role in NBS implementation (Castelo et al., 2023).

Public ownership, leadership, communication, engagement, empowerment, and self-management during the process of NBS projects also needs to be guaranteed (Triodos Investment Management, 2025; Tran et al., 2024; Frantzeskaki, 2019; Hölscher et al., 2023; Castelo et al., 2023; Sarabi et al., 2020). This means that communities can play multiple roles during the entire project. For example, citizens could become true owners of NBS projects, thereby reaping the greater benefits, the urban green spaces can be managed and maintained by the local communities, or citizens can co-create projects with other stakeholders (Triodos Investment Management, 2025; Hölscher et al., 2023; Frantzeskaki, 2019). In order to realize this, citizens need to be encouraged to be open to collaboration with local governments on NBS (Frantzeskaki, 2019). A strategy that is related to this is educating communities on how they can be involved in NBS projects (Castelo et al., 2023). If citizens see which roles and responsibilities they can receive and what contributions they can make through this appointment, they are likely more open to participation.

There are also several strategies that can be employed to ensure broad public support for NBS. Just transition measures need to be implemented and worker rights and inclusiveness need to be promoted in NBS jobs (United Nations Environment Programme, 2024; Kabisch et al., 2016). In line with this, social cohesion should be considered when implementing NBS (Kabisch et al., 2016). To illustrate these strategies, improvements in the quality and size of urban green spaces might also lead to increases in rent, with social displacement as a consequence. This must be considered when implementing NBS to ensure that the measures are just. Next to this, NBS should be designed in an aesthetically appealing manner to ensure citizens appreciate and protect them (Frantzeskaki, 2019). Important variables that play a role are the naturalness of the measures and the type of vegetation that is used. The expectation gap between citizens and engineers should also be bridged to prevent unrealistic public expectations of NBS, and resulting disappointment, from arising (Tran et al., 2024).

Lastly, views on grey solutions and NBS as well as the world need to be changed. To begin with, the burden of proof needs to be shifted from NBS to grey solutions, meaning that NBS would be the preferred option unless grey solutions are proven to be better (Linnerooth-Bayer & Scolobig, 2023). This shift would especially be helpful in the upcoming years as the evidence base for NBS is still limited. Furthermore, the world needs to change from an endless growth model to a degrowth model (Castelo et al., 2023). Society's current paradigm relies to a great extent on economic growth and consumerism, incompatible with a world of finite resources. Therefore, it is required to shift to a degrowth model that focuses on changing the system towards sustainable development, in which NBS can play a vital role. Also, the human-centric view of the world can make people reason that humans are ecologically invulnerable, which can be a dangerous belief for the uptake of measures like NBS. A novel narrative that recognizes ethical participation and negotiation of humans with nature is necessary.

5.2 Governance factors

5.2.1 Governance barriers

To begin with, there is limited stakeholder awareness and engagement (United Nations Environment Programme Copenhagen Climate Centre, 2025; United Nations Environment Programme Copenhagen

Climate Centre, 2024; Van Eekelen et al., 2021; Dorst et al., 2022). Since NBS are not mainstream in infrastructure investment planning, many stakeholders lack awareness of the existence of NBS or on how to plan and implement the measures (Van Eekelen et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2025). Moreover, even if stakeholders are aware of NBS, their engagement in realizing NBS projects is often inadequate, which is especially the case for the private sector as well as the general public (United Nations Environment Programme Copenhagen Climate Centre, 2025; Dorst et al., 2022).

In addition, a significant hurdle is formed by the lack of and difficulty with stakeholder collaboration, coordination, and cooperation (United Nations Environment Programme Copenhagen Climate Centre, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; Dorst et al., 2022; Voskamp et al., 2021; Wetlands International, 2021). Successful realization of NBS projects relies on joint action by stakeholders operating across various organizational and jurisdictional boundaries, but collaborative governance approaches are often experienced as challenging and not all stakeholders are open to it (Dorst et al., 2022; Voskamp et al., 2021). The requirement of stakeholder cooperation and coordination brings further complexity (United Nations Environment Programme Copenhagen Climate Centre, 2024; Wetlands International, 2021). One instance is that local-level institutional arrangements for climate change are often scattered across multiple public offices, which makes coordination for NBS difficult (United Nations Environment Programme Copenhagen Climate Centre, 2025). This can also lead to a lack of clear responsibilities among stakeholders (United Nations Environment Programme Copenhagen Climate Centre, 2024; Kabisch et al., 2016; Sarabi et al., 2020).

A related barrier is the silo mentality (of traditional planning systems and governance structures) and mismatches between the business-as-usual way of working within sectors and governments and the inter- and transdisciplinary collaborations that NBS projects require (Sarabi et al., 2020; Linnerooth-Bayer & Scolobig, 2023; Dorst et al., 2021; Voskamp et al., 2021; Castelo et al., 2023; Kabisch et al., 2016; Hölscher et al., 2023). Silo mentality entails that different departments and institutions all operate based on their distinct visions, goals, ways of thinking, and legal structures, meaning that they are stuck in their own silos (Sarabi et al., 2020). This while NBS are multifunctional solutions that cut across several disciplines as well as institutions. Moreover, the business-as-usual way in which city governments operate often lacks public involvement, even though this engagement is vital for creating support for projects (Hölscher et al., 2023). In addition, municipalities often follow rigid and narrow funding procedures that tend to prioritize economic cost-effectiveness over social and ecological benefits. However, the fact that only a limited amount of frameworks exists for guiding cross-sectoral projects could also explain the struggles with successfully adopting collaborative governance approaches for NBS (Kopsieker et al., 2021).

Next to this, the involvement of many diverse stakeholders in NBS projects also signifies that a lot of opinions and interests need to be considered and local considerations as well as public involvement and perception need to be accounted for (Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023; Kabisch et al., 2016; Voskamp et al., 2021; Tran et al., 2024; EPA Network & ENCA Network, 2020). It can be difficult to map every stakeholder's interests and to come to agreements with them all. To illustrate this, selecting locations for NBS can be a challenge as the landowners of potential locations need to be identified and long-term agreements with them need to be negotiated (EPA Network & ENCA Network, 2020; Voskamp et al., 2021). Since NBS often cover terrain of multiple landowners, it can be difficult and time-consuming to obtain agreement from all of them as each owner has different goals and expectations (Tran et al., 2024). In line with this, stakeholder opposition and unalignment as well as conflicting priorities and interests can form a barrier (Linnerooth-Bayer & Scolobig, 2023; Van Eekelen et al., 2021).

Finally, there are three barriers that are more general of nature but exert a great amount of influence. To begin with, mobilizing institutional support, skill sets, and time is a struggle for many city officials (Hölscher et al., 2023). Moreover, the development, decision-making, and implementation processes for NBS are more precarious and time-consuming as the responsibility for NBS is shared between multiple departments (Voskamp et al., 2021). Finally, grey path dependency, driven by entrenched institutional, technological, regulatory, and financial factors, continues to inadvertently favor grey solutions (Linnerooth-Bayer & Scolobig, 2023).

5.2.2 Governance drivers

Convening stakeholders for the development of NBS policies and projects is an opportunity for better collaboration between sectors and can act as a form of intelligent institutional leadership (Wetlands International, 2021; Frantzeskaki, 2019). Implementing NBS allows institutions "to be tested and to be flexed into more open to innovation and collaborative governance modes. Bringing together stakeholders to develop local policies and solutions such as nature-based solutions can be a form of 'intelligent institutional leadership' that in turn can foster resilience and inclusive urban development" (Frantzeskaki, 2019). This might motivate stakeholders to become involved in NBS projects. Moreover, it is increasingly recognized that NBS adoption requires the inclusion of a diversity of knowledge, which can help with preventing dominant knowledge frames to perpetuate and can lead to more and better NBS implementation (Dorst et al., 2021). In line with this, cities are increasingly willing to engage in public-private partnerships (PPPs) for NBS projects (Tran et al., 2024). The projects can also profit from the existence of already established networks that focus on concepts related to NBS (Dorst et al., 2021). Such networks enable mutual understanding and trust among stakeholders, determine their identities and roles, and can be used for learning, networking and collaboration.

5.2.3 Governance strategies/measures/principles

To start with, stakeholders should be informed about NBS to raise their awareness about the NBS and their role in delivering the organizational objectives (EPA Network & ENCA Network, 2020; Dorst et al., 2021; Tran et al., 2024; Kabisch et al., 2016; Sarabi et al., 2020; Van Eekelen et al., 2021). Grey solutions are often still deemed effective by many organizations, which can be due to the single purpose of agency objectives in comparison to the multiple benefits NBS deliver (EPA Network & ENCA Network, 2020). Therefore, it is necessary to stimulate awareness of NBS their ability to achieve organizational goals. Stakeholders should also engage in NBS knowledge and experience exchanges as well as in city-to-city networks to ensure knowledge transfer and peer-to-peer learning on NBS (United Nations Environment Programme Copenhagen Climate Centre, 2025; Kopsieker et al., 2021; Castelo et al., 2023; Kabisch et al., 2016; Hölscher et al., 2023; Sarabi et al., 2020; Voskamp et al., 2021; Frantzeskaki, 2019). Deriving lessons from realized projects is important for effectively implementing NBS in urban planning (Kabisch et al., 2016). This knowledge, however, can only be put to practice if stakeholders actively engage with the networks that have acquired those experiences. These networks can be used as opportunity spaces for quick learning from successes and failures of peers as well as from learning by doing (Frantzeskaki, 2019).

The most important strategy that stakeholders can adopt might be to be open to, establish, and utilize interdisciplinary and cross-sectoral collaborative governance approaches, structures, and partnerships between and across governments, businesses, knowledge institutes, Non-Governmental Organizations (NGOs), and citizens for NBS (EPA Network & ENCA Network, 2020; Van Eekelen et al., 2021; Triodos Investment Management, 2025; Directorate-General for Environment, 2022; Tran et al., 2024; Frantzeskaki, 2019; Kopsieker et al., 2021; Voskamp et al., 2021; Castelo et al., 2023; Hölscher et al., 2023; Sarabi et al., 2020; Kabisch et al., 2016; Dorst et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2025). This helps with increasing discussion, engagement,

collaboration, co-design, co-creation, and learning processes among stakeholders, integrating the required knowledge and skills to bridge departmental silos, shifting from risk aversion to risk sharing, ensuring that NBS are appealing and socially acceptable designs, and connecting demands for action with those responsible for action. Collaborative governance approaches can for instance be shaped by establishing PPPs or by utilizing networks that have been created by NBS demonstration projects (Sarabi et al., 2020; Kabisch et al., 2016). Administrative barriers should be removed and incentives should be provided to allow these collaborative governance formats to emerge (Kabisch et al., 2016).

To facilitate and encourage collaborative governance, new tools and ways of thinking are required. Tools for engagement, involvement, and co-creation need to be developed (Voskamp et al., 2021; Tran et al., 2024; Frantzeskaki, 2019). This can be done by establishing various informal fora for co-creating NBS (Frantzeskaki, 2019). However, it should be ensured that stakeholders are committed to using these platforms and are encouraged to contribute to them (Sarabi et al., 2020). In addition, reflexive learning should be embedded in collaborative decision-making, connotating that all stakeholders involved critically reflect on their own beliefs, assumptions, actions, and outcomes (Hölscher et al., 2023). Moreover, municipalities can adopt an action-thinking approach by declaring NBS action as their duty task (Kabisch et al., 2016). This means that municipalities take an active role in helping NBS projects forward, for example by setting up partnerships and collaborative arrangements, but does not indicate they should always take the lead or become the owner of the project.

There are also several strategies that can be implemented to stimulate the involvement of various stakeholders. Urban planners can link the benefits of NBS to different urban agendas to create a cross-departmental narrative of integration (Frantzeskaki, 2019). This can tackle departmental disputes and help feel departments and their objectives included in NBS projects. Furthermore, NBS ambassadors should be empowered to promote NBS as well as engage in a science-community advocacy by communicating the benefits and risks of NBS to citizens and politicians (Kabisch et al., 2016). In addition, citizen involvement can be enhanced by considering citizens as equals, in terms of knowledge and idea contributions, to experts, scientists, and consultants (Frantzeskaki, 2019). Next to this, participation fatigue should be prevented by not constantly involving the same citizens.

Lastly, there are two general governance strategies. The first considers ensuring good governance practices of clarity, legitimacy, transparency, and openness to opinions, beliefs, aspirations, and frustrations over the wrongs of preceding processes (Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019). It is important to clearly communicate the aim of NBS projects as well as develop mutual trust that the time spent on them and their commonly produced outcomes are trustworthy and time-worthy (Frantzeskaki, 2019). Establishing an environment of trust is especially important between the city and its citizens. Moreover, the time for decision-making on NBS should be extended to acknowledge the input of the many and diverse groups of stakeholders that are involved in NBS projects and to facilitate collaborative governance (Voskamp et al., 2021).

5.3 Informational and technological factors

5.3.1 Informational and technological barriers

There is a lack of knowledgeable and skilled professionals and knowledge brokers (Sarabi et al., 2020; Linnerooth-Bayer & Scolobig, 2023; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Castelo et al., 2023; Kabisch et al., 2016; Dorst et al., 2022; United Nations Environment Programme, 2024). Currently, there are skill gaps in both core and technical competencies (United Nations Environment Programme, 2024; Sarabi et al., 2020). Furthermore, the presence of knowledge brokers, who are transboundary stakeholders and speak the language of different groups, is crucial for connecting stakeholders at different levels, such as scientists and

policymakers (Sarabi et al., 2020). Related to this is the lack of education and training programs and difficulty with workforce training, as existing programs are often dedicated to grey solutions and it is difficult to change the way people work (Sarabi et al., 2020; Voskamp et al., 2021; Tran et al., 2024).

There is also limited centralized, reliable, and comparable evidence on the effectiveness, efficiency, efficacy, benefits, and costs of NBS (Linnerooth-Bayer & Scolobig, 2023; Kabisch et al., 2016; Sarabi et al., 2020; Wetlands International, 2021; Van Eekelen et al., 2021; Voskamp et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2025; López Portillo Purata et al., 2022; Kopsieker et al., 2021; Castelo et al., 2023). Next to the lack of general performance data, there exist only a few studies on NBS benefits and costs under different climate conditions, which is crucial knowledge as the provision of ES by NBS depends highly on the climate change scenario (Sarabi et al., 2020; United Nations Environment Programme Copenhagen Climate Centre, 2025). These gaps lead to functionality and performance uncertainties (López Portillo Purata et al., 2022; Sarabi et al., 2020; Van Eekelen et al., 2021; Kabisch et al., 2016). There is also no clear overview of the costs and benefits of NBS compared to the costs of damage in case of no climate action (Voskamp et al., 2021).

What further complicates the development of an evidence base for NBS is the difficulty in quantifying and communicating their benefits and costs (Triodos Investment Management, 2025; Castelo et al., 2023; Tran et al., 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; López Portillo Purata et al., 2022). This is due to the cause-and-effect mechanisms underlying the costs and benefits not being well understood and NBS having outcomes that are beyond the economic realm (Tran et al., 2024; López Portillo Purata et al., 2022; Castelo et al., 2023). Evidence on performance and costs of NBS is also difficult to standardize due to the design characteristics and performance being location-specific (Van Eekelen et al., 2021). This partly leads to another hindrance, namely complexity of disseminating results of NBS adoption (López Portillo Purata et al., 2022). However, this factor is also caused by the fact that results need to be reported by indicators that can be easily understood, while still reflecting the scope of projects. Moreover, few frameworks exist for acknowledging and assessing the value of NBS co-benefits and existing NBS valuation tools are not used in decision-making processes when deciding between grey solutions and NBS (Kopsieker et al., 2021; Castelo et al., 2023). As a result, decisionmakers often rely on valuation tools that fail to capture the full range of NBS benefits, leading to their undervaluation (Dorst et al., 2021).

Next to this, there are barriers related to the long-term aspects of NBS. Most projects study NBS from a general perspective and look at the design and early-stage implementation aspects only, despite there being a need for long-term research that addresses maintenance issues and enables monitoring of the impacts the projects have over time (Kabisch et al., 2016). Related to this, there is a lack of design standards and guidelines for maintenance and monitoring (Sarabi et al., 2020). Standards and guidelines, that are tailored to the local conditions of different cities, are vital for responding effectively to a city's context-specific challenges. Since the acknowledgement of local conditions is important for the development of standards and guidelines, providing commonly acceptable maintenance and monitoring frameworks is difficult. Due to this, as well as because of limited data availability, there is uncertainty around how NBS can be best planned, designed, implemented, maintained, and monitored (Sarabi et al., 2020; Voskamp et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024). Lastly, scientifically validated options and knowledge on NBS are often not available when policy windows are receptive to NBS projects (Kabisch et al., 2016). This stems from a mismatch between the short-term cycles of political decision-making and the long-term planning and knowledge development required for NBS.

5.3.2 Informational and technological drivers

Recent advancements in technology, such as satellite monitoring and AI, have made it easier to measure the ES that NBS provide (Triodos Investment Management, 2025). This shift can also aid in making NBS more scalable and cost-efficient. Moreover, a large variety of tools has been developed and is being tested to support the adoption of NBS in cities (Voskamp et al., 2021; Castelo et al., 2023). The tools range from catalogs to software and can help stakeholders with various tasks, such as evaluating implementation sites (Voskamp et al., 2023). Next to these developments, the fact that the potential, benefits, and cost-effectiveness of NBS are increasingly being demonstrated in practice and emphasized in scientific assessments and reports also helps with their further roll out (Voskamp et al., 2021; Castelo et al., 2023). A final driver is the fact that currently over 60 million people globally work in activities categorized as NBS, representing a vast capacity of knowledgeable and skilled professionals on which can be built during NBS projects (United Nations Environment Programme, 2024).

5.3.3 Informational and technological strategies/measures/principles

An evidence base for NBS needs to be built by demonstrating their workings, (technical) feasibility, cost-effectiveness, long-term viability, and scalability (EPA Network & ENCA Network, 2020; Wetlands International, 2021; Van Eekelen et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2025; United Nations Environment Programme, 2024; Kabisch et al., 2016; Tran et al., 2024; Directorate-General for Environment, 2022; Castelo et al., 2023). This can be accomplished by means of demonstration projects and by applying monitoring frameworks (Directorate-General for Environment, 2022; United Nations Environment Programme, 2024; Van Eekelen et al., 2021). Next to this, strategies and partnerships to collect, maintain, and share data need to be developed (Hölscher et al., 2023). The type of data that should be obtained can be determined by systematically selecting context-specific indicators, data collection can be realized by including a diverse group of stakeholders, and the data can be maintained and shared through the use of platforms. Beyond identifying and quantifying the costs and benefits of NBS, it is equally important to map the social and environmental uncertainties and risks (EPA Network & ENCA Network, 2020; Van Eekelen et al., 2021). Risks can help with anticipating results, thereby setting an appropriate level of expectation, and should be considered in the design of NBS projects, along with the adaptive capacity of ecosystems (EPA Network & ENCA Network, 2020). Management options to address the uncertainties and risks should also be developed (Van Eekelen et al., 2021).

Furthermore, the development of tools and indicators that can provide the costs and benefits of NBS is required (EPA Network & ENCA Network, 2020; Van Eekelen et al., 2021; Voskamp et al., 2021; Kabisch et al., 2016; Directorate-General for Environment, 2022). A holistic approach should be taken when developing them, meaning that all (co-)benefits should be accounted for (EPA Network & ENCA Network, 2020). It would be especially helpful to develop tools that can express benefits that are more difficult to quantify, such as livability and aesthetic value, in monetary value (Voskamp et al., 2021). Establishing indicators can also aid in systematically evaluating NBS, thereby increasing comparability and measurability (Kabisch et al., 2016). However, the design of NBS projects should not only be based on evidence of the benefits of the NBS being adopted, but also on localized systems' knowledge (Castelo et al., 2023; Hölscher et al., 2023). This ensures that the solution being implemented is tailored to the local needs and landscape, delivering the benefits that are most relevant in that context. Next to this, NBS need to be designed in a way and scale so that lessons for their effectiveness can be collected and replicated in other situations (Frantzeskaki, 2019). Some designs require localization when being recreated or are too contextually bound to be replicable, so using designs for which replication is possible can be helpful for mainstreaming NBS.

In line with this, developing a catalog of applicable and customizable NBS can be valuable as it would equip cities with both general NBS knowledge as well as specific knowledge on NBS for certain urban challenges (Voskamp et al., 2021). In addition, standards, knowledge tools, and support for the design, development, implementation, and maintenance of NBS need to be provided (Van Eekelen et al., 2021; Triodos Investment Management, 2025; Castelo et al., 2023). Standards can reduce the risk of NBS projects, making them a more attractive investment (Van Eekelen et al., 2021). Moreover, NBS are rarely implemented unless they are integrated into urban planning tools and mechanisms (Castelo et al., 2023). Knowledgeable organizations should support the design and development of NBS projects. Besides the provision of these assets and services, it can be useful for cities to establish knowledge platforms that are open for knowledge gathering, aggregating, and co-creating (Kabisch et al., 2016). Such platforms can be used for continuous learning purposes (Hölscher et al., 2023).

Practitioner knowledge, skills, experience, and expertise also need to be developed, especially as most existing NBS jobs classify as medium-skilled roles while the growth of NBS will lead to a rise in higher-skilled jobs (Directorate-General for Environment, 2022; Tran et al., 2024; United Nations Environment Programme, 2024). Next to this, capacity needs to be built in executing agencies and worker productivity needs to be enhanced to ensure a sufficiently skilled workforce as NBS implementation scales up (Kopsieker et al., 2021; Castelo et al., 2023; United Nations Environment Programme, 2024; Van Eekelen et al., 2021). Though, existing tacit and expert knowledge of stakeholders should also be valorized and exploited as knowledge gained through experiences with NBS projects is instrumental for effectively adopting NBS in urban planning (Kabisch et al., 2016). However, stakeholders should still be provided with new opportunities to enhance their experience with and knowledge on NBS (Sarabi et al., 2020). This can be realized by establishing ULLs, which can provide safe environments to learn by doing as well as opportunities to gather data.

Lastly, greater efforts are needed in both research and information dissemination. More research and development on the topic of engagement is required, for example on how higher levels of engagement can be fostered among diverse stakeholders (Tran et al., 2024). Moreover, it should be researched when and where NBS can help build synergies between climate adaptation and mitigation as many cities could benefit from this combined approach (Castelo et al., 2023). In addition, research on the specific actions that are required and the specific challenges and opportunities that are present in different places and for different ecosystems and species would be helpful (Kabisch et al., 2016). A broader research topic that needs to be explored is the role NBS can play in supporting systems change (Castelo et al., 2023). Finally, information about climate change and extreme weather events needs to be spread further to create urgency for NBS (Tran et al., 2024).

5.4 Physical and ecological factors

5.4.1 Physical and ecological barriers

To start with, NBS typically occupy a larger, and mostly privately owned, area than grey solutions (EPA Network & ENCA Network, 2020; Van Eekelen et al., 2021; Leuven, 2025; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2021; Castelo et al., 2023). NBS that cover more ground have greater potential in delivering benefits, but it can be challenging to find a space of adequate size to implement the desired solutions (United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2025). Moreover, most urban space is privately owned, creating challenges of either purchasing land or negotiating long-term agreements with several landowners (EPA Network & ENCA Network, 2020).

This barrier is exacerbated by the fact that urban space is scarce and competed over (Dorst et al., 2022; Leuven, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et

al., 2023). Even though cities have ambitious greening objectives, there is tension between the need for urban greening and the need for housing and commercial buildings. As urban development projects tend to have more vested interests behind them, they have a competing advantage for urban land (Castelo et al., 2023). Furthermore, there can also be competition observed over the sustainable use of urban space between technological sustainability innovations and NBS (Dorst et al., 2022). This competition is worsened by the general scarcity of vacant space within many European cities due to the high density of the built environment.

Even if urban space is available, not all sites can host NBS (Castelo et al., 2023; Sarabi et al., 2020). The suitability of spaces depends on many factors, including the slope of the roofs and the type of soil (Sarabi et al., 2020). Moreover, the obdurate built environment, representing sunk investments and long life spans, determines the path dependency of future development (Dorst et al., 2021). Therefore, European cities often favor optimization or modernization of existing grey solutions over complete alteration. New technologies like NBS are meant to exist alongside remnants of the grey infrastructure, which can be problematic if NBS have a poor physical fit with the design of grey solutions.

5.4.2 Physical and ecological drivers

One of the most prominent drivers is the climate crisis, since NBS can promote adaptation to climate change, mitigate climate change, and help build climate resilience (Triodos Investment Management, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019; Kopsieker et al., 2021; Wetlands International, 2021; United Nations Environment Programme, 2024; European Commission, n.d.-c; Hölscher et al., 2023). Related to this is the fact that the largest share of the population lives in cities that have high exposure to and are particularly vulnerable for climate change effects (United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020). This is due to several factors, including the fact that many of the fastest growing cities are located in coastal areas and that the built environment tends to amplify these effects, meaning urban populations are likely to experience them most severely.

Next to this, the biodiversity crisis can also be tackled by NBS, as they can help protect, conserve, and restore biodiversity (Wetlands International, 2021; Kopsieker et al., 2021; Castelo et al., 2023; Triodos Investment Management, 2025; Kabisch et al., 2016; Sarabi et al., 2020; United Nations Environment Programme, 2024; European Commission, n.d.-c; Tran et al., 2024; United Nations Environment Programme Copenhagen Climate Centre, 2024). This also shows that NBS can address multiple societal challenges and deliver multiple benefits, which can be a strong justification for stakeholders to opt for NBS (Wetlands International, 2021; European Commission, n.d.-c; Triodos Investment Management, 2025; Voskamp et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Hölscher et al., 2023; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019; Kopsieker et al., 2021).

Another inherent characteristic of NBS that is a driving force is their adaptability to uncertainty and the specific situation at hand, allowing for more resilient and context-sensitive solutions (Wetlands International, 2021; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; European Commission, n.d.-c; Voskamp et al., 2021). Due to future climate uncertainties, adaptive management is becoming necessary for all solutions (Wetlands International, 2021). In addition, NBS are inherently place-based and can be tailored to the specific socio-ecological context at hand, making them well-suited for addressing a wide range of situations (Voskamp et al., 2021). Two additional drivers linked to the nature of NBS are their resource efficiency and scalability,

which make NBS cost-effective, sustainable, and adaptable across contexts (European Commission, n.d.-c; United Nations Environment Programme, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2021).

In addition, NBS can help with addressing the UHI effect by reducing urban temperatures (Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Kabisch et al., 2016; Sarabi et al., 2020; United Nations Environment Programme Copenhagen Climate Centre, 2025; Castelo et al., 2023). NBS also bring more nature and natural features and processes into cities, which has ecological benefits beyond combating biodiversity loss (European Commission, n.d.-c; Voskamp et al., 2021; Hölscher et al., 2023). Furthermore, NBS can safeguard and increase water availability and quality by increasing filtration, evapotranspiration, and storage as well as removing harmful chemicals (Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023; Sarabi et al., 2020). Similarly, NBS can mitigate air pollution and increase air quality by capturing, dispersing, and depositing air pollutants (Kopsieker et al., 2021; Castelo et al., 2023; United Nations Environment Programme Copenhagen Climate Centre, 2024; Kabisch et al., 2016; Sarabi et al., 2020). When adopted in coastal areas, NBS can reduce shoreline erosion (Triodos Investment Management, 2025).

However, NBS also deliver ecological benefits for specific sectors of society. In the agricultural sector, NBS can be employed to combat land degradation and increase the soil fertility and quality (United Nations Environment Programme, 2024; Triodos Investment Management, 2025; Castelo et al., 2023; United Nations Environment Programme Copenhagen Climate Centre, 2024). This in turn can increase agricultural productivity and contribute to long-term food security (Kopsieker et al., 2021; Castelo et al., 2023; Kabisch et al., 2016). Moreover, NBS can support the delivery of natural fertilizers and pesticides, such as pest control and pollination, thereby replacing man-made ones (Kopsieker et al., 2021). Next to this, NBS can help buildings with reducing their energy use by lowering their heating and cooling demands through the provision of natural shading and cooling effects (United Nations Environment Programme Copenhagen Climate Centre, 2024; Kabisch et al., 2016). In addition, the measures can be combined with renewable energy and energy efficiency solutions on buildings to further increase energy savings (United Nations Environment Programme Copenhagen Climate Centre, 2024). Lastly, NBS adoption can promote sustainable modes of transport like walking and cycling.

5.4.3 Physical and ecological strategies/measures/principles

The multifunctional characteristic of NBS can be used to deal with the lack of space in cities (Wetlands International, 2021; European Commission, n.d.-c; Triodos Investment Management, 2025; Voskamp et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Hölscher et al., 2023; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019; Kopsieker et al., 2021). For instance, green roofs cannot solely be used for managing stormwater and cooling buildings, but also as recreational areas for the building users and habitats for multiple species. This example is also related to the strategy of implementing hybrid NBS, such as permeable pavement and green roofs, in places where 'regular NBS' are not feasible (Hachoumi et al., 2021; World Bank, 2021; Evans & Hardman, 2023). There is also a nascent movement to using urban car parks and repurposing leftover infrastructure to create hybrid designs (Evans & Hardman, 2023). Another strategy can be to make use of the potential of redundant car parking within urban areas (Croeser et al., 2022). Street parking takes up a lot of room and could be accommodated in garages to free up space for NBS. Lastly, abandoned, degraded, or brownfield spaces are generally underexplored, but could provide opportunities for revitalization with NBS (Mastervich et al., 2024; Zarei & Shahab, 2025).

6. Results: Factors according to experts

This chapter describes the factors that influence the implementation of NBS in Dutch cities according to experts. Section 6.1 mentions the hypotheses around which the interviews were centered and Section 6.2 shows statistics of the coding process. Then, Section 6.3 delves into the definitions experts provided for the term NBS to provide context for their responses. This is followed by a discussion of the factors influencing NBS adoption in Section 6.4, for which the themes of the hypotheses are discussed before explaining the factors that were identified within the remaining themes. From all these factors, Section 6.5 reveals which were found to be the most critical ones.

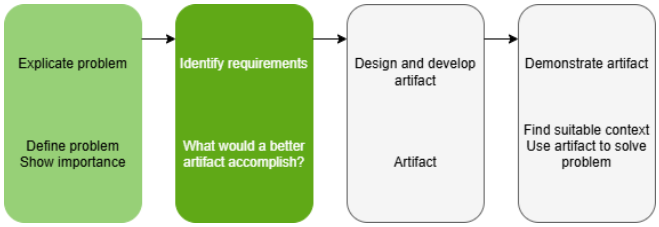

Figure 8 Progress DSR approach - Identify requirements 3

6.1 Hypotheses

Hypotheses within the social and cultural, governance, informational and technological, and physical and ecological themes were chosen. For each theme, one barrier, one driver, and two strategies were selected to ensure that all, or most, of them could be discussed during each interview.

6.1.1 Social and cultural

1. Barrier: Lack of public awareness, support, and acceptance.
2. Driver: NBS can increase the quality of life of citizens.
3. Strategy: Design NBS in an aesthetically appealing way.
4. Strategy: Ensure public communication, engagement, co-creation, maintenance and self-management during the process of NBS projects.

6.1.2 Governance

5. Barrier: Silo mentality and mismatches between the business-as-usual way of working within governments and sectors and the inter- and transdisciplinary collaborations that NBS require.
6. Driver: Stakeholders are organized in networks regarding (concepts related to) NBS.
7. Strategy: Municipalities should adopt an action-thinking approach by declaring NBS action as their duty task.
8. Strategy: Urban planners can link the multiple benefits of NBS to different urban agendas.

6.1.3 Informational and technological

9. Barrier: Lack of centralized, reliable, and comparable evidence on the effectiveness, efficiency, efficacy, (co-)benefits, and costs of NBS.
10. Driver: A large variety of technical NBS tools has been developed and is being used.
11. Strategy: Establish ULLs that can provide appropriate and safe environments to learn by doing as well as opportunities to gather data.
12. Strategy: Develop a catalog of applicable and customizable NBS for cities.

6.1.4 Physical and ecological

13. Barrier: Urban space is scarce and competed over.
14. Driver: NBS can address multiple societal challenges (simultaneously) and can deliver multiple benefits (simultaneously).
15. Strategy: Assign multiple functions to NBS designs.
16. Strategy: Implement hybrid NBS.

6.2 Coding statistics

Table 1 shows how many codes are related to the hypotheses and how many were formulated based on the interview data. For each of these numbers it is presented how many codes are barriers/drivers, strategies/measures, and principles. Notable is that experts mentioned more strategies and measures than barriers and drivers and often stated principles to be of vital importance too. The other category in the table refers to the codes related to the 'experience with NBS' and 'looking ahead' sections of the interview protocol. The coding scheme itself can be found in Appendix C.5.

Table 1 Coding overview

Code type	Number of codes per category
Hypotheses	22
Barriers/drivers	*12*
Strategies/measures	*10*
Principles	*0*
Interview data	142
Barriers/drivers	*44*
Strategies/measures	*73*
Principles	*25*
Other	4
TOTAL	168

6.3 Definition of NBS

One of the first questions interviewees were asked was their definition of NBS. To begin with, some of them compared NBS with related concepts. Expert PA1 considered NBS to be an umbrella term that has been pushed by the EU in recent years, but noted that terms like (Blue-)Green Infrastructure, nature-inclusive, and Nature+ are also used in practice. However, the interviewee did recognize that each concept has different nuances.

Some other experts mentioned that they do not necessarily like the term NBS and prefer to use one of the related concepts. Participant A4 used NBS as it is the policy term, but explained that planners, practitioners, policymakers, and academics alike often have problems with the Solutions part of the term: "*Because a solution to what problem? And is it really a solution or is it like not? I mean a solution is also always creating new problems. So that's why I prefer more of a broader frame like urban green blue infrastructure. Which sounds maybe more generic in general than Nature-Based Solutions, but I find that Nature-Based Solutions sounds like, I mean, it's applied to everything.*". The expert stated that the systemic and transformative nature of NBS is often forgotten, meaning that projects that do not possess these characteristics are wrongfully labelled as NBS. Interviewee P3 stated that people with a design background generally lean towards the term nature-inclusive design, driven by, among other things, the fact that NBS encompass geoengineering measures too, which entails "*looking at how nature can be used to pursue strategic military objectives, so to speak*". This is not at all what this expert means with nature-inclusive design: "*our overarching goal is quality of life for all species*".

The definitions experts provided had both common and unique aspects in them. While all participants stated their own definition, some of them also referred to descriptions given by leading organizations, such as the IUCN Standard for Nature-Based Solutions and the definitions provided by the EC and the IPBES. There were three recurring elements in the interviewees' definitions. They spoke of NBS as measures that (1) work with nature instead of against it, use nature, and/or learn from nature, (2) address multiple societal challenges and deliver multiple ES, and 3) are systemic, with especially the first two aspects being referred to. The following quote illustrates this: "*Well, you work with nature to*

solve a problem, because nature can provide multiple services or multiple benefits at the same time." A2. A unique insight was provided by participant A3, who stated that three principles of nature form the inspiration for NBS: (1) capturing energy that is provided by the sun on-site and converting it into the energy that is needed to survive, (2) capturing water on-site and absorbing it until a saturation level is achieved, before releasing the rest to the next phase of the ecosystem, and (3) participating in the circulation of materials, thus absorbing nutrients from decomposed natural matter.

There was also a topic on which interviewees did not agree, which was whether NBS only learn from and are inspired by nature or if the measures need to use actual living nature as well to qualify as NBS. Expert A1 pointed out that biomimicry designs can also be considered NBS, as the concept also entails taking inspiration from nature, meaning it does not necessarily have to be nature itself. This while participant P2, who provided an example of a windbreaker that represents the movement of leaves and generates electricity, was unsure whether such approaches count as NBS: "*You are mimicking a process of a tree, but you are adapting it and using fully artificial materials and construction methods.*". However, interviewee PA1 stressed that NBS need to be based on living nature: "*So it's not just timber construction or something like that. It really needs to have the characteristics of living nature and use those for all kinds of benefits.*".

6.4 Influencing factors

This section explains the influencing factors of each theme by describing and contextualizing the codes, as each code represents a barrier, driver, strategy, measure, or principle. Given that there are 168 codes, not every code is discussed in depth. Instead, the focus is placed on the codes related to the hypotheses and those that yielded the most interesting insights, while the remaining codes are briefly addressed. Nevertheless, as attention was paid to ensuring clarity and capturing the essence of each code, the short descriptions are sufficient to convey their meaning. All codes are discussed, however, since the aim of the central research question concerns the factors influencing NBS implementation in Dutch cities, and each code will be incorporated into the framework in the following chapter. The terms *experts*, *participants*, and *interviewees* are used interchangeably in this thesis to refer to the individuals who took part in the interviews.

6.4.1 Social and cultural factors

The first factor that influences NBS adoption is public awareness and understanding, with interviewees indicating that it can act as both barrier and driver as the level of awareness and understanding varies among citizens: "*I think there are more and more people being aware, then there are people that are aware but they don't really want to leave their comfort zones, and then there are people that are not aware and do not care.*" P2. Moreover, participants noted that society is often unconsciously aware of or has forgotten about the value of nature as well as that many citizens only have a basic understanding of nature and the benefits it can deliver. Although the increasing occurrence of heatwaves and flooding in recent years have helped put nature on the map, as well as the Corona crisis, citizens tend to forget about it when they are not in a 'crisis mode'. Therefore, interviewees indicated that informing citizens about NBS is a good strategy to raise awareness as well as to break myths about the concept. One measure that falls under this strategy is communicating NBS information via easy-to-understand videos and posters, which experts considered effective given that citizens are typically not inclined to read (scientific) articles: "*Those videos are very simplified and explain why nature in the city is important and what you should do in a growing area or with water or whatever. Scientists should learn to communicate with residents in this way.*" A3.

Related to this are the acceptance of and support for NBS, for which experts, again, stated that this factor also varies. In general, citizens are quite accepting and resistance has decreased since the

introduction of NBS as they are increasingly being implemented: "*And now that many projects are being executed or are already finished, people start really seeing what are the delivered benefits. I think they are not so afraid anymore*." P2. Moreover, interviewee A5 noted that the Dutch culture of managing and living with water may have also resulted in broader acceptance. Nevertheless, if NBS are implemented in the direct environment of citizens, resistance frequently occurs, for instance when NBS mean a reduction in available parking spaces or an alteration of the familiar look of a neighborhood, as participant A5 put it. Furthermore, expert P2 explained that there also remain citizens that simply do not want more nature due to reasons like noise of rustling leaves or the 'messiness' it can create. There are also concerns about stagnating water, the potential attraction of insects or rats, and the use of species that citizens may be allergic to. Because of this, a strategy that was put forward was designing NBS in a smart way, meaning implementing them in a manner that mitigates these risks beforehand, thereby taking away fear and resistance among citizens. Smart design also entails creating NBS in ways that allow citizens to see, experience, and appreciate them. This may involve, for instance, incorporating walking paths through natural areas, even if fencing them off might better support ecological development.

Next to the strategies and measures stated in the paragraphs above, there are various other ways to address the aforementioned factors. To begin with, several degrees of citizen participation can be implemented. The first level is actively accounting for citizens' perspectives by asking them what they think and want as well as seeing if envisioned ideas appeal to them: "*Because if you then implement your innovation and everyone turns out to be against it, you have forgotten something in your innovation phase*." A3. Although some experts mentioned that it is difficult to include the opinion of every citizen, especially people that are not the biggest fan of nature in general, participant P1 mentioned that everyone has their own perception and should be taken seriously.

One step further than listening to the public is actively co-creating NBS projects with them: "*When citizens and communities are engaged together in design and stewardship, it improves the possibility and the acceptance of NBS in general.*" A5. However, some interviewees mentioned that, although the Netherlands is quite accustomed to participatory processes, certain stakeholders, mainly project developers, felt these processes took too long. Expert PA1 noted that this does not imply that co-creation sessions should not be held, but rather that it is not the solution either as it creates complaints from another party. In addition, one of the participants expressed that involving everyone everywhere and all the time means there is no question of speeding things up, while the time to change cities has run out with climate change happening too fast and humanity moving too slowly. Nevertheless, most interviewees described co-creation as one of the pillars of NBS.

However, it must also be noted that practitioners are dealing with the phenomenon of participation fatigue, meaning that citizens are tired of participatory sessions, making it difficult to get people on board of them: "*From my experience as well, from actually directly asking my stakeholders in practice, why don't you come to the meetings? And they said, because we already have been participating for 10 years in these type of sessions and then nothing changes, nothing happens, we don't feel heard.*" P2. Therefore, experts mentioned that alongside co-creation other strategies need to be implemented to ensure citizens are willing to participate. Next to actively listening to and accounting for citizens' perspectives, engaging participatory models need to be used: "*So for instance, what I said in X that they also created this junior team competition specifically to involve school kids, as an add-on to other things, and to make it fun. But they also organized like safari bike tours in the valley, so really something nice that gets people excited.*" A4. Moreover, participation needs to be made as locally relevant and tangible as possible in order to make the project relevant for citizens, thereby motivating them to

participate. This means, for instance, not asking citizens about a broad GI plan, but talking about the realization of a specific park in their neighborhood.

Another form of citizen participation is involving them in maintenance. Allowing citizens to maintain NBS does not only reduce maintenance costs and requirements for municipalities, but also fosters a sense of place and ownership among citizens. While the mere presence of NBS in neighborhoods can already generate this feeling, actively involving citizens throughout NBS projects further strengthens it, thereby reinforcing these drivers for adoption: "*Involving them is a very nice approach for the sense of ownership, of co-ownership, which will make people even voluntarily want to keep an eye on the public space, if it's a public space, it can be a private space. But also taking care of it, and that means also maintenance operations, at least the most basic ones.*" P2. It is worth noting that co-creation and accounting for citizens' perspectives were supported more and emphasized more frequently than involving citizens in maintenance. The latter was seen as less feasible depending on the implemented NBS, requires long-term commitment from citizens, and some interviewees expressed concerns that it might amount to an undesirable transfer of responsibility.

Furthermore, there are several principles that need to be kept in mind when implementing such participatory formats. First, citizen participation must remain realistic, meaning that (1) practitioners should take citizens' opinions into account, but should not make promises they cannot keep in order to avoid disappointment, (2) citizens can influence the details of NBS plans, but professionals must determine the project requirements on a larger scale, and (3) citizens cannot be held solely responsible for maintenance. Moreover, attention should be paid to the composition of participants to ensure that all relevant citizen groups are involved in the participatory process. However, this can be quite difficult: "*So the cities also always say, even when they're trying to really reach out to a diverse population group, it's generally older people who are maybe retired or in general people who are interested in nature, also relatively highly educated people.*" A4. To create a heterogenous sample, community or neighborhood managers can be involved to reach out to different, and especially more vulnerable or marginalized, populations.

In addition, stimulating citizen initiatives and facilitating citizen experiences also helps with increasing awareness, understanding, acceptance, and support. Citizen initiatives should be encouraged and supported by governments, as this resourcefulness can help with scaling up NBS, especially as quite a large surface area in cities is privately owned. This means that citizens can sometimes make more of a difference than municipalities. The second concerns, among other things, enabling citizens to experience the difference between grey solutions and NBS or environments without NBS and locations with NBS, in order to better understand the benefits of opting for NBS. One interviewee mentioned letting citizens sit on a green roof and a black bitumen roof to experience the difference in temperature and comfort. However, citizen experiences can also take the form of municipal actions, such as organized nature walks or initiatives like Tegelwippen: "*But it's also about getting people to take action themselves. For example, I'm a big fan of the Tegelwippen campaign. I've been doing this for years, just participating and trying to facilitate it. And I'm really surprised at how much people enjoy it and every time I come back, they've learned something new about nature in the meantime.*" A2.

Designing NBS in an aesthetically appealing way can also help create support and acceptance. Although some experts indicated that they thought aesthetics are more important in theory than they seem to be in practice, aesthetics were nevertheless considered vital, given that most citizens encounter NBS on a daily basis and aesthetic appeal is seen as one of the benefits of nature. However, the public has varying opinions on what is considered aesthetically pleasing, and aesthetic preference might not always align with biodiversity value, noted participant A5. This matter was also highlighted by another expert: "*That reminds me of a study I recently heard about from someone who has indeed researched*

this topic. They attempted to make a green space in the city more biodiverse or biodiversity-friendly. Many people didn't like it because it looked a bit 'wild'." A2. Therefore, the strategy of designing NBS in an aesthetically pleasing manner needs to be combined with the strategy of informing citizens to make people understand that "*a mudflat is as beautiful as a prairie*" P2.

Returning to the influencing factors, the interests and priorities of citizens can either hinder or drive NBS adoption. Experts indicated that, generally speaking, mainly specific demographic groups are interested in NBS, such as the elderly and citizens who are interested in nature, which also influences the amount of people that actively engage in NBS projects. Although some citizens are willing to contribute to NBS adoption, most do not have time, have other priorities, or are in general not interested in participating in co-creation or maintenance of public NBS as well as in implementing NBS on their own terrain. Moreover, spatial priority is often given to the accessibility of mobility and parking spaces: "*Sometimes there isn't a single tree in the street; they really have zero trees. And then they say, yes, we really want lots of trees, or at least two, three, four trees. But when you say that four trees will cost two parking spaces, they say "but that's not possible".*" A1.

Additionally, the perspective on urban space within society is of great influence. Interviewees pointed out that there is a slow movement visible in which citizens and practitioners alike are starting to realize that current urban challenges require a different way of managing space: "*Stefano Boeri, the one who designed the towers in Milan, I know him and I interviewed him at the time, and he said "I had to learn so much. Especially that there were things I shouldn't do, because I had to leave those to someone else." And we see that now too, don't we? So architects realize that they also need to consult an ecologist and that certain things, such as a black facade, are just not very practical.*" P3. On the other hand, expert P1 stated that there are still planners 'stuck' in the old perspective on urban space and design accordingly. This refers to the inclusion of large amounts of pavement in designs and the selection of plant species based on aesthetics rather than suitability for the given context.

Next to some of the strategies mentioned earlier, there are several others that can help raise citizens' interest in NBS, encourage the public to prioritize nature, and accelerate society's changing perspective on urban space. The first strategy concerns embedding NBS thinking, meaning encouraging both citizens and practitioners to approach projects and daily life from the perspective of how nature can be integrated. Again, this strategy also needs to be combined with informing citizens. Another strategy related to this is shifting the burden of proof from grey solutions to NBS. Currently, grey solutions are implemented as standard and NBS must first prove themselves before they are considered, but this 'burden' can be transferred: "*How do you ensure that you first try to find a solution using nature and only then consider something else? That it simply becomes standard practice. First nature, can we come up with something? And if not, OK, then we'll go for a grey solution or something like that.*" A2.

There are also two other important factors that influence NBS implementation, which are related to the benefits NBS can offer. The first driver is the contribution of NBS to citizens' quality of life in terms of (mental and physical) health, social inclusion, living comfort, neighborhood safety, and so on. "*Because greenness has social-psychological benefits, right? It can make people happier or improve their well-being. And for nature it has been shown that it literally improves your health, that's already evidence-based.*" A1. This driver can be leveraged to build support for NBS by framing solutions around issues that matter to citizens, as private parties often approach such initiatives with a 'what's in it for me' perspective. One quote to illustrate this: "*My idea is that talking about health might be easier, right? If I talk about their children's health, for example, or about creating space for them to play outside, that might be more of a driver for change.*" A2. This strategy can also increase society's acceptance and support. A driver for companies, which stems from the way society views them, is the fact that NBS can offer reputational benefits. Participant P3 stated that the younger generation wants

to work for businesses that contribute to a cause, and that allocating marketing budgets to NBS and related themes can therefore attract new talent. Although this might motivate them to invest in NBS, one interviewee thought that doing well in terms of ESG goals is not as important for companies as it used to be. The framing strategy can also be applied to leverage this driver.

Finally, there are some principles that should be kept in mind to increase the success of NBS. Just implementation needs to be ensured, as NBS are typically implemented in wealthier neighborhoods first, which expert A5 explained can be seen as the "*greenification of the already rich neighborhoods that don't particularly benefit greatly from the health benefits of Nature-Based Solutions."*. Since this raises social justice questions, the expert mentioned that this inequity can be actively counterbalanced by prioritizing underserved areas when implementing NBS. However, just implementation also means preventing that NBS adoption in vulnerable neighborhoods increases property values too much and leads to social displacement, noted interviewee A4, meaning citizens have to move out and move away from where they used to live. In addition, NBS must be adapted to the social and cultural context in which they are implemented, which requires an understanding of that context: "*Just because it works in Berlin doesn't mean it will work in The Hague. That brings us back to the context itself. How do you ensure that Nature-Based Solutions are successful there too? So you need to have a good understanding of the cultural and social context.*" A2.

6.4.2 Governance factors

Similar to the social and cultural theme, the awareness and understanding as well as acceptance and support of practitioners also influences NBS adoption, and whether it is a barrier or driver depends on which stakeholders are involved: "*Not everyone within the municipality understands the importance or the benefits of integrating ecological functions into urban design. I think there's a few positions in the department of spatial planning who really get this point and work on it dedicatedly, but overall I think its acceptance is not yet understood very well.*" A5. However, another participant stated that the municipality has always had employees who are aware that designing and managing public space requires a specific, different approach. Among urban planners and designers, awareness of NBS is beginning to grow, however, the concept is often not yet fully understood, as many are uninformed of its broader implications. Likewise, acceptance and support is also increasing among stakeholders, although one expert noted that it may take some time before the concept becomes widely recognized.

Another important factor is the interests and priorities of practitioners, which often differ between municipal departments. While some departments actively support NBS, others may prioritize matters such as mobility, creating either alignment or conflict across the organization. Expert P1 illustrated this point by noting that the mobility department occasionally selects the widest exit lane dimensions next to parking lots (90 cm rather than 30 cm or 60 cm), thereby leaving limited space for NBS: "*If I have a sidewalk, a 90 cm exit lane, and then a parking lot, then you don't have any green space left. So that kind of fuss, which then goes all the way to the Council, saying "it can't be like this and it has to be different". And yes, then you see that it can swing the other way. Which then comes at the expense of the greenery.*" P1. Moreover, interviewee A3 pointed out that Dutch cities are currently dealing with many other challenges, including a mobility crisis, nitrogen crisis, and housing crisis, which in the end causes NBS to lose out.

Nevertheless, there are several strategies and measures that can be taken to address these factors. To begin with, just as in society at large, NBS thinking needs to be embedded among practitioners. Expert A2 mentioned that if nature is not considered a priority, it always comes as an afterthought when the zoning plan is already finalized or the design has already been made. In addition, it can be useful to develop and use 2D visualization tools and 3D/AR/VR tools to show stakeholders the difference between the current situation and a situation with NBS, or to show a design without and a design with

NBS. This creates awareness and understanding of what NBS are and can look like, while at the same time generating support and acceptance because stakeholders can see what can be accomplished by NBS: "*I think that if you can show people in pictures or in a 3D environment, but especially the difference, in other words, don't just show the design, but also show, look, this is the design as we had conceived it with parking spaces, streets, and sidewalks, but we have now made it nature-inclusive, and now it will look like this. Then people who never think about it have a bit of an 'aha' moment, like, "OK, yes, now I can see through my 3D glasses that it's really very different, and I think this is much nicer."*." A3. Moreover, NBS competitions can be organized to interest businesses in contributing to projects. Practitioner P1 stated that a municipality organized a competition for developing houses during which the designs were scored on, among other things, inclusion of nature-inclusive aspects. Interviewee P3 mentioned that an industrial park organizes an annual competition to determine which company has the most beautiful front yard, from a nature perspective, and contributes most to the ecosystem. Such competitions are also a way of leveraging the reputational benefits driver discussed earlier.

Another influencing factor is the number of stakeholders involved in a project. Since integrating NBS in cities requires extensive cooperation among diverse stakeholders, the process can become complex, as noted by expert A5. Closely related to this factor are the collaborations across governmental departments as well as between organizations and sectors. Such collaborations are essential, as NBS inherently intersect with multiple domains and can address challenges across these different domains, thus creating opportunities for scaling up NBS. The degree of collaboration between different departments varies, but generally there is a silo mentality: "*I think the argument that we got over and over again for the Dutch context, is that there is still not as much coordination between departments as there should be. Everyone still works on the topic that is given to them and there is a siloed approach even now.*" A5. Interviewee PA1 stated that despite this being a barrier, it is also important to recognize that the silos are there for a reason. Next to generalists, specialized people and knowledge are required, meaning that it is also necessary that departments have certain goals they work towards. However, it is important that employees can find each other behind those walls, which is something that is being actively worked on, although not yet very successfully.

Collaboration between organizations and sectors also varies, but participants indicated that it tends to work somewhat better than cross-departmental cooperation. Knowledge institutes, universities, and businesses are increasingly considered as partners in NBS projects. Although one interviewee mentioned that academics exchange a lot of knowledge on NBS, another expert stated that this is not the case among companies: "*I've also looked at the construction sector, for example, that sector alone is so fragmented, from giant companies to small subcontractors working in teams of two or three. Even within a single sector, those connections are few and far between. There are some very good initiatives. But let alone between sectors, so that you can say that the healthcare sector and the construction sector and policymakers and the agricultural sector are all connected, no, that's really not the case yet.*" PA1. Participant P2 indicated that the degree of collaboration varies from project to project and does not necessarily depend on the organization the stakeholders are working for or the sector they belong to, but rather the type of person they are.

Various approaches can be taken to stimulate cooperation between both departments and sectors and organizations. One measure that falls under this strategy is the formation of construction or thematic groups, which means that at the start of a NBS project the key points are established and, based on these, it is determined which stakeholders should be involved. Initially, this will be a broad group, which will likely be reduced to a smaller group after a discussion about the possible designs: "*It may well be that at some point someone says, well, we at Energy have no further involvement in this, because our cables are there and that's fine, and they can then drop out. But other parties involved in*

management or biodiversity, for example, may want to get involved, because there are opportunities for them there. But working together in construction teams in which all parties, including the landscaper, are involved from the outset, that works." A3. Expert PA1 mentioned that the municipality of Utrecht is currently implementing thematic groups and that the municipalities of Amsterdam and Rotterdam are working with a similar method: climate round tables. Related to this is the embedment of such new governance models, as this enables cities to ensure collaborative governance in the long-term. Another measure that can improve collaborative efforts is the installment of a committee that oversees collaboration to ensure that everyone works together. Interviewee A5 mentioned that this is being employed in the metropolitan region of Amsterdam, where a central committee ensures that the 32 municipalities work together on the spatial planning strategy. In addition, stakeholders can use tools to help support these processes. Tools for communication and co-creation can be developed and used to lower the threshold for collaboration between stakeholders, as this facilitates engagement of the different groups. Similarly, serious games can be helpful to see what each stakeholder considers to be important and what kind of NBS are possible based on these preferences. These approaches can also aid in addressing the earlier stated factors of awareness and understanding, acceptance and support, and interests and priorities. Participant P2 indicated that a principle that can be helpful to follow when establishing collaborative partnerships is creating a stakeholder engagement plan to clarify who should be involved and how, when, and why they are participating.

Related to collaboration between stakeholders is the barrier of departmental assignment structures. Governmental organizations often give single-task assignments, meaning, for example, a task for water and a task for biodiversity without connecting them. This while NBS allow stakeholders to achieve multiple departmental goals and can contribute to multiple assignments. To address this barrier, as well as the challenges related to collaboration, a strategy is to link NBS to the urban agendas of various stakeholders. This strategy facilitates connecting the different objectives that NBS can address and enables a more integrated approach. Achieving this requires looking beyond the conventional suspects, for instance, identifying hydrological risks in an area and proposing NBS to increase water retention, and instead examining the full spectrum of functions and challenges involved: "*Ultimately, there is a primary task that a municipality, for example, comes up with: "I would like something to be done about this, and I would like it to be done in a green way." But this requires looking at the entire area and all its uses. And that always brings different tasks to the fore. There is a housing construction task, there is an infrastructure renewal task, there is heat stress.*" PA2. The key is to explore how NBS, and the initial project, can be connected to these broader issues. Pertaining to this, another strategy is making use of the windows of opportunity that present itself: "*Things are being redeveloped, the street is being opened up for maintenance work on the road surface, things are being built or redesigned, and sometimes there is simply an absolute necessity to increase safety in an area. So take advantage of the windows of opportunity that exist.*" PA2.

To gather the required stakeholders for projects, the presence of networks in which stakeholders are organized around NBS, or similar concepts, can be critical. Most interviewees noted that quite a lot of initiatives exist and can be of help. For municipalities, a branch of the VNG, network KANS, and some regional portals for climate and water can be made use of. However, expert P1 stated that there are almost too many initiatives for municipalities, making it difficult to select networks that offer the best prospects for collaboration. Moreover, project developers established the platform KAN, Communities of Practice exist on various levels, and several trade unions are working on climate adaptation and NBS as well. On a higher level, there are some (international) city networks and matchmaking platforms that often arise as a result of an open call, subsidy, or research project from the EU. However, these initiatives, apart from the KIN portal that unites knowledge institutes, governmental organizations, and businesses, are most of the time separate and of short nature. Moreover, networks often do not

exist before a project starts, but are formed along the way. Although there is no umbrella organization or clearly defined networks, participants indicated that there is not necessarily a need to institutionalize these initiatives and networks. Some interviewees also noted that despite the existence of networks, personal relationships are sometimes more important for finding the right people for a project. In addition, even if stakeholders are gathered and their collaboration is stimulated, differences in the 'language' they speak can still create a barrier to the realization of NBS projects: "*Because yes, it really is just practice, it's about that one context, it's very local. And then the scientist comes along, "But generally speaking, you could do it this way or that way." So sometimes there really is a language barrier and it takes some time to find common ground.*" A2.

Leadership or responsibility also influences whether NBS get realized. As NBS transcend domains, no single party feels or takes responsibility: "*There is no single party willing to take up the gauntlet, especially if it involves costs. So it brings many advantages for many different parties, but it falls somewhat between responsibilities.*" PA1. If no stakeholder assumes responsibility or takes the lead, implementation is unlikely to progress. A potential strategy, therefore, is to designate one or more stakeholder groups as responsible for implementing NBS. Expert A5 stated that Dutch mayors have relatively a lot of power, meaning that municipalities could take a leading role. Multiple participants also noted that municipalities are best aware of what happens in practice: "*Because often people in the area where they live know best where it works and what problems there are. Where do basements always flood? Where is heat stress most severe?*" PA1. However, according to most experts, making municipalities the sole responsible party is not considered the best approach. Interviewees explained that the national government should provide direction and a vision for upscaling NBS as well as financial resources to bring stakeholders together. Ensuring interconnectivity of NBS is important, yet this aspect risks being overlooked when stakeholders operate solely within municipal boundaries. In addition, if it is wanted, the national government is needed for ensuring the integration of NBS into policies and regulations. In addition, some experts stated that multiple or all governmental levels, including the EU, should carry a part of the responsibility. Other interviewees explained that citizens also have a responsibility for scaling out, so applying good concepts in other places, in the form of the earlier explained citizen initiatives. Participant P2 indicated that citizens sometimes expect the government to do everything for them and wait too long for the rules to come from the policies. On the other hand, expert A3 stressed that making citizens responsible will lead to sub-optimal outcomes, as most citizens, with a few exceptions, choose the quickest and cheapest options. Lastly, interviewee P3 stated that a part of the responsibility, and self-interest, also lies with companies, as the younger generation often wants to work for businesses that pay attention to such matters. As a result of these statements, quite a few participants indicated the need for a shared responsibility between all parties.

Two other factors that are considered barriers are precedent effects and time. Precedent effects concern governments being afraid that a good example, in this case granting an exemption from the rules to NBS, will be misused by bad examples. Expert A1 illustrated this: "*Well, to use the example of the forest on legs, we can't put it everywhere because there's a gas pipe or something underneath that always has to be accessible. But then we say, yes, but that forest is on legs, so you can move it with two people. But that's not allowed, because they're afraid that others, a French fry stand or whatever, will put them in places where they don't want them to be.*". Furthermore, governmental organizations, as well as other stakeholders, find the time required to implement NBS projects tedious. Co-creation processes in particular are considered too time-consuming, even though other infrastructure projects take just as long and co-creation can yield more and better NBS. Therefore, stakeholders should be more patient when it comes to NBS, since "*The physical infrastructure changes way more slowly than for example the technological infrastructure. It takes a lot of time to change cities that took centuries to exist as we know them.*" P2. Thus, organizational slack time is required in order for stakeholders to

learn about NBS and reach out and talk to other people, as this can make a project more effective and efficient. Moreover, flexibility needs to be embedded: "*It also requires a kind of transition or openness. Not just from governments to have their certain guidelines and orderliness and lines and things done in a certain way, but it also requires a bit of a transition in the thinking of our society and its role, that you allow a little more flexibility and allow and accept a little more uncertainty.*" PA2.

6.4.3 Informational and technological factors

Within the informational and technological system, key factors include the knowledge and capacity of executing agencies, as well as the availability of NBS education/training programs and conferences. The available knowledge varies from municipality to municipality, although some interviewees feel that there is a specific lack of knowledge about urban ecology: "*Urban ecologists are becoming more well-known, but not every municipality has access to them. Some municipalities work with a very small group of people, so you can't be both technically skilled and ecologically knowledgeable.*" PA1. This while participant P1 stated that within municipalities "*there is sufficient brainpower and design power to achieve that.*". However, some experts also noted that governmental organizations often lack time to develop in-depth professional knowledge, and frequent staff turnover within such organizations causes accumulated expertise to dissipate quickly. Because of this, municipalities often make use of external consultants, which does not have to be an issue as long as the relations are good. However, interviewee A4 indicated that the limited capacity becomes problematic when the group remains small compared to those working on other issues. This is the case for several Dutch cities as NBS tend to be relatively less valued than other measures, leading to the risk of NBS disappearing from the agenda. When it comes to learning about NBS, expert P3 indicated that there are a few courses and study programs that address building with nature, but their scope is often broader than NBS specifically. Similarly, conferences on the topic are often smaller initiatives that take place infrequently and tend to attract only a modest number of participants.

There are several strategies and measures that can address these factors. To begin with, capacity within governmental organizations needs to be built to develop a better understanding of NBS within these organizations. Moreover, practitioners need to be educated about NBS, which can be achieved through various approaches. One option is to incorporate NBS into education and training programs within higher education and professional organizations, but also at an early age, i.e., in elementary and secondary schools. Expert PA2 stated that this helps with getting people to think in a nature-based manner and to ingrate this into the way they work later in practice. Another measure to support knowledge transfer is the organization of masterclasses. This can be an opportunity for frontrunners to show other interested practitioners certain perspectives: "*It is important to offer perspectives, perspectives for action, and to show that it works and that it is possible. What flavors are possible, so what people can think of, and how this is received in practice. Where there is resistance, how resistance is dealt with, and, what I personally find very important, how problems and obstacles are dealt with.*" PA2. In addition, frontrunners and beginners need to be mapped to improve knowledge exchange. Beginners can seek support from frontrunners, while frontrunners can benefit from collaborating with one another, as they may also encounter challenges in identifying new sources of information.

Moreover, measures can be taken that are related to another factor that influences NBS adoption, namely the availability and use of tools. Numerous tools are available to support practitioners in expanding their knowledge of NBS and facilitating their implementation in projects, ranging from information booklets to models: "*We have tools that look at system understanding, i.e., the system works in a certain way, these are the ecosystem services that a particular system can provide, and how can you make optimal use of them. There are tools that look at what the challenges are in a particular area, what the vulnerabilities are in an area, and what measures are needed. There are tools that look*

at possible solutions and how you could apply them in this, this, and this way. And there are tools that tell you that if you want to implement this measure, you have to take XYZ into account." PA2. Although this is a huge incentive for the implementation of NBS, experts stated that practitioners can get lost in the supply of tools and are unsure where to look for certain information or do not know which tool will work best for them, thereby hindering them in optimally using the available tools. Therefore, they indicated it can help to create a tool overview that allows for comparison between the tools based on the information stakeholders are interested in. However, "*Despite the fact that there are already quite a few tools available and more are being developed, there is of course still the question of who will use them and whether they will actually do so.*" PA1. This is either because they cannot see the forest for the trees, for which a tool overview can help, or because they do not understand how the tool works, for which education and training programs can be of help.

When it comes to information booklets, interviewees recommended synthesizing essential NBS theory to provide practitioners with a status quo and basic understanding of the concept. Similarly, a nature overview can be created that shows practitioners which plant, shrub, and tree species can be used. Next to this, catalogs with examples of implemented NBS projects can be developed and used to inspire other practitioners. Expert P1 stated: "*I made a very simple booklet where I show what the situation was and what it has become. Then you immediately get a feeling of, OK, so that's achievable, and that's what it looked like before.*". However, some participants pointed out that while a simple booklet can be useful and inspiring, it can also be dangerous as not all variables are explained for all circumstances, and you cannot simply copy-paste projects from different contexts. Still, interviewee A2 noted: "*You can bring everything together and extract the core elements depending on your question, so you can see things they have in common or that are different. So I do think you can learn from each other and inspire each other, so I think the exchange of experiences is important even if you have a different context.*". Nevertheless, most experts emphasized the importance of including a disclaimer in such catalogs, stating that NBS are not plug-and-play solutions. Participant P2 pointed out that for some examples it can be said that they are general, but some others need to be made site-specific. Therefore, when applied in another context, it is crucial to consider the specific local systems, meaning that cities should always adhere to the principle of checking NBS with their context.

Regarding modeling tools, NBS selection tools can be developed or used to aid practitioners in selecting NBS for a specific location based on the context as well as the costs and benefits: "*We have created a tool to help designers make the right choices when designing. So if the groundwater level is very high, you shouldn't plant deep-rooted trees, because they will struggle to survive. If the soil is very loamy, you shouldn't plant certain trees there, and the same goes for sandy soil.*" P1. Moreover, experts stated that (scenario) modeling studies, for instance with GIS, can be employed. However, where the earlier described issue related to tool availability, for modeling tools there are also hindrances concerning the use of the tools. Interviewee P2 stated that one of these is that models containing output on all relevant variables take too long to run to be useful in practice, while lighter tools that are faster are not interconnected and do not provide output on all factors of importance. Therefore, a measure can be to find a way to integrate different models without compromising on computational speed. Another limitation is that tools often provide a snapshot of the expected outcomes of NBS, without capturing their long-term performance. Scenario modeling, however, can be used to explore and predict potential future developments. In addition, tools are not always consistently maintained over time or do things slightly different, making comparison with outputs of other tools difficult. A final note is that the principle of comparing model outputs should be followed, as models are based on assumptions and remain simplifications of reality: "*When you work with a model, you are already simplifying things, you are already making certain assumptions. And if you all make the same assumptions, it seems like it's the truth, but it's just based on that one assumption. And if you have different ones, you can learn*

from each other." A2. Placing models side by side and clarifying their differences makes uncertainties more transparent and provides stakeholders with margins within which the solutions are likely to work.

Another influencing factor that has a major impact on NBS implementation, and is positively influenced by the measures described in the preceding paragraphs on tool use, is data. Data can act as both a barrier and driver, depending on the type of data considered. Three data factors can be distinguished: availability, expressibility, and measurability/predictability. To start with, there is an increasing amount of data available due to more projects being realized and employment of new technologies, although knowledge to make use of this data is not always available, for which education and training programs can be of help. Moreover, some data is not openly accessible and there is no single database that consolidates the available information for the Dutch context. In addition, data from other sectors that is needed to identify common denominators has not yet been integrated with data on NBS. As data is dispersed, an effective measure would be to create comprehensive data overviews. This would make it easier for practitioners to access relevant information, provide a clearer picture of the status quo, and highlight which data is still missing or not publicly accessible. There are already some efforts from knowledge institutes and universities in this regard. Next to this, participant A5 noted that base data on NBS is missing: "*With base data I mean a clear, agreed dataset that classifies interventions, such as wetlands, pocket parks, and green roofs, as NBS categories and contains attributes describing their functions, such as infiltration capacity, shading effect, and biodiversity value. Without that consistent categorization, it's difficult to train models to simulate or compare NBS outcomes directly. Broader green interventions can be modeled, but to say this specific set of NBS delivers X mm of water absorption requires those inputs to be standardized and recognized as NBS, not just generic green space.*". Although emerging efforts are helping with building such a dataset, a sound measure is to classify NBS and their attributes for the Dutch context for modeling purposes. This also requires the establishment of a clear, agreed NBS definition. As noted earlier, numerous definitions exist, making it unclear what exactly is meant by the concept. Furthermore, key figures are essential for being able to decide which NBS would work best for specific areas. Expert PA2 noted that the available key figures are quite location-specific and perhaps too generic, meaning assumptions have been made. There is also not enough data on the potential negative effects of NBS adoption, such as airborne diseases.

Data expressibility refers to the extent to which all relevant variables can be quantified in a meaningful way. Social values, such as social cohesion, are often difficult to capture numerically. While attempts are made to assign quantitative values to them, such numbers frequently have limited practical significance. As these variables are relevant, interviewee A2 recommended using proxies to ensure that they are still included in calculations. However, some experts also stated that sometimes it is more important, and creates a stronger story, when such variables are shown in a qualitative manner and are combined with quantitative methods. Next to this, variables in the social domain can also be quite subjective, which is also important to map. For this, combining objective and subjective methods can be a good strategy. To facilitate the qualitative and subjective part in such integrated studies, or to generate data on social variables in general, survey studies can be employed. Moreover, expressing the benefits of NBS in economic terms is difficult as well, while this is extremely important for creating a business case. The costs and more concrete benefits can be quantified increasingly well due to the availability of more data as a consequence of increased NBS implementation. Although assumptions, information, and calculation rules can be derived from this, there remains uncertainty around the exact costs and benefits. In addition, it is hard to express NBS into key numbers, as there is a broad range of what it could be. A possible strategy to address this challenge is to use averages in calculations, since the primary aim is not to determine exact figures, but rather to highlight the differences between NBS designs and to demonstrate to practitioners the principle of problem-solution alignment. For example,

some NBS may be better suited for water infiltration, while others may be more effective in enhancing biodiversity.

Data measurability and predictability refers to how well NBS can be monitored when employed and how well their long-term performance can be predicted. When NBS have just been realized and are small in scale, it can be difficult to measure the effects as they can be quite minimal and might take a while to develop. Moreover, long-term effects can be hard to foresee, despite scenario modeling being able to predict what might happen to some extent, since scenarios often indicate a range of what the long-term performance might be without providing exact numbers.

As there are several gaps in quantitative data on the costs and (co-)benefits of NBS, both in monetary and non-monetary terms, and the available data is often based on assumptions, a good strategy is to invest in research that focuses on quantifying these costs and (co-)benefits. Moreover, ULLs can be implemented and demonstration projects can be executed to contribute to data collection. These projects also help with generating qualitative data on how the public, politicians, policymakers, and practitioners react to NBS, increasing the awareness, understanding, acceptance, and support of these parties, and shifting their interests and priorities. ULLs also provide an environment for stakeholders to experiment and learn by doing, thereby increasing their knowledge level. In addition, co-creation and other new governance models can be shaped throughout the projects. An important note for realizing ULLs and demonstration projects is ensuring that the principle of monitoring is followed. Stakeholders are sometimes more interested in designing and testing rather than in monitoring and measuring, while this aspect is vital for creating argumentation for future NBS projects as well as for confirming data that is based on assumptions.

Returning to the influencing factors, there is an increasing amount of research being done on NBS that drives adoption. This research not only leads to the availability of new data and tools, but also creates new insights and ammunition that increase the possibility of NBS and can be used to convince stakeholders to implement. For instance, expert A1 mentioned that research revealed new options for wadis: "*Everyone always just builds wadis in the grass and in grasslands or on roadsides. It has now become apparent that it is actually trees that improve wadis, right? These are all advancing insights based on research.*". Additionally, interviewee A3 noted that research helps support the choices of parties interested in adopting NBS, as stakeholders often ask, for example, to what extent NBS can contribute to urban cooling. However, little research has been done on the link between NBS and health, as most studies focus on nature in general. Therefore, participants A1 and A2 stressed that further investigation on this relation is required. Technological advancements can also be a driving force, as they may be able to generate new data or improve NBS, thereby making implementation more attractive. For instance, expert P2 noted that green walls are quite expensive, but that "*the technology is developing in the sense that they have less and less embodied energy and water needs*".

6.4.4 Physical and ecological factors

To begin with, the ES that NBS offer can help address urban problems, or generally help create a nicer living environment, making them drivers for NBS adoption. One of these ES is improvement of air quality, although it is noteworthy that the impact NBS can make in this regard can sometimes be limited according to interviewees: "*There have been projects in which cities have been greened because it is good for air quality. Yes, plants filter particulate matter from the air, but not to such an extent that it reduces the concentration of particulate matter in the city by 10%.*" A3. Biodiversity is seen as another important driver that is valued by society, with expert P3 stating that declining biodiversity is a bad news item, while working on nature-inclusive design is considered good news. Participant PA2 noted that although biodiversity is not the most easy to concretize benefit of NBS, society tends to feel strongly about it. Furthermore, many appreciate NBS' capacity to act as a climate change adaptation

and mitigation measure that reduces urban heat through cooling, thereby alleviating the UHI effect, and decreases hydrological risks by, among other mechanisms, enhancing water infiltration: "*So in X, where we are now implementing something, it is being done because there are all kinds of problems with too little greenery anyway, but also with air quality and the heat issues that prevail there. We have run models there, so we know that by 2050 the temperature there will be above 50 degrees Celsius. But they also know that these neighborhoods are sinking, that they already have flooding problems and will have even more in the future.*" A1.

Next to delivering ES that can tackle climatic challenges, benefits like aesthetic appeal and creation of recreational spaces also drive forward NBS adoption. Moreover, adaptability and multifunctionality are inherent traits of NBS that can be used as strong arguments for their adoption. Adaptable behavior means the solutions can be implemented in various contexts, with expert A1 explaining that NBS are, by definition, customized solutions that adapt to the climate, environment, light, space, people, and air. The multifunctionality characteristic is viewed as the strong suit of NBS by all interviewees: "*I think the strength of Nature-Based Solutions lies in the fact that they offer more co-benefits than technical systems.*" A1. The participants also noted that multifunctionality is where the main business case for the measures lies, and that the match for space cannot be won by focusing on only one (co-)benefit, which has been wrongfully done in the past. In order to make use of the multifunctional nature of NBS, a strategy can be to assign multiple functions to the NBS being implemented: "*So you're not just talking about solving the problem, such as flooding or a rain peak or Urban Heat Island issues, but you always need another problem to solve as well. That could be the perception that people simply enjoy sitting in the shade or perhaps walk their dog closer to home.*" A1. Interviewee A3 mentioned that this requires urban planners to stop designing either/or and start designing both/and. However, participant A5 stressed that although multifunctionality is a great asset, it cannot always be realized. The expert illustrated this point with the example of a wetland in Rotterdam that also serves as a rowing area, explaining that not every wetland can be made publicly accessible in this way.

There are also several factors within this domain considered as barriers. Expert P2 pointed out that the presence of existing systems, such as underground infrastructure, can prevent NBS implementation completely. However, interviewees mentioned that a way of managing these existing systems that still allows integration of NBS to some degree is the implementation of hybrid NBS: "*Those hybrid solutions mainly arise because in the Netherlands, but also in many other countries, you are already part of an existing system. And very often it's an existing system that you have to connect to, so you're actually talking about a transition. First, you have to keep both systems intact, and only when you can completely replace the system do you have a system redesign. But in practice, this is almost never the case.*" A1. Participant A2 also emphasized that there is a lot of variety in the field of hybrid measures, and that some people unjustly say that green roofs are not possible due to it being too heavy. There are many types of green roofs that are very light or heavier, which have a sedum roof or can be turned into a garden. Expert P2 noted that although green roofs are possible on most new construction, for older buildings it needs to be checked if the structure of the building can withstand the extra load. In city centers there are also monumental buildings and heritage rules that need to be accounted for. In addition to implementing NBS on buildings, NBS can also be integrated into other existing systems or products, such as bike paths, sidewalks, and parking spaces.

However, not all spaces are suitable for holding NBS: "*There are issues with groundwater levels and soil conditions in Dutch cities.*" A5. In addition, implementing NBS when the soil structure is not optimal can cause the solutions to remain wet for longer, which will provoke resistance among citizens and can harm future NBS projects, stated interviewee P1. Therefore, participant PA2 mentioned the following strategy: "*Also explicitly look at the soil, how it can be utilized, used, and optimized.*". In addition,

experts explained that space for NBS is limited to begin with, as many cities are densely populated and various sectors, especially mobility and housing, compete for the available land. Interviewee A4 stressed that it is difficult to integrate all these functions, making it challenging to involve NBS. There are several strategies and measures that can be implemented to deal with this lack of space. Assigning multiple functions, as underscored in the previous paragraph, and implementing hybrid NBS can address this barrier. The first was illustrated by participant A3: "*In the design world, we are currently very stuck in the mindset that something is either a place for a tree to grow or a parking space, but we no longer have room for that, and climate adaptation no longer allows us that option. Something in the city must have at least three functions.*" A3. For the latter, expert PA1 stated that hybrid NBS might be the most practical or pragmatic solutions, as some choices are almost impossible to make and there is also space needed for housing and transportation. Moreover, considering mobility is one of the biggest competitors for space in the city, another strategy can be to reshape this sector to make room for NBS. Interviewees noted that this can be realized by various measures, such as closing off certain streets for cars, shifting towards shared mobility, or reducing the amount of parking spaces.

Next to this, there are strategies that focus on NBS adoption on smaller scales, such as implementing single plants. Expert P2 noted that although this is not ideal from the principle of using a systemic approach, it is better than nothing. Interviewee P3 highlighted that creating so-called pores in spaces and structures is another option: "*There are also some nice examples of underground parking lots with a hole in them, where two parking spaces are removed and replaced by a tree that grows all the way up above the parking garage. But that can also be done on a very small scale, like that beautiful school in Boulanger Billancourt, where the facades are slightly staggered, creating gaps where all kinds of moss and grass can grow.*". Moreover, if there is no public space available, a strategy can be to use private space as well and find measures that can help with realizing this. As a last resort, since this is a somewhat controversial view with most experts not considering it a form of NBS, the use of biophilic or biomimicry design can be explored. This means implementation of solutions that are inspired by nature but do not consist of actual nature.

Returning to the barriers, another important one is maintenance requirements, as maintaining NBS can be quite time-consuming, costly, and labor-intensive. Interviewee PA2 noted that maintenance personnel may not be keen on this need for increased or altered maintenance requirements. In addition, it can be difficult to predict the maintenance timeline, especially compared to grey solutions, creating fear and uncertainty around the potential costs of maintenance: "*With grey infrastructure, you can often calculate what it will look like in 20 years and what it will look like in 40 years, and then we need these investments to patch it up a bit, and the end of its lifespan is in so many years or so. Whereas with green infrastructure, it is of course really unpredictable.*" PA1. Expert P2 explained that one way to reduce the typical maintenance needs of NBS is using species that require no maintenance, meaning that the space still looks well even without maintenance.

Lastly, there are principles that should be kept in mind. It is important to account for climate conditions and trophic pyramids when selecting NBS. Participant A4 noted that the consequences of inadequate selection are already becoming apparent, with some first-generation NBS dying because the chosen solutions were not well-matched to their context. Attention should also be paid to trophic pyramids, since they can help determine the desired composition and abundance of fauna and, consequently, which NBS are needed to sustain the ecosystem. A principle that is more related to the maintenance aspect mentioned earlier is balancing maintenance and natural processes. Expert P1 pointed out that a wadi they implemented, and maintained through occasional mowing while otherwise allowing natural processes to unfold, became one of the most biodiverse sites among all their research locations. However, according to participant A1, in most cases a minimum level of maintenance and

management needs to be ensured in order for NBS to keep delivering their benefits: "*It's not like it's a perpetuum mobile. Many people think that nature regulates itself, and nature does regulate a lot of things itself, but if you set goals for what nature should regulate, then you often still have to steer it in that direction.*". Thus, a balance between maintenance and natural processes needs to be strived for.

Two other principles are related to ongoing discussions in the biodiversity community. The first entails ensuring that NBS contribute to biodiversity, as this is not always the case: "*Because there are many examples of greenwashing when it comes to Nature-Based Solutions. We might plant a plantation of trees because it's good for climate adaptation, but it does nothing for biodiversity.*" A2. Therefore, this interviewee stated that, given the multifunctional nature of NBS, at least some contribution to biodiversity should be ensured as a minimum requirement. Another point of discussion is whether only native plant species should be used or whether exotics should also be considered: "*Then people say, OK, from an ecological point of view, certain species are not native, so we don't want them. And on the other hand, you might have the discussion about, yes, but the city is already such a created ecosystem, it's different from the countryside. So shouldn't we be a little more flexible about which species we plant in a city? And also with climate change.*" A2. Therefore, using native species can be followed as a baseline, but caution should be exercised to also include species that can handle future climate scenarios, as mentioned earlier.

Linked to this are the principles of using multiple species and ensuring robustness. "*We have said that it is always wise to make it robust, so don't just focus on one species. Then you have one pest or one heatwave or whatever, and that whole species disappears.*" stated interviewee P3. The principle of robustness does not only entail the creation of a climate-robust system and the use of multiple species, but also a system in which NBS can function independently of each other. Expert P3 indicated that this means that, for instance, even if a street is blocked, NBS do not stop working because they are no longer connected. Nevertheless, interviewees stressed that connections between NBS are important and that creating interconnected green and blue areas, and extending the network beyond the city scale, can generate substantially greater benefits than implementing a few isolated NBS projects: "*It is also important in the city that you think bigger, that you think in terms of a sponge city and the water systems in and around a city. So that you don't just look at the urban area, but also at the surrounding landscapes. To have a kind of holistic perspective on this and not just work on individual measures.*" PA2. A final principle stated by participants is ensuring the selection of NBS that are compatible with the implementation site.

6.4.5 Financial factors

Within the financial theme, costs, especially for maintenance, were considered an important factor. Participant P1 stated: "*That booklet X contains a table comparing the costs of green space maintenance with the costs of road maintenance. It shows that green space maintenance is cheaper than the maintenance of paved spaces if you do it smartly.*". Other experts claimed NBS can be more costly due to intensive management requirements. However, some interviewees also pointed out that a part of the maintenance costs can be covered by allowing citizen maintenance, as stated earlier. An alternative standpoint was taken by expert P3, who noted that the costs associated with NBS are higher, but that the difference is relatively limited, about 2% to 3%, which the participant considered quite minimal compared to the percentual rise of property values. It can thus be concluded that interviewees had varying perspectives on how the costs compared to grey solutions, meaning it remains unclear whether it is a barrier or driver in the Dutch context.

Nevertheless, it may be a good measure to compare the costs and benefits of NBS with those of grey solutions to demonstrate that NBS are often cheaper or only slightly more expensive, as participant P2 mentioned that many decisionmakers, politicians, and developers still think that NBS are more costly

than they actually are. Similarly, grey solutions are often more expensive than society perceives them to be: "*Because that is also sometimes a problem, that the true costs are often not included in such a cost-benefit analysis. So climate impact, health impact, or biodiversity impact are not taken into account at all when calculating the costs of certain solutions.*" PA1. The expert also highlighted that not all benefits of NBS, for instance in terms of avoided damages, are always included. Therefore, conducting a proper comparison of the costs and benefits of NBS and grey solutions could help improve the financial image of NBS significantly. Moreover, subsidizing NBS can help with making investment more attractive for public and private parties alike.

Related to the costs of NBS is their business case. On the one hand, the multifunctional nature of NBS makes for a strong case, but on the other hand, it is difficult to make a concrete business case because the benefits are often enjoyed by stakeholders other than those who bear the costs. Interviewee A3 illustrated this point: "*For street trees and urban trees, you can use the i-Tree model to calculate the monetary value that urban trees deliver to the city. The only problem is that these values do not end up in the city council's bank account, because they belong to everyone.*". Moreover, as highlighted in the informational and technological theme, assigning monetary value to certain benefits of NBS can be challenging, which complicates the development of robust business cases. The strategies and measures identified in that theme can therefore also be applied here. So, making a business case for NBS can be difficult, but it becomes feasible when appropriate strategies are applied.

As far as financial resources are concerned, their availability depends on what the capital is needed for during a project. While the EU funds many research projects, the budget for measuring and monitoring is not always present. Expert PA2 explained that this is because this activity is seen as less interesting compared to designing and experimenting, despite being vital for creating justification for future NBS projects. Moreover, financial flows within governmental organizations are often separated for each department, making integration for NBS projects difficult: "*The point is that if you have pillarized financing structures and assign them to single tasks and give them a budget for that, you are not promoting cooperation.*" PA2. This while NBS can contribute to multiple tasks at the same time. Therefore, the participant emphasized that these financing structures need to be combined to foster joint financing, collaboration, and, ultimately, NBS adoption. This also partially addresses the aforesaid business case barrier, although it only eliminates or reduces the gap between benefits and costs within organizations, and not between organizations. In addition, interviewee A2 indicated that co-financing models need to be established to enable multiple public and private stakeholders to collaborate on NBS projects and share the costs.

There are also two financial drivers. One of them is the fact that NBS adoption supports enterprises and entrepreneurship in the sustainability domain, as noted by expert A4, which is not often thought of compared to the social and ecological benefits NBS provide. The other factor concerns the increase in property values that NBS can create, for which interviewee P3 highlighted that this caused project developers to quickly jump on board at the beginning. In addition, participant A5 emphasized the importance of adhering to one key financial principle: allocating sufficient financial resources for NBS maintenance.

6.4.6 Political factors

The first political factor that is of importance is the number of beneficiaries the measures have. As the multifunctional nature of NBS entails that there are benefits for all societal groups, this drives forward implementation. Another factor that was raised by many was the existence or absence of political interest in NBS and the question of whether or not NBS are considered a political priority. Interviewee PA1, for instance, had the impression that given the current political context, nature is no longer the highest priority on the agenda. This while political will is considered vital and a lack thereof can prevent

NBS adoption. As the political landscape is constantly changing and differs between cities too, experts mainly pointed out that the factor political will was of influence and did not necessarily state whether it was a barrier or driver by standard. Safeguarding NBS implementation in a fluctuating political climate was therefore seen as extremely important, with participant A5 mentioning the following strategy: "*embed NBS in long-term planning frameworks to reduce vulnerability to political cycles*".

Next to political interests and priorities, many experts stressed that the presence of supportive and coherent policies for NBS is vital too, and that both the Netherlands and the EU have some in place. Participant A5 stated that the Delta Program and the National Spatial Strategy empower municipalities to promote NBS and related measures and interviewee A4 mentioned that the EU has strong initiatives and goals on NBS and biodiversity in general. Even though quite a few supportive policies exist, experts felt that the current set can be expanded and that cities can take inspiration from each other's policies. Participant A5 also mentioned one political principle regarding the implementation of maintenance policies for NBS to ensure the (long-term) success of the measures. If NBS are not properly maintained over time, they may lead to issues such as pest infestations and a decline in aesthetic appeal, which in turn can cause a decrease in support and acceptance for future NBS projects.

6.4.7 Legal factors

Within the legal domain, land ownership and use can act as a barrier, mentioned participant PA1, since governments have limited say over what private property owners should implement, and quite a large area of the city is privately owned, stated expert P2. Organizing NBS competitions and stimulating citizen initiatives, strategies highlighted in other themes, might motivate businesses and citizens to adopt NBS. Another vital factor are regulations. One participant mentioned that current regulations make NBS adoption difficult: "*Even in other countries that are very nature-oriented, the regulations are geared towards these grey systems. So very often, even though they could solve it, they have the space, and they may even have the people for co-creation, it still has to be possible through regulation.*" A1. Moreover, if supportive regulations for NBS are in place, loopholes can sometimes be found in them, leading to sub-optimal or minimal implementation. Expert A3 illustrated this with the UK's Biodiversity Net Gain Regulation, which obligated project developers to deliver 10% more biodiversity compared to when they started: "*But when we converted it to Dutch terms, it actually turned out that if you built a building with a green roof on what used to be a meadow, you would be 3% short of biodiversity, so you would be in the red. But if you installed a blue-green roof, you would be 180% in the black. So you would gain 180% when you only needed 10%. You will see that project developers will say, "Oh, so I only need to make 1/18 of my roof blue-green.""*". This while the objective was to make buildings greener to minimize environmental impact. Nevertheless, there are several supportive regulations in place in the EU and various Dutch cities that actually stimulate NBS implementation.

With several Dutch cities having already implemented NBS regulations, these can be replicated by other cities. One option is the creation of a NBS point system in which developers need to score points for incorporating NBS in their designs before they can start construction. An alternative is mandating the inclusion of greenery or water storage in newly built homes: "*For every apartment added to the city, X m² of green space must be added and X millimeters of water storage space must be created. And the greener and higher quality it is, the smaller your task becomes.*" P1. A similar approach can be applied to streets under reconstruction, for which the removal of a percentage of pavement can be mandated by regulations. In addition, a no loss or biodiversity net gain regulation can be implemented, despite the latter having the risk of being 'misused' as clarified earlier. The regulations that affect new construction (and renovation) projects can also address the land ownership and use barrier.

While the aforementioned measures all fall under the general strategy of implementing coherent and supportive regulations, which expert A3 indicated can be difficult given the current state of society,

another strategy is allowing flexibility in regulations in favor of NBS, for example to enable citizen maintenance of NBS. This is because in the Netherlands most matters are laid down in guidelines and objectives, and rules often specify quite strictly how things should be done, noted interviewee PA1. Moreover, one legal principle was mentioned that also relates to maintenance, which is using maintenance agreements to ensure citizens commit to managing NBS in the long-term: "*We draw up a contract for this to ensure that it is not too non-committal. And if someone is enthusiastic and after two months decides that they don't like it after all, that you do enter into a kind of commitment.*" P1.

6.5 Critical factors

One of the final questions of the interview focused on which factors interviewees considered to be the most critical for scaling up NBS in Dutch cities. To begin with, several experts pointed towards social and cultural factors as the most determinant. Public awareness was considered significant, alongside the recognition that societal prioritization of NBS should be realized. Expert A4 highlighted that recognizing and prioritizing nature is necessary for citizens to understand that, for instance, it is more important to have some trees instead of a few parking spots. Participant A3 noted that it is also required to make a continuous effort with stressing that NBS improve citizens' quality of life, and that framing is vital for gaining public support and acceptance: "*If you are talking about Nature-Based Solutions in industrial areas, link that to the energy transition, because that is what the area is currently focused on. If you are talking about housing and neighborhoods, link it to climate adaptation. So, initially, water storage, because that allows you to reduce damage caused by flooding. Link it to heat. Heat doesn't cost people money, but they do experience it and find it unpleasant.*". The importance of considering citizens' opinions, co-creating with them, and involving them in maintenance was also recognized by many interviewees.

Furthermore, experts emphasized that NBS thinking needs to be embedded within governments and across society at large. Participant A2 explained that this entails initially evaluating whether NBS can address the problem, and only then considering grey solutions if necessary. Interviewee P3 explained that this way of thinking is still not considered normal for many citizens and practitioners alike, and that incorporating fauna and flora in designs should become standard practice. From a governance point of view, experts stressed that silos need to be broken down to enhance collaboration between departments, sectors, and organizations. They mentioned that linking NBS to various urban agendas as well as changing the current structure of departmental assignments could help reduce the silo mentality: "*You can achieve real results by linking different landscapes and different tasks on a larger scale and coming up with truly integrated solutions. That's what makes a difference. So I think one of the biggest barriers is that single-task policies are still being used.*" PA2.

When it comes to informational and technological aspects, several participants stressed that a better picture of the costs and (co-)benefits of NBS needs to be obtained, as this is important for developing argumentation for NBS, stated expert A4 and P3. Moreover, interviewee A5 stated that the term NBS needs to be better defined and that the concept needs to be classified and coupled to attributes for modeling purposes. The expert also mentioned that capacity and knowledge among practitioners needs to be built and NBS need to be integrated into education and training programs.

Moreover, two participants mentioned factors in the physical and ecological system as vital. Expert P1 stated that the lack of urban space is a critical barrier and should be addressed by giving mobility a different place in society, for instance by restructuring the car parking infrastructure. Participant PA2 stressed that it is also key to look beyond the city scale and create interconnected green and blue areas: "*I think it is necessary to adopt a landscape or area-based approach in order to move from "I*

have a good idea for this small area" to "We are moving towards a naturally designed Netherlands". Because ultimately, it is also about the scale of the benefits.".

Some other interviewees mentioned political factors as most critical. A few participants pointed out that political will requires attention. Expert P2 gave an example to clarify this point: "*Like Hidalgo is doing in Paris, a beautiful example of how a mayor in this case gives room and priority for this to happen at a large, systemic scale. And that is what we need: that political will sets climate and NBS as a priority in territorial development.*". Interviewee PA1 mentioned how shifts in political interests and priorities continuously take place, thereby limiting the upscaling potential. The participant illustrated this with the Green Deal, which is now completely overshadowed by the competitive focus of the EU, although the original problem remains the same. Offering resistance against such dynamics is a challenge. Expert A5 mentioned a pro-NBS, consistent political landscape as important too and came up with a strategy to achieve this: embedding NBS in long-term planning frameworks.

Lastly, according to some experts, the legal landscape should also adapt in order to facilitate NBS adoption on a larger scale. On the one hand, interviewee A1 pointed out that there are still a lot of regulations that make it impossible. On the other hand, participant A3 emphasized that existing regulations do not necessarily hinder upscaling, but rather the absence of mandates that require NBS adoption: "*It must be less non-committal. It must simply become mandatory, so that the choice for Nature-Based Solutions is removed from the financial domain and brought into the functional domain.*".

7. Results: Seeds of Change Framework

This chapter focuses on the development of the Seeds of Change (SoC) Framework based on the insights of the previous chapters as well as a demonstration of its use and value by inclusion of several illustrative cases. The framework's content was determined by the expert interviews, while its characteristics were based on the literature review on frameworks as well as suggestions that were put forward by interviewees. The elements of which the framework consists are explained in Section 7.1, which also discusses on what the choices for these aspects are based. The framework's elements are shown in Section 7.2. The framework in its entirety can be found in Appendix D.

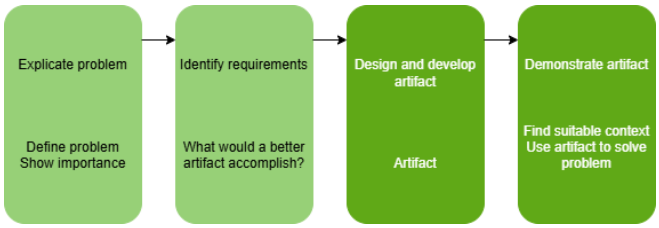

Figure 9 Progress DSR approach - Design, develop, and demonstrate artifact

7.1 Elements of the Seeds of Change Framework

The first chapter of the framework consists of six introductory sections, based on the IUCN Global Standard for Nature-Based Solutions (International Union for Conservation of Nature, 2020b). The first section outlines the need for NBS and provides a definition of the concept, while the next two sections clarify the framework's value and purpose, elements found in all reviewed frameworks. Because the assessed frameworks often emphasized their type, nature, and timing of use, these aspects are also addressed here: the SoC Framework is a guiding implementation framework and intended primarily for the planning and implementation phases. However, it can be applied both prospectively and retrospectively, similar to the NBS planning and evaluation framework developed by De Lima et al. (2022). The fourth section identifies the intended users of the framework, drawing on a Theory of Change approach suggested by an expert. Yet, since many frameworks target a broad audience, a balance was sought between inclusivity and user specificity. The fifth section provides a detailed overview of the framework's structure to support practical use, and the final section explains how it can be applied in practice. For the latter, the framework draws inspiration from governance methods found in other frameworks and particularly references the framework developed by Deely et al. (2020).

The second chapter contains the tables for identifying barriers and drivers, selecting strategies and measures, and becoming aware of principles. The process of assigning a relevance level to barriers and drivers is based on the Barrier Identification Framework in which threat levels could be attributed to barriers (Deely et al., 2020). The strategies and measures are formulated in the imperative form without specifying who should implement them, following the approach used by Nesshöver et al. (2017). All factors are written concisely, and jargon was avoided to maintain user-friendliness, as emphasized by experts. Moreover, the framework is entirely presented in tabular form to minimize textual overload and to ensure that stakeholders can easily follow the steps required to apply it. The use of such visual elements was recommended by a participant to enhance clarity and accessibility.

The third chapter provides additional information and context. This structure was chosen because one expert suggested that first summarizing the findings, as done in Chapter 2, would help keep the content manageable and maintain the reader's focus on the most important elements, while more detailed explanations could be presented later, an approach realized in Chapter 3. Tables were used to provide one-line definitions for each factor, following the example of the Barrier Identification Framework (Deely et al., 2020). In addition, expert comments and illustrative cases were included to clarify the framework's content and demonstrate its practical use and value. These elements were

both suggested by interviewees and observed in frameworks, such as the Green Cities Framework (Garcia-Blanco et al., 2022).

7.2 The Seeds of Change Framework

7.2.1 Chapter 1

This chapter introduces the SoC Framework by providing background information on NBS, arguing for the necessity of the framework, detailing what the framework does, stating who can use the framework, clarifying what the framework looks like, and explaining how the framework can be used.

7.2.1.1 Background

Need for change

Dutch cities are increasingly grappling with environmental challenges, with two of the most significant issues being **climate change** and a **decline in biodiversity** (United Nations, n.d.-a; Generation Climate Europe, 2024). Climate change has led to an increase in the probability and magnitude of extreme weather events, more health risks, a loss of species, and decreasing water availability and crop yield (United Nations, n.d.-a). With climate change heavily impacting cities and their basic services, housing, infrastructure, health, and human livelihoods, they need to play a key role in **climate mitigation and adaptation measures** (United Nations, n.d.-b; European Commission, n.d.-a; United Nations, 2024b). The Netherlands' low elevation levels and densely populated cities make the country **particularly vulnerable to flooding and the UHI effect** (Netherlands Environmental Assessment Agency, n.d.; Steeneveld et al., 2011; Mohajerani et al., 2017; Ritchie & Mathieu, 2019). Moreover, biodiversity loss is accelerating at an unprecedented rate, thereby threatening the delivery of various Ecosystem Services, including the provision of fresh water, clean air, food security, fuel sources, and natural medicines as well as the regulation of diseases, crop pests, and the quality of air, water and soil (Connop, 2016; World Health Organization, 2025). The Netherlands is **one of the world's leaders in biodiversity loss** (Soons et al., 2022).

Nature-Based Solutions as promising measures

These conditions necessitate innovative **urban strategies** to **combat climate change and stimulate biodiversity**. Moreover, the measures must be **adaptable** and **multifunctional** in nature because of uncertain local climate impacts and biodiversity issues as well as the manifold of spatial needs within the urban environment, linked with the social, economic, and environmental components of cities (Voskamp et al., 2021). This combination of requirements has led to the appeal of using **Nature-Based Solutions** (NBS), which are multi-purpose solutions that aim to address **societal challenges** by protecting, sustainably managing, and restoring natural and modified ecosystems (International Union for Conservation of Nature, n.d.-a). The solutions are **supported and inspired by nature**, allowing them to bring more, and more diverse, nature and natural topographies and processes into cities (European Union, n.d.). Due to their multifaceted character, they are able to adapt to local needs and can simultaneously provide a **range of social, environmental, and economic benefits**. Thereby, they help build **resilience** while being **resource-efficient** and **cost-effective**.

7.2.1.2 Why do we need the SoC Framework?

Despite the recognized potential of NBS and the growing acknowledgment that action is urgently needed, their **implementation in Dutch cities remains limited** (PBL Netherlands Environmental Assessment Agency, 2023). As adoption is determined by a **complex and context-dependent system of factors**, there is a pressing need for a better understanding of what influences (successful) realization of NBS projects and what is required to achieve it. Projects are shaped by an interplay of **barriers** and **drivers**, making awareness of these factors critical. At the same time, knowledge of the

strategies and **measures** that can overcome barriers, leverage drivers, and serve as broader enablers of successful execution is equally important. In addition, certain **principles** can be taken into account that further contribute to more effective implementation. The **Seeds of Change Framework** developed in this booklet brings these elements together, providing guidance for practitioners on how to approach NBS in practice from a **common understanding of the challenges and opportunities** involved. By systematically capturing barriers, drivers, strategies, measures, and principles, the framework aims to strengthen the conditions for NBS adoption in Dutch cities and contribute to **unlocking their full potential**.

7.2.1.3 What does the SoC Framework do?

The Seeds of Change Framework is an implementation framework with a guiding nature that enables users to systematically identify the barriers and drivers that influence their NBS projects, as well as select the strategies and measures that can be applied to address these factors or to generally stimulate implementation. In addition, it highlights the principles that should be followed to ensure sound NBS practice. The primary application of the framework is prospective, **guiding decision-making and design during the planning and implementation phases of NBS projects**. The framework enables stakeholders to understand which factors influence their NBS project and how to address them, while also serving as a tool to compare competing NBS projects. It can also be applied retrospectively to **evaluate what went well, identify areas for improvement, and draw lessons for future projects**. The framework's content is **grounded in insights from interviews with experts** in the field of NBS, including both academics and practitioners. Its characteristics were shaped by the requirements identified by these experts, complemented by a close analysis of existing frameworks for NBS planning and implementation.

7.2.1.4 Who can use the SoC Framework?

The Seeds of Change Framework is mainly intended for stakeholders directly engaged in the planning and implementation of NBS projects in Dutch cities, or alternatively, for those responsible for evaluating projects after their completion. It is envisioned that **various governmental levels** (i.e. the national government, the provinces, the municipalities, and the regional water authorities), **urban planners**, **businesses**, **knowledge institutes**, **universities**, **financial institutions**, and **non-profit organizations** will all be primary users of the framework.

7.2.1.5 What does the SoC Framework look like?

This information booklet consists of two chapters, following this introductory chapter, designed to enhance the user's understanding of their NBS project(s) and thereby support their (successful) realization.

Chapter 2 presents an overview of the framework by outlining **seven themes of influencing factors**: (1) social and cultural (SC), (2) governance (G), (3) informational and technological (IT), (4) physical and ecological (PE), (5) financial (F), (6) political (P), and (7) legal (L). This chapter enables practitioners to systematically identify the barriers and drivers influencing their project(s), determine and select which strategies and measures can be implemented to address these factors or generally support their project(s), and recognize the principles that constitute good practice.

The first table lists influencing factors for which stakeholders must **identify whether they function as a barrier, driver, or both**. Next, the framework asks stakeholders to **assess the relevance of each factor**, classified as none, low, medium, or high. The following column refers to **numbered strategies and measures that can be selected to address each factor** (e.g., to overcome a barrier or leverage a driver). Commas indicate that one or several approaches may be selected, while plus signs (+) denote combinations of approaches that must be applied together. Typically, strategies and measures

correspond to the same theme as the factor (e.g., political approaches address political factors). However, in some cases, strategies or measures from another theme can be applied. In those cases, the first letter of the relevant theme is indicated in parentheses after the number (e.g., (G) for governance). Separate **tables list the strategies and measures as well as the principles**, each with a unique number. If strategies or measures fall under a broader approach, they are sub-numbered and written in italics (e.g., *1.1 X*). While strategies and measures can be used to address specific barriers or drivers, they may also be applied more generally to stimulate NBS implementation. Principles, on the other hand, can always be taken into account. All tables are made for each theme separately.

Chapter 3 provides **one-line definitions for each factor** as well as **expert commentary and illustrative cases for selected factors** within each theme. This chapter offers additional context and demonstrates the practical application and value of the Seeds of Change Framework. The order of the factor definitions corresponds to their order in the tables in Chapter 2.

7.2.1.6 How can the SoC Framework be used?

Step 1: The workshop or meeting during which the framework is used should be facilitated by an expert on NBS. This expert should introduce the concept of NBS, clarify which project(s) are under assessment, and explain how the framework works. **Step 2:** The stakeholders involved in the NBS project(s) should be divided across the different themes, ensuring that users apply the parts of the framework that align with their expertise. **Step 3:** The stakeholder groups should apply the framework by identifying barriers and drivers, assessing their relevance, selecting appropriate strategies and measures, and noting relevant principles. **Step 4:** The different groups should share their findings with all stakeholders to enable an open discussion, after which the final content of the framework should be determined.

7.2.2 Chapter 2

This chapter contains tables for identifying barriers and drivers, selecting strategies and measures, and becoming aware of principles. As the information in these tables has already been explained in Chapter 6, the tables are not shown here and can be found in the Seeds of Change Framework in Appendix D.

7.2.3 Chapter 3

This chapter provides one-line definitions for each factor, along with expert comments and illustrative cases for selected factors. Since the definitions are primarily intended for practitioners and expert commentary has already been included in Chapter 6, only the illustrative cases are presented here. The definitions and expert comments can be found in the Seeds of Change Framework in Appendix D.

7.2.3.1 Social and cultural

The Community Garden Emma's Hof in The Hague was co-created with citizens between 2007 and 2011 on the site of an abandoned building (Urban Nature Atlas, 2021a). The project was initiated by a group of 8 citizens. A continuous effort was made to inform citizens about both nature and the project to enhance awareness, understanding, support, and acceptance as well as to increase participation. While citizens came up with the general plan and goals for the park, engineering consultant Arcadis developed the exact design of the park, and various other public, private, and NGO stakeholders also participated. Co-planning and consultation took place in the beginning of the project through use of engaging participatory formats, such as workshops, focus groups, surveys, participatory mapping, and community meetings. Implementation was joint, and after completion citizens founded Stichting Emma’s Hof, which now owns the land and organizes maintenance with volunteers and a nearby primary school. Beyond ecological benefits, the garden's main aim was to increase the quality of life of neighborhood citizens. Emma's Hof contributes to social interaction and cohesion, promotes cultural diversity by reducing social isolation of cultural minorities and elderly, puts children in contact

with nature, increases health and well-being, provides a sense of ownership and management, and improves livability. This case highlights the value of encouraging citizen initiatives, layered citizen participation (planning, co-creation, maintenance, management), the drivers quality of life, sense of ownership, and sense of place, and the importance of keeping participation realistic as well as making it locally relevant, tangible, and engaging.

The NK Tegelwippen is an annual competition between Dutch municipalities that encourages citizens to replace pavement tiles from their gardens with greenery (NK Tegelwippen, n.d.). Municipalities facilitate participation to not only raise awareness and understanding of NBS by letting citizens experience nature, but also to build support, acceptance, and a greater appreciation of nature as a priority. In 2024 alone, over 5.5 million tiles were replaced, with almost 60% of the Dutch municipalities taking part and realizing a range of greening projects: from mini gardens to green schoolyards and from private garden transformations to large neighborhood projects (Kennisportaal Klimaatadaptatie, 2024). This case demonstrates how citizen experiences can foster a nature-oriented mindset among citizens and drive NBS adoption. Non-participating cities could follow this example or organize alternative initiatives such as guided nature walks.

7.2.3.2 Governance

The City Island (Park Tour) is an ongoing project in the municipality of Utrecht that concerns the creation of a climate-proof city island of 45 acres that includes multiple NBS along two canals with a cycling/walking tour of 12 kilometers around it, thereby forming a large city park (Urban Nature Atlas, 2021c; Gemeente Utrecht, 2024). The project has been linked to the urban agendas of several stakeholders by integrating elements relevant to them, which stimulated multi-stakeholder collaboration and enabled the realization of NBS on a large scale. For example, attention to water management attracted Rijkswaterstaat, a focus on climate adaptation and mitigation engaged the Coalition Spatial Adaptation Utrecht, and the recreational features, including the cycling/walking tour, led to the involvement of architecture firms, designers, and sport associations (Urban Nature Atlas, 2021c). The project is led by a central committee, RSE, that oversees the collaboration, but smaller construction or thematic groups work on the various subprojects, including spatial interventions and area developments (Gemeente Utrecht, 2024). Visualization tools are used to generate renders of the park, making NBS designs more tangible for stakeholders. This case shows how using such tools, linking NBS (projects) to the urban agendas of multiple stakeholders, installing a central committee, and establishing construction or thematic groups can strengthen collaboration among stakeholders.

Haskoning recently developed the serious game Engreeneering to support multi-stakeholder decision-making for NBS (Haskoning, n.d.). The game is based on the fictional 'Valley Town', where the demand for housing has increased, and requires stakeholders to make choices about the development of a greenfield site near a nature reserve and river. Stakeholders can base their decisions on three criteria, being costs, citizen satisfaction, and nature, meaning that their decisions show where their interests and priorities lie. They can directly see the impact of each decision on the short-term and long-term on citizens, budgets, and ecosystems as well as the benefits of NBS and ROI. By earning points for improved decisions, stakeholders learn to balance trade-offs. The game is designed to raise awareness of NBS, highlight their value for cities, and foster collaboration among stakeholders. This case shows how tools for collaboration, in this case a serious game, can create awareness, shed light on and shift stakeholders' interests and priorities, and can help with encouraging collaborative approaches.

7.2.3.3 Informational and technological

TKI Eco-System-City was an Urban Living Lab project that consisted of several pilot projects in Alphen a/d Rijn, Arnhem, Rotterdam, and Utrecht (TKI Eco-Systeem-Stad, n.d.). Its aim was to generate

knowledge and NBS designs for challenges concerning drought, heat, flooding, and opportunities for biodiversity in the cities. The central research questions focused on the urban water balance for greenery, the types of greenery suitable for future cities, and how considering these factors affects the social costs and benefits of urban green. The project taught stakeholders extensively about NBS and led to demonstration projects, data generation through monitoring, and the creation of models, nature overviews, and catalogs. Results were published in journals, shared through videos, and presented at conferences. This case shows the value of Urban Living Labs in generating and disseminating knowledge, data, and tools, while also increasing awareness, understanding, acceptance, support, and the perceived importance and priority of NBS among policymakers, stakeholders, and society.

The municipality of Eindhoven developed an inspiration booklet for NBS that can be seen as a combination between a synthesization of essential NBS theory and a catalog of example NBS projects (Roijackers, 2018). The first part of the booklet focuses on defining the concept, identifying which challenges can be addressed with NBS, describing the types of NBS available, and how these NBS can address the issues. While this section already introduces several examples of NBS, the second part provides more in-depth examples of realized NBS projects. This case highlights the importance of establishing a clear and shared definition of NBS, as well as the value of providing accessible theoretical foundations and practical examples. Such resources help disseminate knowledge, inspire practitioners, and enhance their awareness and understanding of NBS.

In June 2025 two experts from Wageningen University & Research and Deltares gave a masterclass on NBS for practitioners working in governmental organizations (Natuur en Milieufederaties, 2025). They presented a climate- and future-proof vision for the Netherlands in 2120, built around five guiding principles in which NBS play a central role. This vision was translated into practice by demonstrating how NBS are already being implemented at numerous locations, both in the Netherlands and abroad, and it was emphasized that nearly every street in the Netherlands requires modifications with NBS to achieve the 2050 goals for heat, flooding, and drought resilience. The session also addressed questions on how to build acceptance and support among policymakers, society, and other stakeholders, how regulations can facilitate NBS adoption, and which tools can be used to make the societal and economic value of NBS visible. The masterclass led to a working visit in September, where participants explored local NBS projects and learned from on-the-ground experiences. This case illustrates the importance of organizing masterclasses to help practitioners exchange knowledge, share perspectives, and bridge the gap between vision and practical implementation.

7.2.3.4 Physical and ecological

The Willem Alexander Park is a roof park in Utrecht that is built on the A2 highway tunnel (Urban Nature Atlas, 2021b). As Utrecht is densely built and populated, there is a lack of space within the city. By making use of an existing system, in this case a highway tunnel, a hybrid NBS was created by implementing a park of 80,000 m^2 on the tunnel's roof (Gemeente Utrecht, n.d.). The park consists of prairie plantings for which various species have been used. While the park is maintained, natural processes are allowed to unfold, thereby constantly expanding the amount and variety of plants. However, actions were taken to protect certain species, especially native and valued kinds (Urban Nature Atlas, 2021b). Moreover, the soil has been optimized by addition of minerals and fibers to make it stable for NBS and to improve the water retention capacity (Gemeente Utrecht, n.d.). The park was designed to deliver multiple benefits and to serve several functions (Urban Nature Atlas, 2021b). One of the main goals was the creation of a connecting ecological green zone, connected to other green zones in the city, to promote the mobility of species. The park contributes to biodiversity by preserving and strengthening existing habitats and ecosystems as well as providing new habitats for various species, including butterflies, bees, and birds. In addition, it manages stormwater and rainfall by

providing storage, improves air and soil quality, and enhances waste management. Furthermore, the park serves as a recreational space for citizens, offering walking paths, gardening, and urban agriculture, which also increases citizens' access to healthy and affordable food. The aesthetic appreciation of the park is also recognized as a benefit. Beyond ecological gains, the park delivers several benefits in the social and cultural domain: it provides opportunities for social interaction and physical activity, fosters social cohesion, and contributes to citizen's overall health and well-being. All these functions are deliberately assigned to the park, which is also reflected in its design consisting of five segments with a thematic program: (1) connect & meet, (2) art & culture, (3) sports & games, (4) nature & education, and (5) food & drinks. This case illustrates how space limitations can be overcome by creating hybrid NBS with existing infrastructure. Moreover, it demonstrates how the various (ecological) drivers and multifunctionality characteristic of NBS are leveraged by assigning multiple functions to the park. Also, it shows the importance of optimizing soil use, balancing maintenance and natural processes, creating a network of connected NBS, and implementing multiple species.

7.2.3.5 Financial

The RESILIO project aimed to address several climate challenges, including flooding, heat, energy consumption, water supply, and urban livability, by implementing smart blue-green roofs on social housing complexes in climate-vulnerable neighborhoods in Amsterdam (Urban Innovative Actions, n.d.). The project installed these systems on 12,683 m^2 of rooftop space on four different building complexes in Amsterdam neighborhoods as well as the Tropenmuseum (RESILIO, n.d.). The green roofs have enhanced water retention, allowing for storage of extra water under the green plant layer (Urban Innovative Actions, n.d.). This way, the roofs reduce the impacts of heavy rain, increase the cooling effect as well as the survival rate of the plant layer in case of drought, improve building insulation, and contribute to biodiversity and quality of life. A large part of the project's financing, almost €5 million, came from the European Regional Development Fund (ERDF) subsidy of the EU, which can be used for, among other things, green initiatives (that reduce disparities) (European Commission, n.d.-b). This case shows how making use of subsidies can enable the realization of NBS.

Moreover, during the project the value proposition of these roofs was assessed by means of the Total Economic Value (TEV) framework to demonstrate that NBS can result in (higher) net benefits (than grey solutions) as well as to indicate how a business case for NBS can be built in the future (RESILIO, 2022). When assessing the business case, assigning numbers to (co-)benefits can be difficult. The RESILIO project used a combination of revealed preference methods for valuing the costs and stated preference methods, including shadow/direct pricing for avoided damage costs and estimation of the Willingness-To-Pay (WTP) by means of surveys, for valuing the (co-)benefits. The results showed that while the technology used in the RESILIO project is still under development, there is potential for a positive cost-benefit analysis. A reduction in maintenance costs, use of the roofs in a multi-functional manner, and achievement of economies of scale can tip the scale to cost-effectiveness under all scenarios. The disconnect in benefits and costs that typically hampers the business case for NBS was mitigated by introducing transfer mechanisms for costs and benefits. Attention was also paid to including all benefits of NBS, such as option value which cannot be provided by grey systems. This case shows how a proper comparison of the costs and benefits of NBS and grey solutions can lead to a positive business case for NBS as well as how the factors maintenance costs and business case can influence the realization of NBS.

7.2.3.6 Political

To gain insight into the role of policies as an influencing factor, a useful approach is to analyze existing policies across different governmental levels in the Netherlands to identify both challenges (barriers) and opportunities (drivers) for NBS implementation. At the highest level, the European Green Deal

provides a broad policy framework that aims, among other things, to make Europe climate-neutral and to protect biodiversity and ecosystems (European Commission, n.d.-d). On the national level, the Delta Program on Spatial Adaptation (DPRA) focuses on making the Netherlands climate-proof and water-resilient by 2050, seeking to mitigate the impacts of heat, drought, flooding, and inundation (Kennisportaal Klimaatadaptatie, n.d.). Moving to the provincial level, the Province of Utrecht has adopted the Implementation Program on Climate Adaptation, which outlines how the province aims to strengthen the resilience of its cities, rural areas, and citizens against the effects of climate change (Provincie Utrecht, 2024). This program is aligned with the DPRA and also serves to set direction for lower governmental levels. In the southwest of the province, fourteen municipalities, the Province of Utrecht itself, the De Stichtse Rijnlanden Water Board, the GGD Utrecht, and the Utrecht Safety Region collaborate through a Regional Adaptation Strategy (RAS), which focuses on maintaining water resilience and climate robustness (Gemeente Utrecht, 2022). The RAS is further linked to the DPRA through annual consultations, ensuring coherence between regional and national agendas. Finally, at the municipal level, the City of Utrecht has implemented its Vision on Climate Adaptation. This strategy is closely aligned with the aforementioned RAS as well as other national, provincial, and municipal plans and visions. This multi-level policy alignment illustrates how the existence of supportive policies and coherence across governance levels can act as a strong driver for NBS adoption.

7.2.3.7 Legal

The municipality of The Hague wanted to stimulate green and nature-inclusive construction to enhance biodiversity, reduce heat stress and flooding, contribute to opportunities for experiencing nature in the city, and improve citizens' well-being and health (Gemeente Den Haag, 2022; Klasberg & Mulder, 2018). Therefore, they decided in 2016 to become the first city in the Netherlands to implement a point system for Green and Nature-Inclusive Construction to stimulate NBS adoption in new development projects. This system requires building developers of large-scale new construction projects to comply with this system and to guarantee sufficient greenery on and around the construction site by meeting a certain number of points. Although the system is not yet mandatory for small- and medium-sized projects, it provides a useful starting point for achieving nature-inclusive construction for these projects too. The system can also be applied when renovating buildings, but as there are more restrictions when it comes to renovations, large-scale renovation projects are assessed on a case-by-case basis to see which measures are feasible. Construction projects must earn a required number of points by selecting from a range of measures. These measures fall into three categories: (1) facade and roof installations, such as facade gardens and green roofs, (2) accommodations for animals, such as nesting sites, and (3) green interventions in the surrounding environment, including pocket parks, wadis, or clusters of trees and shrubs. Previously, the required number of points depended on the urban zone of the construction project, with distinctions made between the historic center/old city districts, residential areas, large-scale developments and high-rise buildings, and industrial estates (Klasberg & Mulder, 2018). Currently, a single point system applies uniformly across the entire city (Gemeente Den Haag, 2022). Other municipalities can adopt a similar point system, but as it is custom-made, it must be adapted to their local context (De Groot, 2021). Some municipalities, including Amsterdam and Zaanstad, have recently done this (Schreurs & Van der Wal, 2021; Gemeente Zaanstad, n.d.). This case shows how enforcing NBS implementation through regulations, for which the point system was selected in this example, can significantly contribute to scaling up the solutions.

8. Discussion

This chapter is dedicated to the discussion. Section 8.1 reflects on the methodology, discussing what went well and what could be improved if the researcher were to start over. This is followed by Section 8.2, which reflects on the main findings and what they mean for the implementation of NBS as well as positions them within existing literature on NBS. Although data collection and analysis has taken place with great meticulousness, there are always limitations due to several factors, which are discussed in Section 8.3. Directions for future research are provided based on them, as well as broader avenues that are inherently interesting and valuable to explore.

8.1 Methodological reflection

The design science research approach was employed throughout this thesis. The approach provided structure for identifying requirements from both literature and practice, building a strong foundation of insights for the development of an artifact: the Seeds of Change Framework. The review of grey and academic literature helped the researcher gain an understanding of the characteristics important to such a tool. Without this, the researcher would have had to develop a framework with only the content as a starting point. However, initially the focus was also on recurring design elements, now left out of the thesis, while it would have been more beneficial to focus on characteristics from the outset. In the literature review on influencing factors, all seven themes were examined, whereas only four themes were explored in depth during the interviews. Although this initial broader scope enabled a thorough understanding of the dynamics at play, if the researcher were to conduct this study again, the thematic focus would be narrowed earlier. The semi-structured interview format successfully allowed experts to introduce additional factors they considered important, complementing the hypotheses under investigation. Yet, the protocol may have been too flexible at times, enabling interviewees to drift toward experiences beyond the study's scope. Future interviews would benefit from clearer guidance on the thematic boundaries during each part of the conversation, while still reserving time at the end for open input. The framework was developed based on insights from both literature and experts, after which it was applied to illustrative cases. With additional time or support, such as a team of student researchers, its development could have been more collaborative, particularly through co-creation with practitioners. This would also have made it possible to demonstrate the framework through an in-depth case study. Overall, the selected methodological choices aligned well with the available time and resources, though some elements could have been more tightly scoped. Section 8.3 further reflects on several of these methodological limitations.

8.2 Implications of the results

The main results of this thesis are the identified influencing factors and the developed framework. Because the influencing factors answer the first part of the main research question, they are discussed first. The hypotheses are evaluated and it is determined whether they can be confirmed, rejected, or remain inconclusive. This is followed by a discussion on which factors appear to be unique to NBS. While some barriers and drivers also apply to other large infrastructure projects, particularly grey solutions, many factors are more specific to the nature-based approach and therefore uniquely influence NBS implementation. The most distinctive factors are highlighted, based on interviewees' insights, to further clarify the contribution of this study. The second part of the main research question is addressed by the Seeds of Change Framework, which is discussed next. The framework is positioned within literature to show how it contributes to knowledge, how it relates to existing frameworks, and which gaps it helps to fill.

8.2.1 Influencing factors

8.2.1.1 Hypotheses

8.2.1.1.1 Social and cultural

Literature suggests there is a lack of public awareness, support, and acceptance. This hypothesis can neither be confirmed nor denied, as it varies among citizens, thus can act as both barrier and driver. While limited awareness and understanding was put forward by several studies, its contextual explanation was not provided (Sarabi et al., 2020; Kabisch et al., 2016). Participants indicated that society is becoming increasingly aware due to crises highlighting the need for NBS. However, most citizens' awareness does not lie on the surface, meaning they need to be frequently reminded of it, and their understanding is often limited, thus does not reach all the implications NBS have. When it comes to acceptance and support, both literature and interviewees indicated that in case of a lack thereof, this can be rooted in a fear of the unknown and resistance to change (Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020). However, due to increased implementation over the past years, the support for NBS has risen as citizens see the added value and difference with the situation before. This development is also reflected in literature, which notes that sustainability principles and values have been gaining increasing prominence in urban development discourses, and that the public is showing growing interest in NBS (Dorst et al., 2021; Voskamp et al., 2021; Castelo et al., 2023).

The ability of NBS to enhance citizens' quality of life, under which several aspects can be considered, was proposed as a driver in literature, and has also been found in the interviews. While literature highlights that NBS can generate employment opportunities, reduce inequalities, preserve cultural and natural heritage, protect livelihoods, and generally enhance community resilience, these aspects were not mentioned by participants (United Nations Environment Programme, 2024; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019). This may be because interviewees were not fully aware of these elements, considered them less relevant within the Dutch context, or viewed them as secondary to other quality-of-life dimensions. However, two experts who have worked on NBS from a societal perspective stressed that NBS can also enhance inequality by being implemented primarily in wealthier neighborhoods or leading to social displacement, which was also put forward as a concern in literature (Woroniecki et al., 2020). Improvement of health was mentioned the most by experts, followed by increased living comfort, social cohesion and a sense of place, sense of ownership, and neighborhood safety. These facets have all been found in literature too (Kopsieker et al., 2021; Castelo et al., 2023; United Nations Environment Programme Copenhagen Climate Centre, 2024; Tran et al., 2024; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019).

Designing NBS in an aesthetically pleasing way was put forward as a strategy to increase acceptance and support among citizens. Literature suggests that NBS need to be appealing to fit into the urban mosaic (Frantzeskaki, 2019). For green roofs, for instance, the vegetation gaps, weedy species, and type of vegetation determine how they are perceived and accepted by citizens. The naturalness of the solutions can also be an important variable. Although some participants indicated that they thought aesthetics are more important in theory than they seem to be in practice, aesthetics were nevertheless considered vital, given that most citizens encounter NBS on a daily basis and aesthetic appeal is seen as one of the benefits of nature. However, it also became clear that the public has varying opinions on what is considered aesthetically pleasing, and aesthetic preference might not always align with biodiversity value. Therefore, this strategy should be implemented with care and also requires society to adapt their view on what is considered beautiful. Moreover, the perception of a wide range of citizens should be taken into account to determine what collectively is seen as aesthetic.

Ensuring public communication, engagement, co-creation, maintenance and self-management during the process of NBS projects was also tested as a hypothesis. Although interviewees generally agreed with this, there were some nuances observed. While literature indicates that "citizens are to be seen as equals in terms of knowledge and ideas' contributions to experts from the city and from science and consultancy", experts emphasized that participation must remain realistic (Frantzeskaki, 2019). This indicates a more limited influence of citizens' perspectives. Co-creation is widely recognized as a pillar of NBS adoption by literature and interviewees (Sarabi et al., 2020; Castelo et al., 2023; Tran et al., 2024). However, some experts emphasized practical limitations of participatory processes, arguing that some stakeholders may also resist them as they can significantly extend project timelines. Noteworthy is that while literature broadly describes co-creation, interviewees stated specific approaches that should be followed during the process, such as making participation locally relevant as well as using engaging formats. This indicates that the concept of co-creation for NBS is not yet explored in depth in literature and that there is a search for the best way to shape this, as also noted by several experts. Both literature and participants indicated citizens should also be involved in maintenance, although some interviewees thought of it as less feasible, stated that it required long-term commitment from citizens which can be difficult, and some expressed concerns that it might amount to an undesirable transfer of responsibility (Hölscher et al., 2023; Frantzeskaki, 2019). These points were not brought up in literature. A final remarkable insight is that interviewees mentioned involvement of all citizen groups as vital, while literature generally leans more towards paying attention to vulnerable communities specifically (Castelo et al., 2023; Hölscher et al., 2023).

8.2.1.1.2 Governance

Silo mentality and mismatches between the business-as-usual ways of working within governments and sectors and the inter- and transdisciplinary collaboration required for NBS was hypothesized to act as barrier. In research, this barrier is one of the most frequently mentioned factors of influence, indicating its importance. Literature states that within governmental organizations, the siloed lines of working, departmental agendas, fields of duty and restricted responsibilities, and timeframes are hampering NBS uptake (Dorst et al., 2021; Voskamp et al., 2021; Kabisch et al., 2016). Nevertheless, one practitioner stated a sufficient level of municipal collaboration and the other two mentioned that it varies from context to context. This while the academics and interviewees with a dual role all noted that there is not as much collaboration as there should be, despite governments actively working on improving in this regard. This difference in perspective might suggest that departmental collaboration is going better in practice than literature signals. While most scholars have written about the lack of collaborative efforts within governmental institutions, others kept their formulation more broad, indicating that limited collaboration between sectors and organizations also hampers NBS adoption (Sarabi et al., 2020; Dorst et al., 2021; Linnerooth-Bayer & Scolobig, 2023). Although experts pointed out there is more collaboration in this regard, especially between universities and knowledge institutes, the connections are still sparse. Therefore, the hypothesis can be confirmed.

For a driver it was stated that stakeholders are organized in networks regarding (concepts related to) NBS. Dorst et al. (2021) explained that the relations between stakeholders and the ways in which they organize themselves can enable understanding, trust, and collaboration among stakeholders as well as determine roles and identities. The networks provide opportunity spaces for stakeholders to meet, exchange knowledge, and team up for projects. However, experts' views varied in this regard, meaning that the hypothesis remains ambiguous. A noticeable trend is that practitioners are generally more familiar with multiple networks and can readily name them, whereas most academics required more time to recall specific examples and were often uncertain about exact initiatives, though they were most of the time aware of the existence of such networks. Interestingly, one practitioner indicated that there are almost too many initiatives for municipalities, making it difficult to select which

networks offer the best prospects for collaboration. Furthermore, participants noted that many initiatives are separate, of short nature, or did not exist before the project start. Although there is no umbrella organization or clearly defined networks, they indicated that there is not necessarily a need to institutionalize these initiatives and networks. In addition, some experts also noted that despite the existence of networks, personal relationships are sometimes more important for finding people for a project. The availability of networks thus seems to be less of a driver than literature suggests.

Another strategy literature put forward was making municipalities responsible for realizing NBS. Kabisch et al. (2016) noted that this governmental level should adopt an action-thinking approach by declaring NBS action as their duty task. Experts expressed varying opinions on this idea. Some interviewees explained that municipalities are better aware of what happens on the ground than higher governmental levels, also noted by Biasin et al. (2024), and that greenery is already their responsibility. However, according to most participants, the national government is needed as well to provide direction and vision, contribute financial resources, bring stakeholders together, and integrate NBS into policies, laws, and regulations. Many also underscored that multiple or all governmental levels can carry part of the responsibility. While some explained that citizens have a responsibility too in the form of citizen initiatives, another expert mentioned that a part of the responsibility, and self-interest, also lies with companies. As a result of these statements, quite a few interviewees concluded their answer by pointing towards a shared responsibility among all stakeholders, indicated by Hawxwell et al. (2019) as well. This means both vertical and horizontal multi-level governance, a concept that has been increasingly gaining traction in literature over the past decades, not just in the sustainability domain (Sajida, 2025). It can thus be concluded that there is an ongoing search for the best governance approach and division of roles and responsibilities.

The strategy of linking the benefits of NBS to the urban agendas of different stakeholders was also tested as a hypothesis, and was confirmed by experts. Frantzeskaki (2019) formulated it as an approach to make NBS a common solution within governments by creating a departmental narrative to inspire colleagues as well as to make them feel included. As NBS address multiple objectives simultaneously, narrative frames can draw attention to the topics of interest of various departments that the benefits of NBS touch upon, thus linking NBS to urban agendas, to ultimately enhance collaboration across departments and stimulate NBS adoption. Experts noted that this ‘what’s in it for me’ approach is strategic and effective not only within governments, but also across sectors and other organizations.

8.2.1.1.3 Informational and technological

A lack of evidence on the effectiveness, efficiency, efficacy, benefits, and costs of NBS was suggested as a barrier in literature, and has been partially confirmed. Studies indicate that the evidence base for NBS is limited, due to, among other things, it being a relatively new concept (López Portillo Purata et al., 2022; Van Eekelen et al., 2021; Sarabi et al., 2020). According to experts, an increasing amount of data is available, but the issue lies in the fact that not all data is openly accessible and no clear overview exists. Nevertheless, there are some gaps remaining, such as base data that classifies and categorizes NBS, key figures, and data on the potential negative effects, which was not found in literature. Experts also noted that the benefits can be difficult to quantify or assign monetary value, similar to statements made in literature (Van Eekelen et al., 2021; Kopsieker et al., 2021; Voskamp et al., 2021; Castelo et al., 2023; Sarabi et al., 2020). Remarkable is that the issue of not being able to measure and monitor variables of interest was brought up by participants, as it can be difficult when NBS are just realized or are small in scale, but not highlighted in literature. Furthermore, interviewees indicated a lack of data on long-term effects, while literature suggests that the costs and benefits under different climate conditions are unknown (Sarabi et al., 2020; United Nations Environment Programme Copenhagen Climate Centre, 2025; Van Eekelen et al., 2021; Kabisch et al., 2016). This discrepancy can be explained

by differences in focus. Practitioners primarily encounter challenges related to data collection in early project stages or for small-scale interventions, where measurable outcomes have not yet materialized. Their emphasis lies on the feasibility of generating data within limited timeframes and spatial scales. In contrast, literature tends to adopt a more theoretical and long-term perspective, focusing on the uncertainty surrounding the costs and benefits of NBS under varying scenarios.

As a driver, the rich availability of tools that provide knowledge or help inform decisions based on data, was proposed as a hypothesis and confirmed by the experts; however, several nuances emerged. Some participants indicated that practitioners can get lost in the supply of tools and are unsure where to look for certain information or do not know which tool will work best for them, thereby hindering them in optimally using the tools. Although Voskamp et al. (2021) provided an overview of the available tools and indicated their main characteristics, it shows that such efforts often do not arrive at practitioners or do not become widely known. Moreover, some experts also explained that it remains the question whether stakeholders who have access to tools will actually be incentivized to use them.

To share knowledge on NBS or to become more educated on the topic of NBS, a catalog with applicable and customizable NBS for cities can be developed or used. This hypothesis can be confirmed, albeit some perspectives need to be clarified. Voskamp et al. (2021) indicated that "knowledge on measures in general, and specific knowledge on NBS for particular challenges" should be incorporated. Experts mainly pointed out that a case study compendium can serve as valuable reference material for practitioners. Although contexts are varying, they noted that common elements can be derived from examples and certain (parts of) projects are applicable in multiple locations. Nevertheless, almost all participants underscored that NBS are not plug-and-play solutions, thus need to be adapted to the local context, and that this disclaimer should be included in the catalogs. This context-sensitivity remark was not explicitly made in literature.

The second strategy that was proposed was establishing ULLs that can provide appropriate and safe environments to learn by doing as well as opportunities to gather data. Literature suggests that ULLs can aid stakeholders in learning about NBS and testing out different governance formats, including co-creation (Sarabi et al., 2020; Frantzeskaki, 2019; Aniche et al., 2024). While experts confirmed this is part of ULLs their purpose, they also indicated that the Living Labs can help get a grip on and address stakeholders' awareness, understanding, acceptance, and support, similar to demonstration projects, as well as enable data collection. As a lot of data is based on assumptions, monitoring ULLs allows for verification of existing data as well as the provision of new data. However, some interviewees expressed that most attention is often paid towards designing and experimenting, since monitoring is seen as the less interesting and valuable part, despite its essence for justifying future NBS projects. This underscores the importance of broadening the scope of ULLs, both in literature and practice.

8.2.1.1.4 Physical and ecological

Urban space being scarce and competed over was considered a barrier in literature, which was also reported by all interviewees. Literature suggests that European cities are densely built, making urban vacant space scarce, as well as the fact that NBS need to compete with other sectors or sustainability measures (Dorst et al., 2022; Leuven, 2025). Similar statements were made by experts, claiming that the housing and especially the mobility sector are the biggest competitors, although literature mainly pointed out the construction sector as competition. Furthermore, sustainability innovations, such as solar panel parks, were less frequently mentioned as alternative priorities by interviewees.

For a driver, the multifunctional nature of NBS was put forward as a hypothesis, and has been confirmed by participants. Notable is that literature and most interviewees mention the ability to deliver multiple benefits and address multiple societal challenges as part of the NBS definition without

explicitly stating it as a driving force or indicating how this benefit can be leveraged (United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Hölscher et al., 2023). It could be that by including the characteristic in the definition they already indirectly imply that this trait deserves recognition. Nevertheless, it would be beneficial to emphasize it more prominently in academic work in the future. Especially given the fact that many experts viewed multifunctionality as the strength of NBS, an element necessary for building a business case and winning the spatial competition, and a way to get many stakeholders interested, thereby enabling adoption and upscaling of the solutions.

Assigning multiple functions to NBS designs and implementing hybrid NBS were tested as strategies, which have both been validated by the participants. Again, the strategy that concerns assignment of multiple functions was indirectly referred to in publications stating multifunctionality as a trait (Kabisch et al., 2016). However, during the interviews the strategy was explicitly mentioned by several experts to address space concerns as well as to leverage NBS their potential. Regarding the implementation of hybrid NBS as an approach to tackle the presence of existing systems and spatial constraints, most interviewees came up with the more 'well-known' options, such as using green roofs, walls, and facades on buildings (e.g., houses and offices). There was only one expert who also indicated hybrid designs for bike lanes, pavement, and parking spaces. This suggests that hybrid NBS other than greenery on typical buildings might be less considered. While literature also suggested green roofs and vertical greenery systems, integration into urban car parks and repurposing leftover infrastructure were also mentioned (Hachoumi et al., 2021; World Bank, 2021; Evans & Hardman, 2023).

8.2.1.2 Unique factors for NBS

Within the social and cultural domain, the drivers quality of life, sense of ownership, sense of place, and reputational benefits are more unique to NBS. Unlike most grey solutions, NBS frequently generate direct social and community-level benefits and strengthen the reputation of involved stakeholders. Although awareness and acceptance influence most infrastructure projects, they require explicit attention in the context of NBS due to the novelty of the approach.

From a governance perspective, collaboration across departments, sectors, and organizations is vital for many infrastructure projects, but the multifunctional character of NBS amplifies this need. NBS intersect with a wider range of domains and user groups than grey solutions. While stakeholders are accustomed to collaborating on traditional projects such as dikes, NBS are sometimes automatically viewed as the municipality's responsibility, despite differing substantially from nature in general. Consequently, issues around leadership and responsibility become more prominent for NBS.

For the informational and technological aspects, data expressibility and predictability are particularly relevant for NBS. As many NBS benefits are difficult to express quantitatively or in monetary terms, there is a deliberate effort required to ensure that these variables are properly considered in decision-making. Moreover, the long-term performance of the solutions is hard to foresee, as NBS are quite context-dependent and rely on natural processes. Next to this, compared to other infrastructure types, NBS still lack clear definitional boundaries, reinforcing ambiguity and hindering uptake.

Within the physical and ecological system, the adaptable and multifunctional nature of NBS offers a clear advantage over grey alternatives. Moreover, several benefits of NBS, like aesthetic appeal, enhanced biodiversity, and urban cooling, cannot (easily) be provided by traditional infrastructure projects. Nevertheless, maintenance requirements pose a more substantial challenge, as NBS may require more or different forms of maintenance, and their long-term maintenance needs are less predictable than those of grey solutions.

For the financial theme, maintenance costs for NBS are often perceived to be higher than for grey solutions, even though this is not always the case and can be offset by benefits such as increased property value. Still, this perception makes maintenance costs a more significant barrier for NBS. In addition, whereas business cases for grey measures follow well-established procedures, NBS produce benefits beyond the economic realm as well as benefits that are enjoyed by different parties than those bearing the costs, thereby complicating financial justification.

When it comes to the political arena, NBS differ from grey infrastructure in the breadth of their beneficiaries: because they generate environmental, social, and economic benefits, they are relevant to a wider set of societal groups. Yet, supportive policies dedicated specifically to NBS remain limited, reflecting their relative novelty and indicating the need for political attention and institutional support.

Within the legal landscape, barriers related to land ownership are more pronounced for NBS, given their strong potential in private spaces, unlike most grey infrastructure, which is typically implemented in the public domain. Furthermore, many existing regulations are oriented towards conventional infrastructure, suggesting the need both to develop NBS-specific regulatory frameworks and to remove legal obstacles embedded in current rules.

8.2.2 Framework

There are only a few NBS frameworks designed for use during the planning or implementation phases (Wickenberg et al., 2021). Especially the amount of frameworks that incorporate, or focus on, influencing factors is limited. Moreover, most of them include only barriers and drivers, such as the frameworks proposed by Deely et al. (2020), Connop et al. (2016), and Sarabi et al. (2020), while omitting strategies and measures to address them. As a result, these tools remain largely conceptual and provide limited guidance to stakeholders. The Seeds of Change framework advances the current landscape of NBS frameworks by including all influencing factors (i.e., barriers, drivers, strategies, measures, and principles) into a single tool and by guiding stakeholders in applying the framework in ways that support the realization of more, and more successful, NBS projects.

Beyond standalone use, the framework can also be used in combination with, or integrated with, other frameworks. For combined use, the SoC Framework can be complemented by the framework provided by Raymond et al. (2017). While the SoC framework helps stakeholders remove barriers and leverage drivers to stimulate implementation, the framework by Raymond et al. (2017) focuses on maximizing the co-benefits delivered by NBS. Used together, the frameworks can enhance both the extent of NBS adoption and the quality of outcomes (i.e., scale of the benefits). Another option is combining the SoC Framework with the modeling framework developed by Bellamy et al. (2017), which helps stakeholders identify areas most in need of NBS using habitat suitability models and health deprivation data. Whereas Bellamy et al. (2017) support site selection, the SoC Framework can support the selection of appropriate NBS types by helping compare the presence and relevance level of influencing factors and assessing how easily strategies and measures can be applied to address them.

For integration with existing frameworks, the SoC Framework could be embedded in the NBS strategic planning framework designed by Sarabi et al. (2019). Their framework prompts stakeholders to identify and predict barriers and enablers, supported by predefined lists, to inform the selection of NBS types. These lists could be expanded to incorporate the more extensive and refined set of factors identified in this thesis, including drivers, and could adopt the relevance-level approach developed here. Two alternative integration pathways are the planning and evaluation framework by De Lima et al. (2022) and the planning framework by Calliari et al. (2019). Both provide step-by-step guidance for planning NBS, focusing respectively on optimizing environmental, social, and economic outcomes and on supporting decision-making between grey solutions and NBS. While each dedicates a step to

identifying enabling and constraining factors, as well as threats and opportunities, these steps remain broadly defined and offer little direction on which specific barriers and drivers may apply or how they can be addressed. The SoC Framework could fill this gap by being integrated into these stages.

8.2 Limitations and future research

To begin with, there are several limitations related to the chosen research approach. The DSR approach typically consists of six phases, while only the first four phases were executed within this thesis. Especially phase five, evaluation, is important to verify whether the designed framework supports a solution to the problem and, in case aspects can be improved, iterate back to the development of the framework phase. Future research could evaluate the framework by means of a focus group with stakeholders to improve its effectiveness.

Next, there are limitations related to the methods employed. The framework was developed by the researcher based on the insights provided by experts and the characteristics derived from existing frameworks. However, as the researcher is not working as a practitioner with NBS, it would have been better to develop the framework in a collaborative manner, such as a workshop, with practitioners. This method was also suggested by several interviewees and could be done in future research to ensure that the framework would be useful for the intended target group. In addition, the framework was applied on a few illustrative cases to demonstrate its use and value. The researcher opted for this method as there were time constraints and illustrative cases require minimal resources. However, for a more thorough application of the framework, an in-depth case study could have been performed. As this requires more information on the case being used than is available online, additional interviews or a focus group with stakeholders that have worked on the specific case would be required.

The scoping of the research also has its limitations. The interviews in this research focused on four themes and a few hypotheses within each theme. As other factors within these themes or other themes and their corresponding factors might also influence NBS implementation, future studies could take other factors as hypotheses. In addition, this research focused on identifying the barriers and drivers that affect NBS implementation as well as the strategies, measures, and principles that can aid in successfully realizing NBS. Despite this approach being a valuable starting point for understanding the system, and the researcher taking into account that factors can function as both barrier and driver, the interaction effects and other dynamic processes between the factors are not fully examined. The study only looked at how strategies and measures could influence barriers and drivers and how principles were related to them based on the experts' quotes and the interviewer's interpretation of them. However, it was not questioned how these barriers and drivers influence one another. Future studies could focus on discovering these relations and employing cognitive mapping to visually present them. Related to this, NBS implementation is also influenced by psychological mechanisms that underpin individual-level behavior towards adopting NBS (Bellmann et al., 2025). These underlying behavioral determinants can be identified by employing the COM-B model, considering participants' capabilities, opportunities, and motivation (Michie et al., 2011). Future research could investigate these influences and include them in the causal map mentioned earlier.

Another limitation is that the context differs between interviewees. Some of them have been involved in projects in many different Dutch cities, while others are generally concerned with one municipality. A few experts have also worked on projects outside the Netherlands and illustrated some of their arguments with such instances. As context differs between participants and the influencing factors are context-dependent, highlighted by the differences in interviewees' perspectives, generalization of the results to all NBS projects in Dutch cities should be done with caution. While the variety in experts' backgrounds provided a holistic view on influencing factors and allowed development of a framework

applicable to multiple Dutch cities, it would also be interesting if a future study only interviews experts who work on projects in the same municipality.

Furthermore, there are limitations related to the design of the interviews. The limited amount of time to execute the interviews meant that the sample size consisted of 10 participants. Although not many new insights were revealed nearing the end of the interview process, the sample remains relatively small. Moreover, not all experts had the time and expertise to discuss each theme and hypothesis, leading to some topics being considered less than others. Therefore, the results should be interpreted with care. It might be interesting to redo the research with a bigger sample size to see if the same factors and accompanying explanations are given.

Another important limitation of the research is bias. This might arise if interviewees provide socially desirable answers. Even though the experts were made aware that the interviews would be analyzed anonymously, there are a few signals that indicate bias in the study. Some of them made slight changes to the transcript afterwards and one participant noted that they would like to make a statement on a certain topic but would not be able to do so. Next to this, it can happen that experts feel pressure to not always speak freely, as they might have critical notes on their organization or projects. Another possibility is that interviewees could have felt obligated to represent the organization's point of view instead of their own experience and perspective.

Some bias could also be observed in the researcher's questions, mainly caused by the fact that the interview protocol was based on a predefined research framework. Although this allows for systematic identification of the factors, it may also result in boundaries in data interpretation. Some room was created by asking relatively neutral questions about the hypotheses on the barriers and drivers, since some factors can act as both, and the semi-structured approach meant the researcher tried to achieve a balance between steering the interviewees towards the topics of interest and letting participants speak freely. Although it was tried to ask questions without directly pointing towards the hypotheses being examined or a specific answer, the questions may still be a bit direct as the study's purpose is to test the hypotheses. This means that experts could have felt the need to answer in a socially desirable manner or possibly emphasized topics they thought the interviewer wanted to hear. This while other factors may have been equally, or even more, important. An unstructured interview approach might help reveal interviewees' true perspective and can generate more in-depth and contextualized responses. Interviewing more people or interviewing more people from a smaller scope, for instance from the same municipality, might also help reduce bias and better validate the results.

Moreover, the outcomes of the analysis are shaped by the researcher's interpretation of the interviews. If another scholar would have conducted the same analysis, they could have formulated codes differently or assigned quotes to different themes or factor types. Although subjectivity is inherent in qualitative research, there are several methods for balancing personal perspectives with the pursuit of objectivity, thereby strengthening the validity of findings. Future research could benefit from collaboration with multiple researchers, which can bring different perspectives to the table. Independently analyzing the same data and comparing the results can help identify discrepancies and counteract (individual) biases, ultimately leading to a more robust interpretation.

Next to suggestions based on limitations, there are also avenues that are inherently valuable to explore. The decision-making process for NBS consists of several rounds. As the stakeholders that are involved and the activities that take place are different for each round, it might be interesting if future research unravels the decision-making process for NBS and examines which factors are of importance in each round. This could be done by interviewing practitioners within municipalities, as they are the most aware of how those processes takes place, and basing the interview protocol on a predefined

research framework that is focused on decision-making processes, such as the Nutt framework or rounds model (Nutt, 2008; Teisman, 2000).

Influencing factors may also vary depending on contextual conditions. To begin with, they can be influenced by how long the stakeholders that are involved in projects have been working with NBS, as noted by several participants. It might be valuable to study which factors belong to which 'maturity level', since this can help practitioners in a more targeted way and, as an added benefit, also shows how far they have progressed with implementing NBS. Second, it may be interesting to investigate whether different types of NBS are influenced by distinct sets of factors. A comparative analysis could help determine whether the framework requires differentiation across NBS categories. Third, because private-space interventions involve different stakeholders than public-space projects, future studies could examine how stakeholder configurations affect the relevance of certain factors. Future research might also consider interviewing a larger sample of practitioners and academics to see if differences can be observed, as this can mean that factors that are considered important in literature might not play a role in practice. This could lead to a redirection of research efforts. Related to this, interviewing a more specific subset of practitioners like municipal policymakers might reveal alternative insights. As an add-on, this can be done for a few municipalities to demonstrate whether the factors are dependent on local conditions, such as the location or size of the municipality.

9. Conclusion

The conclusion chapter is divided into three sections. To begin with, Section 9.1 provides an answer to the four sub-questions and concludes by answering the main research question. This is followed by Section 9.2, which shows what the contribution of the research to the academic literature is. Lastly, in Section 9.3 recommendations for improving, increasing, and accelerating the implementation of NBS in Dutch cities are provided, thereby highlighting the societal contribution of the research.

9.1 Answers to research questions

9.1.1 Sub-question 1

The first sub-question considers: "*What characteristics should a NBS framework designed for use during the planning and implementation phases possess?*".

The review on frameworks revealed that certain characteristics are recurrent. Most frameworks begin their guidebook or supporting text by clarifying the framework's type, nature, purpose, and value. Furthermore, the reviewed frameworks often specify during which phase(s) of the urban planning process the framework should be applied. Most frameworks are designed to be applicable across different contexts and accessible to a broad audience. Additionally, both the intended use and target user group are typically defined at the outset of the framework. For the framework's application, some recommended a specific governance approach that can be followed. Content-wise, an important element found is the distinction between context, process/activities, and outcomes. For a barriers and drivers approach specifically, organizing them into themes and assigning a relevance level to each factor can provide clarity and overview. All frameworks that included strategies or measures formulated these in the imperative form to communicate action while avoiding the assignment of responsibilities, since this depends on the context. In addition, the text included in the frameworks is formulated concisely. All frameworks are accompanied by a guidebook or supplementary material to support practitioners in their application. Frequently, expert comments or real-life cases are incorporated to illustrate the content of the framework and demonstrate its use and value. Overall, the frameworks strived to achieve a balance between text and visual elements by including sufficient written explanation to ensure that users can understand the framework without immediately consulting supplementary information, while avoiding excessive text by integrating visuals.

Interviewees mentioned relatively similar elements. They underscored the importance of stating for whom the framework is intended and selecting a format that fits with these users. For this, reasoning from a Theory of Change can be of help. Moreover, usability in terms of word choice, size, and required attention span was another important characteristic that was highlighted. This implicates keeping sentences short and concise and avoiding jargon. It was also noted that summarizing the findings first could help keep the content manageable and maintain the reader's focus on the most important elements, while more in-depth explanations could be provided in subsequent sections. Moreover, experts stressed the importance of dedicating enough time to visualization. For this, it was suggested to include visual elements, such as funnel diagrams and yes/no or flow charts, to complement text. Lastly, many participants pointed out that the use of examples and references is helpful.

9.1.2 Sub-question 2 & 3

The second sub-question considers: "*Which barriers and drivers influencing the implementation of NBS are identified in literature, and which are perceived by experts within Dutch cities?*". The third sub-question considers: "*Which strategies, measures, and principles to support successful implementation of NBS are identified in literature, and which are proposed by experts for Dutch cities?*".

Both literature and experts indicated that the factors of influence can typically be classified across the themes of social and cultural, governance, informational and technological, physical and ecological, financial, political, and legal. The factors discussed in the following paragraphs were considered important by interviewees.

Within the social and cultural realm, factors such as awareness and understanding, acceptance and support, interests and priorities, and perspectives on urban space vary among citizens and can therefore function as either barriers or drivers. To address these factors, several strategies can be employed, including informing citizens about NBS and their benefits, framing NBS in ways that align with citizens' values and priorities, stimulating citizen-led initiatives, and embedding NBS thinking broadly across society. Moreover, citizen participation is a cornerstone of successful NBS projects and can take multiple forms, ranging from incorporating citizens' perspectives to co-creation and active involvement in maintenance. Drivers within this domain include the ability of NBS to enhance citizens' quality of life and to foster a sense of place and ownership. Key principles to uphold are ensuring just implementation, for instance by prioritizing underserved neighborhoods, including all relevant citizen groups, potentially through the involvement of neighborhood managers, and maintaining realistic expectations about the extent and form of citizen participation.

When it comes to governance, limited collaboration between departments as well as organizations and sectors significantly hinders NBS adoption. This challenge is further exacerbated by departmental structures that focus on single-task assignments, while NBS inherently serve multiple objectives. To foster collaboration among stakeholders, various strategies can be applied, including the use of communication and co-creation tools, the establishment of construction or thematic groups, and the strategic linking of NBS to broader urban agendas. Moreover, as NBS transcend administrative and sectoral boundaries, the absence of clearly defined responsibilities often impedes implementation. Assigning responsibility to specific stakeholder groups, through multi-level governance structures, national or municipal leadership, or citizen-led stewardship, is therefore vital. While formal networks can serve as valuable platforms for connecting practitioners, exchanging knowledge, and facilitating cooperation on NBS projects, informal personal relationships also play a critical role.

For the informational and technological aspects, influencing factors are data availability, expressibility, measurability, and predictability, as well as the presence of appropriate tools. Although data on NBS is becoming increasingly available, several barriers persist. These include the lack of open access to all data, the absence of a central database that provides an overview, the challenge of expressing certain variables quantitatively or monetarily, difficulties in identifying the right tool for specific purposes, and the fact that existing tools often only offer a snapshot of NBS outcomes. To address these challenges, several strategies can be employed: developing a comprehensive data overview, using averages or proxies in calculations, combining qualitative and quantitative methods, creating an overview of available tools, and employing scenario modeling to explore long-term effects. In addition, limited knowledge within governments remains a barrier, which can be mitigated through education and training programs, the establishment of ULLs, and the development of informational materials such as a nature overview, synthesized NBS theory booklets, or catalogs of exemplary NBS projects. When using the latter, it is essential to ensure alignment with the local context. Finally, monitoring within ULLs should be ensured to generate data.

Within the physical and ecological system, several benefits delivered by NBS, including improved air quality, enhanced biodiversity, reduced flood risk, and the provision of recreational spaces, serve as key drivers for their adoption. The inherent adaptability and multifunctionality of NBS further promote their implementation. However, the general lack of space in cities, limited availability of suitable locations, existing systems in place, and maintenance requirements form hindrances. To address these

barriers, strategies like assigning multiple functions to NBS designs, optimizing soil use, implementing hybrid solutions, and using zero maintenance species can be employed. Key principles to consider include creating interconnected networks of green and blue spaces, which yield greater benefits than isolated interventions, and ensuring ecological robustness by incorporating diverse species and accounting for local climatic conditions.

Within the financial domain, the (maintenance) costs of NBS are an important factor, although experts have varying perspectives on it. While some argue that the costs are higher, others point out that the percentual difference is minimal, especially given the increase in property value. Making a strong business case is also experienced as challenging: while NBS provide an array of benefits, they are difficult to express in monetary value and are often enjoyed by stakeholders other than those who bear the costs. As far as financing is concerned, its availability depends on what the capital is needed for during a project. Moreover, financial flows within governmental organizations are often separated for each department, making it difficult to integrate them for NBS projects. Combining departmental financing streams, establishing co-financing models, using subsidies, and comparing the costs of NBS with grey solutions, are all strategies that can help address these factors.

For the political theme, the existence of political interest in and prioritization of NBS is vital for its adoption. Participants indicated that NBS are currently not often on the priority list of politicians. To create a consistent, supportive political landscape and reduce vulnerability to political cycles, embedding NBS in long-term planning frameworks can be of help. Equally important is the presence of supportive and coherent policies for NBS, of which both the Netherlands and the EU have some in place. Despite this, interviewees felt that the current set can be expanded and that cities can take inspiration from policies implemented in other municipalities.

Factors within the legal landscape are also of influence. Land ownership and use can act as a barrier, as governments have limited say over what private property owners should implement, and quite a large area of the city is privately owned. Another important factor are the regulations in place, of which some currently make NBS implementation difficult or impossible. However, there are also several supportive regulations in place in the EU and various Dutch cities, of which the latter can serve as measures that can be copied in other cities. Examples are implementing a no loss or biodiversity net gain regulation, creating a NBS point system, mandating the inclusion of greenery/water storage, or mandating pavement removal. Nevertheless, some of these regulations contain loopholes that result in suboptimal or minimal NBS implementation.

9.1.3 Sub-question 4

The fourth sub-question considers: "*What is a suitable framework for these experts to consider when planning and implementing NBS, and how can this framework be used in practice?*".

The insights from literature and expert interviews are synthesized in the Seeds of Change Framework. The framework enables its users, which can be various governmental organizations, urban planners, businesses, knowledge institutes, universities, financial institutions, and non-profit organizations, to systematically identify the barriers and drivers that influence their NBS projects as well as select strategies and measures that can be applied to address these factors or to generally stimulate implementation. In addition, it highlights the principles that should be followed to ensure sound NBS practice. The primary application of the framework is prospective, guiding decision-making and design during the planning and implementation phases of NBS projects. The framework enables stakeholders to understand which factors influence their NBS project and how to address them, while also serving as a tool to compare competing NBS projects. It can also be applied retrospectively to evaluate what went well, identify areas for improvement, and draw lessons for future projects.

The framework consists of three chapters. The first chapter introduces the framework by providing background information on NBS, arguing for the necessity of the framework, detailing what it does, stating who can use it, clarifying what it looks like, and explaining how it can be used. This is followed by the second chapter that contains tables for identifying barriers and drivers, selecting strategies and measures, and becoming aware of principles. The first table lists influencing factors for which stakeholders must identify whether they function as a barrier, driver, or both. Next, the framework asks stakeholders to assess the relevance of each factor, classified as none, low, medium, or high. The following column refers to numbered strategies and measures that can be selected to address each factor. Separate tables list the strategies and measures as well as the principles, each with a unique number. All of these tables are made for each theme separately. The third chapter provides one-line definitions for each factor, along with expert comments and illustrative cases for selected factors. The illustrative cases are realized NBS projects in Dutch cities that show how the content of the framework can be found in practice, thereby highlighting its application and value.

9.1.4 Main research question

The main research question considers: "*What are the factors influencing the implementation of NBS in Dutch cities, and how can these factors be integrated into a guiding implementation framework to support the adoption of NBS?*".

There are many factors, which can either be barriers, drivers, strategies, measures, or principles, that influence the adoption of NBS in Dutch cities. The factors can generally be categorized into seven overarching themes: (1) social and cultural, encompassing aspects such as public awareness, quality of life, and citizen participation; (2) governance, which includes collaboration between stakeholders and the clear allocation of responsibilities; (3) informational and technological, referring to the availability of data, knowledge, tools, and technical capacity; (4) physical and ecological, covering elements like spatial availability, ecological benefits, and the inherent characteristics of NBS; (5) financial, which relates to maintenance costs, property value impacts, and the use of subsidies; (6) political, addressing political interests and priorities and the coherence and presence of supportive policies; and (7) legal, encompassing the regulatory environment, including existing laws and land ownership considerations.

The multitude of factors and their interrelations underscore that NBS adoption is governed by a large, complex, and interdependent system of influences. Consequently, stimulating implementation efforts necessitates a multifaceted approach that addresses this systemic nature. The differing perspectives of the experts further illustrate that this system is highly context-dependent and must therefore be assessed individually for each project. In this regard, the Seeds of Change Framework serves as a valuable tool. It supports stakeholders in systematically identifying barriers and drivers, assessing their relevance, selecting suitable strategies and measures, and recognizing key principles. By providing concise one-line definitions for each factor, the framework enables a quick grasp of their core meaning, while the inclusion of expert commentary and illustrative cases enhances its practical applicability by demonstrating how the framework operates in real-world settings.

9.2 Contributions to literature

To begin with, this research provides a comprehensive understanding of the barriers and drivers that affect NBS implementation in Dutch urban contexts, the strategies and measures that can be applied to address these factors or generally support successful implementation, and the principles that can be followed to ensure sound adoption. Previous studies have often focused on the broader theme of climate adaptation and mitigation, such as Reckien et al. (2015), or on concepts related to NBS, like Sharma et al. (2016). Moreover, research on NBS specifically has tended to focus on contexts outside the Netherlands. Given that NBS are highly context-dependent and possess distinct characteristics, this

has left a gap in understanding what influences the adoption of these solutions in Dutch cities (Dorst et al., 2022). This thesis helps with filling this gap. In doing so, it also contributes to explaining the implementation gap: despite the acknowledged need for NBS and their recognized potential, their adoption remains limited. This can be clarified by the existence of a complex system of influencing factors, including barriers.

Moreover, testing hypotheses on these factors revealed which of the factors identified in literature play a part in practice in Dutch cities. It also showed that some factors previously assumed to be barriers can in fact act as drivers, or both, and vice versa. The nuances in experts' responses as well as the (subtle) differences in perspectives among participants, further confirmed that influencing factors are highly context-dependent. They cannot only vary across countries, but can also be different within national boundaries and even between projects in the same geographical area. This finding underscores that factors limiting NBS adoption in one context may serve as driving forces in another.

Third, this thesis brings together barriers, drivers, strategies, measures, and principles within a single integrated study. Existing research often examines only one part of this spectrum, for instance, studies such as Perrault (2022) focus exclusively on barriers, while others combine barriers and drivers, like Han and Kuhlicke (2021), without recommending approaches to address them. Some other studies emphasize strategies and measures drawn from implemented NBS projects, yet these are frequently not explicitly connected to the contextual barriers and drivers that shaped them, as seen in Faivre et al. (2017). Research that does establish such links tends to focus on a single project, such as Dartée et al. (2023), one specific type of NBS, as in Chappin et al. (2024), or only a subset of influencing factors, for example Duffaut et al. (2022), rather than the full set of interactions. Even when all factors are considered, strategies and measures often receive limited attention. This thesis is distinctive in treating all influencing factors with equal weight and directly deriving strategies and measures from the contextual barriers and drivers identified.

Finally, this study contributes to the landscape of NBS frameworks that can be used during the planning and implementation phases of projects. Most existing frameworks pay limited attention to these two phases of the urban planning cycle (Wickenberg et al., 2021). Planning involves, among other things, the selection of sites or measures, but making informed decisions in this phase requires a sound understanding of the factors that shape NBS adoption and of how these can be addressed through targeted action. Successful implementation similarly depends on the continuous identification and addressment of barriers and drivers throughout the process. Yet, among the limited number of NBS frameworks available for the implementation stage, only a few explicitly address these influencing factors (Connop et al., 2016; Deely et al., 2020). Moreover, these are all conceptual frameworks and only contain barriers and/or drivers, without providing strategies and measures that can deal with them. This while stakeholders involved in the planning and implementation of NBS in practice need actionable insights on how they can address the factors that impede or stimulate NBS adoption. This thesis fills this gap by integrating all factors into an implementation framework that can guide practitioners toward systematically identifying barriers and drivers, selecting strategies and measures, and becoming aware of principles. This leads to more widespread and successful NBS implementation.

9.3 Recommendations for practice

Regarding the most critical factors of influence, it is recommended that stakeholders involved in the planning and implementation of NBS projects become aware of these factors. Each stakeholder group should act on this knowledge in ways that align with their specific roles, responsibilities, and capacities, addressing the factors they are best positioned to influence. Civil society as well as practitioners play a role in increasing public awareness of the climate change and biodiversity crises and emphasizing the

role that NBS can play in addressing these challenges. Creating acceptance and support for NBS as well as building societal prioritization for the solutions requires continuous efforts to communicate how these solutions enhance citizens' quality of life and to frame them in alignment with what is valued by society. Moreover, citizen participation represents a key pillar of successful NBS projects and should be embedded throughout the process by accounting for citizens' perspectives, co-creating with them, and involving them in maintenance. It is also important to embed NBS thinking across society at large, meaning fostering a mindset in which NBS are considered by default rather than the exception. Governmental organizations should also embed NBS thinking institutionally as well as built knowledge and capacity among its practitioners. Moreover, together with other sectors and organizations, they need to break down silos to improve collaboration between them. This can be achieved by linking NBS to various urban agendas as well as adapting the current structure of departmental assignments to facilitate more integrated working arrangements. Researchers and educators should strengthen the evidence base for NBS by developing a clearer understanding of their costs and benefits, which also enables stronger justification for their adoption. In addition, they need to enhance conceptual clarity through establishing a clear definition of NBS, classifying NBS and coupling them to attributes for modeling purposes, and integrating the solutions into education and training programs. Practitioners can also play a role in building the evidence base and gaining conceptual clarity. Within the physical and ecological system, the limited availability of space poses a substantial barrier, which could be mitigated by the mobility sector reshaping its systems and reallocating space to create room for NBS. Policymakers and political leaders need to stimulate and sustain political will, as well as make NBS of political interest and a priority. Embedding NBS in long-term planning frameworks can help secure consistency in political commitment. Regulatory authorities need to revise regulations that hinder implementation and introduce regulations that mandate NBS integration into urban development.

Regarding the use of the Seeds of Change Framework, it is recommended that stakeholders involved in the planning and implementation of NBS projects apply the framework at the start of the project with all involved parties. This helps create a shared understanding of the influencing factors and how they can be addressed, thereby leading to increased and more successful implementation of NBS. Nevertheless, application of the framework is limited by the knowledge and experience of its users. Incorrectly assuming that a barrier is not relevant, when in reality it poses a significant threat to the project, may result in stakeholders suggesting pursuing a project that will ultimately fail. Conversely, mistakenly assuming that certain barriers are present and certain drivers are absent may lead to users abandoning a project that could have been successful. To avoid such costly mistakes, users should, wherever possible, collect and analyze data to verify their assumptions about potential barriers and drivers. Before applying the framework to current NBS projects, stakeholders are encouraged to first use it retrospectively on a completed project in which they were involved. This allows them to become familiar with the framework's structure and factors while simultaneously evaluating the planning and implementation process of that project. In doing so, they not only gain hands-on experience with the framework, but also practice critical reflection by identifying what went well, where improvements could be made, and what lessons can inform future projects. Such evaluation is valuable, even when no new NBS projects are immediately planned, as it strengthens individual learning and memory building and may reveal additional factors that have proven to be of influence in practice but are not yet included in the framework.

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Appendix

Appendix A Framework analysis

A.1 Connecting Nature Framework

A.1.1 Content

The Connecting Nature Framework considers NBS implementation as an interactive, iterative, and non-linear process that runs through three development phases: planning, delivery, and stewardship (Hölscher et al., n.d.; Collier et al., 2023). Each phase consists of seven elements, being technical solutions, governance, financing and business models, nature-based enterprises, co-production, impact assessment, and reflexive monitoring, that cities need to take into account to help them shape their NBS project. Cities can choose themselves with which element of the framework they want to start and consider the other ones in an order that suits their context. However, for some phases certain elements are more important than others. Co-production, governance, and financing and business models are especially important for planning, reflexive monitoring and entrepreneurship are crucial during the delivery phase, and impact assessment is vital for stewardship. The element of technical solutions encompasses each phase.

A.1.2 Important characteristics

- Recognition that the planning cycle consists of different phases and that a multitude of elements that are interrelated require consideration in each phase (phases highlighted)
- Inclusion of a guidebook that details each element and explains how it can be translated into urban practice with either a step-by-step plan or visual
- Each element is supported with insights from implementation (as the framework has been tested in various cities)
- Co-production and ongoing monitoring of goals and impacts is crucial when using the framework
- Starting point and order of steps is determined by the local context and needs
- Recognition that the implementation process of NBS projects is iterative and non-linear
- Purpose and value of using the framework are described
- The framework can be used in various contexts
- The framework is intended for a wide audience

A.2 NBS planning framework

A.2.1 Content

The NBS planning framework is conceptual of nature and addresses three different components (Albert et al., 2021). To begin with, criteria are introduced to define NBS as the substantive focus of the planning process, which are challenge-orientation, ecosystem process utilization, and practical viability. This in contrast to common NBS characteristics, such as co-benefit generation and cost-effectiveness, which are regarded as facultative. These characteristics should not be considered defining criteria as they unnecessarily narrow down the concept of NBS and require a case-specific analysis instead of simple stipulation. Next, six steps are given that comprise a comprehensive approach to planning NBS. These steps are: (1) co-define setting, (2) understand challenges, (3) create visions and scenarios, (4) assess potential impacts, (5) develop solution strategies, and (6) realize and monitor. The approach should be embedded in the given governance setting. Lastly, the implementation of the steps is guided by five planning principles: place-specificity, evidence base, integration, equity, and transdisciplinarity. For each criterion and principle, a checklist of supportive procedures for practical application of the framework is given.

A.2.2 Important characteristics

- Focused on one phase and the various steps within that phase (phases highlighted)
- Elaborate explanation of each component and the elements within each component
- Introduction of obligatory criteria to ensure that all stakeholders are on the same page
- Regarding common NBS characteristics as facultative
- Ideal process of consecutive steps described, but recognition that the real planning cycle is adaptive, iterative, and will often only cover some steps
- Principles given that should be followed during the planning process to enhance the likelihood of successful implementation
- Supported by insights from a case study
- Checklist of supportive procedures for practical application of the framework given (for the principles and criteria), written in imperative verb form to communicate action
- Interdisciplinary collaboration is required when implementing the framework
- Purpose and value of using the framework are described
- The framework can be used in various contexts
- The framework is intended for a wide audience

A.3 Green Cities Framework

A.3.1 Content

The Green Cities Framework is structured in three modules: process set up, elaboration of the strategic document, and NBS project co-design (Garcia-Blanco et al., 2022; Barker et al., 2024). The first module focuses on setting up the process and co-designing the NBS strategy. The second module encompasses three core interactive phases, which are planning, mobilizing, and evaluating and reporting. The final module considers the co-design of NBS projects. Each module, and phase within the modules, consists of various steps that guide the process. The components of the framework should be read in an organic rather than sequential manner, as each city needs to find its own starting point depending on their momentum of opportunity, interests, and maturity in the development process. The framework is accompanied with guiding principles that contribute to successful NBS implementation.

A.3.2 Important characteristics

- Consists of three modules, which each consist of various steps (and sometimes phases)
- Elaborate explanation of each of these elements is provided
- Distinctive characteristics of NBS are kept in mind during the design
- Use of a multi-scale approach mainstreamed with the scales of urban planning
- Steps are written in imperative verb form to communicate action
- Inclusion of a guidebook that explains how the framework can be used
- Accompanied with a set of guiding principles that can contribute to successful implementation of NBS
- Supported by comments from real cases as well as inspirational case study examples
- Recognition that components of the framework should be read organically instead of sequentially
- Each city can find its own starting point to the framework (process) depending on their momentum of opportunity, interests, and maturity in the development process
- Purpose and value of using the framework are described
- The framework can be used in various contexts
- The framework is intended for a wide audience

A.4 NBS Barrier Identification Framework

A.4.1 Content

The NBS Barrier Identification Framework can be used by stakeholders to easily identify which barriers might impede the implementation of their NBS projects (Deely et al., 2020). The framework consists of five barrier-categories, which are institutional and governance, socio-cultural, knowledge, technical and biophysical, and funding and market. Each of these categories consists of various barriers to which a threat level of none, low, medium, or high can be assigned by the stakeholders. The authors point out that before using the framework, it is important that stakeholders have a clear definition of NBS and understand which measures can be categorized under this concept. The framework can be used on its own to provide a reference point for stakeholders on the barriers that other NBS projects have encountered, which allows them to consider their capacity to handle each barrier. An alternative approach is using the framework for comparing various projects on their non-monetary difficulties. In addition, the framework can enable researchers to tailor it to their users, meaning that users with the appropriate level of knowledge judge the existence and threat level of specific barriers. Lastly, the framework can be used within stakeholder participatory approaches to stimulate debate about the existence of barriers in NBS projects and what possible solutions can address them.

A.4.2 Important characteristics

- Barriers are categorized across five categories based on their context and description
- Recognition that most barriers transcend a singular category, but that the most relevant category is ultimately chosen
- For each barrier a threat level of none, low, medium, or high can be assigned by the stakeholders
- Elaborate explanation of each barrier category and barrier
- Recognition that framework can be applied individually or in group dynamic, but that collaborative use has advantages as the framework can be tailored to its users
- Emphasis on involving an individual who is able to discuss NBS during the use of the framework to introduce other stakeholders to the concept and ensure agreement on a definition of NBS, understanding of which NBS exist, and discussion of their advantages
- Elaborate recommendations given for the framework its application (also see content)
- Recognition that the framework is guiding (intention is to guide thinking about barriers)
- Purpose and value of using the framework are described
- The framework can be used in various contexts
- The framework is intended for a wide audience

A.5 NBS project design framework

A.5.1 Content

The NBS project design framework considers five steps to be key elements that need to be addressed in projects (Nesshöver et al., 2017). These elements are (1) ensure the use of sound multi-disciplinary and trans-disciplinary knowledge, concepts, and methods, (2) deal with uncertainty, complexity, ambiguity, and conflicts to achieve equitable trade-offs, (3) ensure the involvement of multiple stakeholders and a wider public, (4) develop common understanding of multifunctional solutions, and (5) evaluate and monitor for mutual learning across scales. The first four steps also consist of several smaller recommendations. Moreover, there are four structural and systemic enablers that must be in place to support NBS beyond individual projects: (1) set up long-term investment and financing to reap benefits of NBS, (2) develop and implement appropriate institutional arrangements/designs, (3) ensure equitable distribution of benefits and risks, and (4) ensure environmental targets to be included and monitored.

A.5.2 Important characteristics

- Considers five procedural and strategic steps that ensure that NBS are well-integrated, context-specific, and inclusive at the project level (processes and principles needed during the design and implementation phase)
- These steps flow into structural and systemic enablers that must be in place to support NBS beyond individual projects (foundational conditions needed to institutionalize NBS and sustain their impact over time, across multiple projects and scales)
- Elaborate explanation of each element is provided
- Steps and recommendations are written in imperative verb form to communicate action
- Purpose and value of using the framework are described
- The framework can be used in various contexts
- The framework is intended for a wide audience

A.6 ProGIreg framework

A.6.1 Content

The proGIreg project focuses on ULLs in four front runner cities in which NBS are developed, tested, and implemented (proGIreg, 2022). The follower cities closely follow the progress and engage in city-to-city exchanges to replicate the projects of the front runner cities. This project took several years and the lessons that have been learned are stated in various reports. The summary of all these reports has been reviewed, as it synthesizes the approach that has been followed and can be replicated in other cities. The framework considers two activities to be important for planning and implementing NBS, which are spatial analysis and co-design. The spatial analysis entails six steps, which are a data availability check, analysis of existing plan and policy frameworks, basic data collection and area-based stakeholder identification, quantitative data collection and interpretation, data synthesis and spatialization, and formulation of conclusions. After this activity has taken place, cities should engage in co-design planning by means of several workshop rounds. Each workshop round has a different focus and should decide on different matters. It is important that six co-design principles are followed during these workshops: (1) be open, inclusive, and diverse, (2) share goals and vision, (3) think long-term, (4) be experimental and reflective, (5) be flexible, and (6) be transparent. Each principle is shown in a process map to show which activities ensure that it is taken into account and to which outcomes these activities lead. The framework also provides guidelines and points of consideration that were brought forward after the workshops took place as well as four changing parameters that were identified and should be considered in a flexible manner during co-design. All these activities, steps, principles, and guidelines are explained and illustrated by examples of the various cities participating in the project. Moreover, several barriers and opportunities for the two main activities are provided, with recognition that these are context-dependent. It is also highlighted which NBS, urban scales, and stakeholders are accounted for to provide the context in which the framework should be considered.

A.6.2 Important characteristics

- Two important activities considered during the planning and implementation phase (phases highlighted), each consisting of several steps and/or principles and/or important parameters
- Supported with examples from the proGIreg project to illustrate
- Elaborate explanation of each element is provided, either in text or in actual framework
- Barriers and opportunities for each activity are provided, with recognition that some of them apply to all or multiple cities while others are very context-dependent
- Highlighting the context that should be considered when using the framework (which NBS, urban scales, and stakeholders)
- Distinction made between process, activities and their outcomes

- Recognition that recommendations are flexible
- Inclusion of a roadmap to show the process in one overview
- Steps and recommendations are written in imperative verb form to communicate action
- Purpose and value of using the framework are described
- The framework can be used in various contexts
- The framework is intended for a wide audience

A.7 NBS co-benefits assessment framework

A.7.1 Content

The NBS co-benefits assessment framework consists of two related parts and can be used during the various phases of NBS projects (Raymond et al., 2017). The first part of the framework assists in acknowledging and assessing the co-benefits of NBS within and across 10 societal challenges: (1) climate mitigation and adaptation, (2) water management, (3) coastal resilience, (4) green space management, (5) air quality, (6) urban regeneration, (7) participatory planning and governance, (8) social justice and social cohesion, (9) public health and well-being, and (10) economic opportunities and green jobs. These co-benefits can occur within and across 4 domains, being climate and physical environment, ecosystems, biodiversity, and socio-economic and socio-cultural systems. This means that four dimensions of benefits may appear simultaneously when implementing NBS, which are co-benefits for human health and well-being, integrated environmental performance, trade-offs and synergies to health, biodiversity, or economy, and potential for citizens their involvement in governance and monitoring. For each societal challenge, it was identified which actions could help, what benefits to expect, how to measure those benefits (indicators), and how to go about measuring the benefits (methods). The second part of the framework concerns a seven-stage process for positioning co-benefit assessment within policy and project implementation: (1) identify problem or an opportunity, (2) select and assess NBS and related actions, (3) design NBS implementation processes, (4) implement NBS, (5) frequently engage stakeholders and communicate co-benefits, (6) transfer and upscale NBS, and (7) monitor and evaluate co-benefits across all stages. Each stage is accompanied with pertinent questions, which also cover topics related to barriers and drivers of NBS implementation as well strategies that can address these factors. The scheme in which these stages are represented shows alternative routes and feedback loops between various stages. Moreover, the stages are shown in a flexible and circular scheme to ensure that each stage is not totally independent from the others and that the same sequence does not always take place.

A.7.2 Important characteristics

- Can be used during multiple phases (phases highlighted)
- Helps with acknowledging and assessing the value of the co-benefits that appear within and across 10 societal challenges and 4 domains
- Provides for each challenge which actions could help, what benefits to expect (impacts), how to measure those benefits (indicators), and how to go about measuring the benefits (methods)
- Presents a seven-stage process for positioning co-benefit assessment within policy and project implementation by describing both how successful NBS projects can be implemented and how the solutions generated through the NBS projects can be innovated
- Considers idea of alternative routes and feedback loops between various stages
- Highlights importance of considering the central part of the framework (co-benefit monitoring and evaluation) in each stage of the implementation process
- Stages are shown in a flexible and circular scheme to ensure that each stage is not totally independent from the others and that the same sequence does not always take place

- Elaborate explanation of each of the framework its elements is provided
- Recognition that the framework is guiding (intention is to guide thinking and help with identification of the multiple values of NBS implementation) and requires further operationalization and tailoring to specific context
- Purpose and value of using the framework are described
- The framework can be used in various contexts
- The framework is intended for a wide audience

A.8 NBS benefits and barriers framework

A.8.1 Content

The NBS benefits and barriers framework states that a detailed consideration of habitat services, biodiversity-led approach, and multifunctionality are necessary to maximize the ES provision of NBS (Connop et al., 2016). Moreover, NBS should be designed based on the challenges that are present in the local context as well as the characteristics of the local animals, plants, and ecosystems. This biodiversity-led approach should be combined with a multi-stakeholder approach when planning and implementing NBS. The framework presents various NBS typologies typical of the urban context and links them to examples of ES that may be provided by multifunctional design. These potential benefits are juxtaposed against potential barriers of implementation to present foci for research and innovation that can support NBS development and maximize benefits. The framework has been applied to three case studies, which demonstrated that the framework can help with achieving multifunctionality, identifying which stakeholders are required, affecting transformation by using an experimental approach, feeding this back into policy, and addressing some barriers that prevent broader application.

A.8.2 Important characteristics

- States that a detailed consideration of habitat services, biodiversity-led approach, and multifunctionality are necessary to maximize the ES provision of NBS
- Considers the city as social ecological system
- Presents various NBS typologies typical of the urban context and links them to examples of ES that may be provided by multifunctional design of NBS
- Juxtaposes the potential benefits against potential barriers of implementation to present foci for research and innovation that can support NBS development and maximize benefits
- Highlights importance of locally contextualizing NBS design based on challenges as well as animals, plants, and ecosystems present in context
- Highlights importance of co-development of methods for including a strategic approach to implementing biodiversity-led NBS by developers and planners (multi-stakeholder approach to planning and implementation)
- Creates understanding of interconnectedness of citizens, policies, and physical spaces to enable development of NBS
- Supported by case studies to illustrate the use of the framework
- Purpose and value of using the framework are described
- The framework can be used in various contexts
- The framework is intended for a wide audience

A.9 NBS planning and evaluation framework

A.9.1 Content

The NBS planning and evaluation framework highlights the importance of considering NBS as processes, identifying long-term results, and assessing the multi-dimensional effectiveness of NBS through a participatory approach (De Lima et al., 2022). It can be used to evaluate both ongoing

projects as well as guide new ones. Moreover, the framework can be utilized to show relations between NBS targets and SDGs and 2030 Agenda. It considers the planning cycle phases of NBS projects, while allowing methods for verification, comparison, and measurement of their effectiveness using certain indicators. The following phases are recognized by the framework: (1) research and development, (2) planning, (3) conceptual design, (4) detailed design, (5) construction, (6) monitoring, (7) evaluation, and (8) adjustments. By taking into account these phases, the tool considers three stages of NBS projects: context assessment, NBS implementation and adaptation process, and NBS results. The first stage details the context, which denotes the spatial location that is being considered, which challenge needs to be solved, which specific goals need to be addressed, and how drivers, barriers, and other factors influence these aspects. The process of NBS implementation considers the adoption of NBS, which is characterized by its type, scale, and actors engaged. This stage has process indicators across three dimensions, which are environmental, social, and economic. The third and final stage represents the NBS project results encompassing outcomes and impact indicators across the three dimensions. All indicators must aim at human well-being as the ultimate goal and co-benefits are considered to be positive unintended consequences. Based on how the project scores on the indicators, adjustments can be made to improve the application. The framework provides a list for both the process and impact indicators.

A.9.2 Important characteristics

- Can be used during multiple phases (phases highlighted)
- Highlights importance of comprehensiveness, considering NBS as processes, identifying long-term results, and assessing potential multi-dimensional effectiveness of NBS through a participatory approach
- Framework can also be used to show relations between NBS targets and SDGs and 2030 Agenda
- Considers planning cycle phases while allowing methods for verification, comparison, and measurement of effectiveness using indicators
- Contains a list of indicators to evaluate or guide assessment of three sustainability dimensions that are considered
- Highlights the importance of considering context, process and results
- Recognition that several stakeholders need to be involved when using the framework to draw on their experience and knowledge related to identifying problems and solutions
- Inclusion of a guide that shows how the framework should be used
- Elaborate explanation of each of the framework its elements is provided
- Purpose and value of using the framework are described
- The framework can be used in various contexts
- The framework is intended for a wide audience
- The framework can be used retrospectively and prospectively

A.10 IUCN Global Standard for NBS

A.10.1 Content

The IUCN Global Standard for NBS aims to equip stakeholders with a framework that can help them with consistently designing and verifying NBS projects that yield the outcomes they desire for solving societal challenges (International Union for Conservation of Nature, 2020a; International Union for Conservation of Nature, 2020b). It creates a common language and understanding of the NBS concept and what it requires to be successfully implemented, thereby ensuring consistent and grounded application of NBS that are designed and executed with high quality. However, the standard is not intended for establishing a rigid, normative framing with fixed thresholds indicating what NBS should

achieve. The standard's mere purpose is to support its users in applying, strengthening and improving their NBS interventions. The standard consists of eight criteria, which are (1) NBS effectively address societal challenges, (2) design of NBS is informed by scale, (3) NBS result in a net gain to biodiversity and ecosystem integrity, (4) NBS are economically viable, (5) NBS are based on inclusive, transparent, and empowering governance processes, (6) NBS equitably balance trade-offs between achievement of their primary goal(s) and the continued provision of multiple benefits, (7) NBS are managed adaptively, based on evidence, and (8) NBS are sustainable and mainstreamed within an appropriate jurisdictional context. Each criterion is illustrated by a case study and supported by several indicators. The standard is accompanied with a self-assessment tool to calculate the percentage match of a NBS project against the criteria. This way, it can be identified whether the project adheres to the standard. There is also a governance structure proposed for the use of the standard and the self-assessment tool, consisting of an international standard committee, a scientific committee, a user group, and operationalizing hubs.

A.10.2 Important characteristics

- Aims to equip users with a framework that can help them with consistently designing and verifying NBS that yield the outcomes they desire for solving societal challenges
- Aims to ensure that the application of NBS is credible and that its adoption is tracked and measured for adaptive management so that its deployment inspires others
- Ensures consistent and grounded application, a systematic learning environment that can improve and evolve the implementation of NBS, and realization of the full potential
- Provides an opportunity to create a global user community that helps with successful NBS implementation
- Translates NBS into targeted actions for implementation, reinforces best practices, and addresses and corrects shortfalls
- Purpose of the framework is to support users in applying, strengthening, and improving their NBS interventions
- Value of the framework is providing credibility to the design when speaking to investors and other stakeholders, recommendations for improvement (identification of gaps and solutions), engagement and communication across sectors (start new conversations, provide a common framework and language to discuss, in this case, trade-offs)
- Highlights that application and mainstreaming of the framework requires scientific rigor, academic research, good governance and a willingness on the part of the various stakeholders
- Should not be seen as a rigid, normative framing with fixed thresholds indicating what NBS should achieve
- Consists of 8 criteria and 28 indicators
- Accompanied with a self-assessment tool to calculate the percentage match of a NBS project against the criteria and identify whether the project adheres to the standard
- Recommends a certain governance structure for using the standard
- Supported with case study examples to illustrate how the framework can be used
- Recognition that the standard is guiding
- The framework can be used in various contexts
- The framework is intended for a wide audience

Appendix B Literature review on factors

B.1 Financial factors

B.1.1 Financial barriers

To begin with, there is a temporal barrier as NBS typically experience long lead times due to the efforts that are required for designing and developing the projects (Knight et al., 2022). This causes delays in the project's revenue generating phase. Moreover, the benefits of NBS projects typically accrue in the long-term, meaning that NBS yields operate on a medium to long-term timeframe. As it takes time to generate return on investment, investing in NBS is only economically attractive over the long-term (International Union for Conservation of Nature, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; López Portillo Purata et al., 2022). Another barrier that relates to bagging the benefits of NBS projects is the fact that they are usually not fully captured at the site at which the project is implemented (International Union for Conservation of Nature, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025). As the benefits are distributed across stakeholders, it is difficult to calculate the economic value of the NBS project and for investors to gain sufficient direct benefit from it.

Another barrier concerned with financial gain is the fact that the evidence base on the financial returns and benefits of NBS is weak (Knight et al., 2022; López Portillo Purata et al., 2022). Due to NBS being a new asset class, transparent and public data on the return on investment and performance of these solutions is lacking (Knight et al., 2022). Moreover, current data on the economic viability of NBS only reflects returns generated directly by NBS projects, bypassing long-term economic benefits of working with nature (López Portillo Purata et al., 2022). Instead of generating income in the traditional sense of cash flows, NBS provide benefits to communities and positive externalities in the form of added benefits as well as avoided costs. This difficulty with correctly calculating the benefits of NBS results in a lack of clear payoffs, allowing the private sector to perceive NBS as a social responsibility or philanthropic act instead of investments that can generate income and other societal benefits.

Next to this, a common perception is that NBS involve more costs compared to grey solutions, even though several studies have shown that NBS are often cheaper (Sarabi et al., 2020). Maintenance costs are seen as a challenge, as it is essential they are made to ensure that NBS keep on delivering their benefits, but can be difficult to estimate due to their dependency on external factors like weather conditions (Tran et al., 2024). Furthermore, the upfront costs of NBS projects are high and due diligence can create high transaction costs, which is particularly the case for small-scale NBS projects (Knight et al., 2022; United Nations Environment Programme Copenhagen Climate Centre, 2025). Although there are many cases where the benefits outweigh the costs, the perception of high costs can pose a barrier to NBS uptake (Knight et al., 2022; Sarabi et al., 2020).

There is also a lack of financial resources in both the public and private domain for NBS, which hinders the frequency and quantity of NBS investments (United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2021). For municipalities this is because their revenues are mostly dedicated to the development and maintenance of grey solutions as well as social expenditures (Sarabi et al., 2020). In addition, it is difficult to obtain funding from the EU, entrepreneurs, or citizens (Kabisch et al., 2016; Sarabi et al., 2020). Applying for EU funding is complicated and requires co-financing, which many cities are unable to afford (Kabisch et al., 2016). Moreover, citizens and entrepreneurs are often not aware about what is in it for them or deem NBS to be the responsibility of the local government, thereby preventing them from investing (Sarabi et al., 2020). Besides this, the financial landscape consisting of many investors and NBS projects makes it difficult to coordinate budgets and investments between public and private stakeholders and across sectors, leading to

fragmentation of smaller investments dispersed across sectors (Knight et al., 2022; United Nations Environment Programme Copenhagen Climate Centre, 2024; Tran et al., 2024).

Furthermore, there are limited financial incentives available, such as tax exemptions, tax reductions, or subsidies, that can encourage entrepreneurs, citizens, and the public sector to invest in NBS (Sarabi, 2020; López Portillo Purata et al., 2022; United Nations Environment Programme Copenhagen Climate Centre, 2024). There is also a lack of risk sharing and reduction mechanisms, while NBS are high risk investments (Van Eekelen et al., 2021; Knight et al., 2022; López Portillo Purata et al., 2022; Triodos Investment Management, 2025). NBS have many inherent characteristics, such as comprising a long-term investment, that contribute to a high risk level (Knight et al., 2022). However, risk sharing and reduction measures that can lower this investment risk are often absent, leading to corresponding difficulties in calculating risk-adjusted returns (Van Eekelen et al., 2021).

Finally, there are challenges in creating a good investment picture for NBS. To begin with, there is a lack of bankable NBS projects and the financial viability of existing ones is often weak, largely because NBS typically generate limited short-term revenue (Knight et al., 2022; Linnerooth-Bayer & Scolobig, 2023; United Nations Environment Programme Copenhagen Climate Centre, 2024; Van Eekelen et al., 2021; Knight et al., 2022). Moreover, potential revenue streams often lack a proven track record, making them less attractive to investors (Van Eekelen et al., 2021). In line with the lack of short-term, trustworthy revenue streams, the immaturity of carbon markets combined with the fact that it is hard to monetize benefits except for carbon also impedes NBS investment (United Nations Environment Programme Copenhagen Climate Centre, 2025; Triodos Investment Management, 2025; Knight et al., 2022). There has been skepticism surrounding carbon markets due to past scandals that involved low-quality carbon credits, making this revenue stream less desirable for investors (Triodos Investment Management, 2025). However, monetization of benefits other than carbon is difficult and a strong scalable market for non-carbon ES is absent (Knight et al., 2022). Next to this, there is also a lack of appropriate business models for NBS (Sarabi et al., 2020).

B.1.2 Financial drivers

A frequently mentioned driver is that NBS are cost-effective and often cheaper than grey solutions (European Commission, n.d.-c; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Hölscher et al., 2023; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Kopsieker et al., 2021). Although it was earlier stated that maintenance costs can be a challenge and are habitually perceived to be high and uncertain, in practice the maintenance costs of NBS are often lower than of technological alternatives (Castelo et al., 2023). Next to this, adopting NBS can create up to 32 million jobs globally (United Nations Environment Programme, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2024; Kopsieker et al., 2021). Moreover, NBS align with Environmental, Social, and Governance (ESG) goals and can redefine sustainable investing by offering a compelling blend of environmental stewardship and financial returns (Triodos Investment Management, 2025). Alignment with ESG goals is increasingly vital for meeting consumer expectations as well as attracting investors.

While impact investing offers reputational benefits, investors also expect financial returns from NBS projects (United Nations Environment Programme Copenhagen Climate Centre, 2024; Triodos Investment Management, 2025). Investors can earn income by selling the carbon, water, and biodiversity credits that NBS projects deliver (United Nations Environment Programme Copenhagen Climate Centre, 2024). Related to this is that the until soon non-monetary outcomes of NBS are increasingly being monetized, which creates additional revenue streams for NBS projects and makes it easier to calculate the benefits (Castelo et al., 2023). In addition, NBS adoption can increase the value

of properties in the neighborhood, which in turn leads to higher municipal revenues from increased property taxes (United Nations Environment Programme Copenhagen Climate Centre, 2024).

Apart from this, NBS can reduce the costs and financial burden of several sectors, thereby decreasing costs to governments and individuals (Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024). To begin with, NBS can decrease the damage costs from extreme weather events (United Nations Environment Programme Copenhagen Climate Centre, 2024). This is especially important in light of the evolving climate crisis resulting in the occurrence of more extreme weather events, which will increasingly place substantial financial burdens on urban services and infrastructure (United Nations Environment Programme Copenhagen Climate Centre, 2025). NBS can also reduce infrastructure costs, lower the financial burden on health services, bring down water production costs, and decrease heating and cooling expenses of buildings (Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024).

Besides these direct financial gains and cost savings, NBS also provide an array of indirect economic benefits. NBS make cities more appealing, thereby attracting and retaining investors, businesses, and a talented workforce (Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024). This in turn stimulates the amount of economic activity within the area. Related to this, NBS implementation can lead to increased foot traffic, which also stimulates economic activity (United Nations Environment Programme Copenhagen Climate Centre, 2024). Another driver for businesses is that NBS can increase access to green spaces for employees, which boosts their productivity and health, ultimately reducing sick days (United Nations Environment Programme Copenhagen Climate Centre, 2024). A final driver, unrelated to the previous ones, is that the EU and cities themselves are increasingly willing to fund, sometimes in partnership with private parties, NBS implementation and maintenance (Voskamp et al., 2021; Tran et al., 2024).

B.1.3 Financial strategies/measures/principles

De-risking NBS and improving their risk-return profile can make NBS projects more attractive for investors (Linnerooth-Bayer & Scolobig, 2023; Wetlands International, 2021; Van Eekelen et al., 2021; Directorate-General for Environment, 2022; Sarabi et al., 2020; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2025). One way to achieve this is establishing a dedicated public fund that can be used to support the NBS project development phase and to leverage any additional costs or risks of NBS investments, which can help improve the risk-return profile (United Nations Environment Programme Copenhagen Climate Centre, 2025; Van Eekelen et al., 2021). An alternative is increasing the credit profile of NBS projects and/or their sponsor, for example by the project sponsor bringing in collateral to reduce the financial risk of the project for private investors (Van Eekelen et al., 2021). Furthermore, the insurance sector can be engaged to tap into their risk reduction needs and damage cost expertise (Directorate-General for Environment, 2022). Finally, a different avenue is providing guarantees to cover NBS project risks or emerging country (political) risks, which can be done through insurance or by the government (Van Eekelen et al., 2021).

Moreover, public and private financing of NBS should be stimulated and supported (Linnerooth-Bayer & Scolobig, 2023; Triodos Investment Management, 2025; Tran et al., 2024; Directorate-General for Environment, 2022; Kabisch et al., 2016). As there are high expectations that private financing can contribute significantly to bridging the NBS funding gap, private financers should be encouraged to invest in NBS (Linnerooth-Bayer & Scolobig, 2023). This can be achieved by de-risking NBS projects, providing subsidies for NBS, or establishing partnerships between private sector stakeholders and NBS initiatives by linking project-based carbon credit generation to corporate net-zero goals (Directorate-General for Environment, 2022; Triodos Investment Management, 2025). However, the public-good character of NBS can remain a challenge in this regard. Currently, the majority of NBS funding already

originates from public sources, a trend that is likely to grow through various initiatives. However, for municipal and national governments to lead effectively, they will still require increased budgets to enable NBS investments. In line with enhancing financing, another powerful instrument can be to encourage divestment from nature-negative assets (Linnerooth-Bayer & Scolobig, 2023; Kabisch et al., 2016).

Furthermore, multilateral partnerships and co-finance agreements can be created between and across various public and private parties, such as engineering companies, governments, development banks, and climate funds (Wetlands International, 2021; Directorate-General for Environment, 2022; Van Eekelen et al., 2021; Leuven, 2025). This will not only alleviate the risks perceived by private financers, but can also help with pooling resources for NBS and unlocking new investments. One example of establishing co-finance agreements is stimulation of public budget coupling in multi-purpose NBS projects (Van Eekelen et al., 2021). However, to encourage such blended finance approaches, a shared ambition between stakeholders must be created (Wetlands International, 2021). This can be done by helping the parties understand and consider the full range of benefits associated with NBS instead of disregarding the positive externalities beyond the scope of the donor or national budget planning.

Moreover, learning from, leveraging, and piloting existing revenue-generation NBS models and testing them with value-capture arrangements can enhance the attractiveness of NBS for private investors (United Nations Environment Programme Copenhagen Climate Centre, 2025). This requires NBS to be structured and presented regarding value proposition, delivery, and capture. For NBS in rural areas, an example of this is leveraging entrance fees and proceeds from ecotourism. In line with this, markets for natural capital and revenue streams from natural capital should be created, after which these revenue streams should be integrated into NBS projects (Wetlands International, 2021; Van Eekelen et al., 2021). The most well-known example is carbon credits, which are created by reducing GHG emissions or by removing carbon from the atmosphere (Wetlands International, 2021). Similar markets and revenue streams can be developed for the other ES that NBS provide, for instance in relation to compensating biodiversity and habitat loss (Van Eekelen et al., 2021).

Besides this, biodiversity proofing and tracking of relevant EU and national investment should be improved to more accurately and regularly assess progress of funding against intermediate needs and objectives in order to be able to take additional action where necessary to stay on course for the 2030 commitments (Kopsieker et al., 2021). Likewise, investments should be targeted to contexts with the most potential for NBS and financing structures should be tailored to these local contexts (United Nations Environment Programme, 2024; Triodos Investment Management, 2025). Adapting financing structures entails not blindly imposing pension fund risk-return preferences, but asking for each project what it needs to succeed (Triodos Investment Management, 2025).

Moreover, the investment picture of NBS projects can be improved by strengthening their business case and developing tools that can guide stakeholders on how to build such a business case (Voskamp et al., 2021; Sarabi et al., 2020). A strong business case is especially important for external financing bodies and can therefore help with establishing successful PPPs (Sarabi et al., 2020). Furthermore, tools that provide insight into the valuation and financial aspects of NBS can be helpful (Voskamp et al., 2021). In line with this, the development of bankable NBS projects should be stimulated to increase private sector financing (Van Eekelen et al., 2021).

Lastly, there are two strategies that are not related to a specific concept. The first is to increase the use of European Structural and Investment Funds, blue/green bonds, and impact bonds for NBS (Van Eekelen et al., 2021; Kopsieker et al., 2021). For instance, a blue bond label indicates that the project will contribute to the development and preservation of coastal and marine ecosystems (Van Eekelen

et al., 2021). This increases both the visibility of the project as well as that of project sponsors. As many investors have targets stating that a specific part of their funds must be invested in sustainable projects, buying blue, or green, bonds can help them achieve these goals. This demand for financing opportunities in NBS can result in more advantageous financing terms for the project sponsors.

B.2 Political factors

B.2.1 Political barriers

To start with, there is a lack of awareness and urgency among policymakers and politicians (Sarabi et al., 2020; Voskamp et al., 2021; Kabisch et al., 2016). Even though many urban planners are aware of the existence of NBS and the benefits they can provide, this awareness might not exist among policymakers and politicians (Kabisch et al., 2016; Voskamp et al., 2021). Next to lacking awareness, a low sense of urgency among these stakeholders can also pose a barrier to mainstreaming NBS, as "an inadequate event-based risk perception is widespread, and it results in the sense of security that denies any sense of urgency among policymakers" (Sarabi et al., 2020). As a result, many politicians are not fully aware of the potential of NBS in addressing societal challenges.

However, even if awareness and a feeling of urgency are present, a lack of political will and support can still hinder NBS uptake (Sarabi et al., 2020; Voskamp et al., 2021). Politicians often prefer measures with tangible and immediate outcomes, which is opposite to the characteristics of NBS as they typically need a while to produce benefits (Sarabi et al., 2020). In line with this barrier is the lack of political long-term commitment and continuity (Sarabi et al., 2020; Linnerooth-Bayer & Scolobig, 2023; Voskamp et al., 2021; Van Eekelen et al., 2021; Castelo et al., 2023; Kabisch et al., 2016). This is partly due to political decisionmakers keeping in mind future elections, causing them to be more interested in short-term, low-risk outcomes instead of applying long-term thinking (Sarabi et al., 2020). Moreover, as structural changes in local governments or periodic local elections take place, political continuity of NBS policies can be harmed (Voskamp et al., 2021). This while the development of NBS requires long-term planning, implementation, and maintenance (Kabisch et al., 2016). Therefore, it can be noted that there is misalignment between the long-term NBS goals and the short-term actions and decision-making cycles that are firmly integrated into city administrations.

The lack of supportive policies is another barrier that hinders NBS implementation, while the presence of clear government guidelines is vital for the creation of market growth for NBS (Sarabi et al., 2020; Dorst et al., 2022; Linnerooth-Bayer & Scolobig, 2023; López Portillo Purata et al., 2022; Tran et al., 2024; Kopsieker et al., 2021; Dorst et al., 2021). A reason for this insufficiency can be that policies are typically drafted for existing problems, technologies, and approaches, which means that innovative approaches like NBS often experience a mismatch or require novel policy paradigms to mitigate their development risks (Dorst et al., 2021). Not only NBS policy development, but also its enforcement and monitoring are reported to be insufficient (Dorst et al., 2022). Next to a shortage of policies specifically designed for NBS, there is also inadequate climate and biodiversity proofing of other national and regional plans (Kopsieker et al., 2021).

Related to this policy barrier is the fact that there is a lack of coordination between municipal, regional, and national policies as well as across associated policy realms, leading to inconsistencies and conflicts between them (United Nations Environment Programme Copenhagen Climate Centre, 2025; Sarabi et al., 2020; Kopsieker et al., 2021). This in turn can lead to fragmented governance arrangements that offer limited leeway for NBS implementation (Kopsieker et al., 2021). Moreover, policymakers often experience difficulty in exploiting NBS synergies between policy domains with complementary objectives due to potential compromises and trade-offs that need to be made about the delivery of various benefits, which are often niched under different domains within governments (United Nations

Environment Programme Copenhagen Climate Centre, 2025). The existence of few frameworks that can guide cross-sectoral policy design and implementation could be a reason for these barriers (Kopsieker et al., 2021). Lastly, the availability of room on the political agenda for sustainability issues like NBS can be a factor of concern, as they may be crowded out by other problems such as housing shortages (Dorst et al., 2021).

B.2.2 Political drivers

NBS can contribute to the economic policy objectives of the EU and can help realize the social and environmental justice goals on the European agenda (Kopsieker et al., 2021; Tran et al., 2024). The vital role of NBS in achieving economic policy objectives is recognized in the EU's Green Infrastructure Strategy and social and environmental justice goals have been high on the agenda since health and financial inequalities are still prominent in society (Kopsieker et al., 2024). Next to this, NBS support the achievement of the UN SDGs, particularly SDG 11 Sustainable Cities and Communities (Voskamp et al., 2021; Tran et al., 2024).

It is not just policies that can positively influence NBS adoption, but also statements that have been made by policymakers and politicians as well as other developments in the political landscape (Triodos Investment Management, 2025; Castelo et al., 2023; Sarabi et al., 2020; Kopsieker et al., 2021; Tran et al., 2024; Voskamp et al., 2021). The Intergovernmental Panel on Climate Change, the UN, the IUCN, and the EC declared the implementation of NBS as a key strategy for climate change and biodiversity action and encouraged cities to implement them (Triodos Investment Management, 2025; Castelo et al., 2023; Sarabi et al., 2020). Related to this, a strong convergence of voters in the European election on manifestos that supported bolder EU action to fight planetary degradation was visible and policymakers recognized NBS as a means to this end (Kopsieker et al., 2021; Tran et al., 2024). As functional and desirable, in this case environmentally and socially sustainable, infrastructure forms the basis for civil society, the interest of policymakers is being driven towards NBS (Tran et al., 2024).

Next to expressing interest in NBS, concrete actions to stimulate the implementation of NBS projects have also taken place on various political levels (Voskamp et al., 2021; Castelo et al., 2023). The EU has set its agenda to implement NBS research and innovation projects, countries increasingly include NBS in their Nationally Determined Contributions, and various international city initiatives on sustainable urban development have been implemented. Lastly, a general driver is the fact that NBS have many beneficiaries (United Nations Environment Programme Copenhagen Climate Centre, 2024).

B.2.3 Political strategies/measures/principles

Politicians and policymakers should be informed about NBS to increase their awareness and mobilize them (EPA Network & ENCA Network, 2020; Dorst et al., 2021; Tran et al., 2024; Kabisch et al., 2016; Sarabi et al., 2020). New ministers or local politicians and policymakers can provide a catalyst for NBS proposals if they are aware of all their benefits. Therefore, good examples of NBS need to be shared in an accessible way with these stakeholders. Interest among politicians and policymakers can also be raised by aligning NBS across policy goals and programs to showcase them as urban strategic priorities (Hölscher et al., 2023; Directorate-General for Environment, 2022). An example is emphasizing how NBS with climate benefits can also contribute to the health goals of cities (Directorate-General for Environment, 2022). Next to this, policymakers should normalize the use of value-based approaches in procurement and contracting processes (Wetlands International, 2021). This will challenge the market to propose solutions that maximize co-benefits for society and nature.

Moreover, several strategies concern changes in existing policy to increase their supportiveness of NBS. To start with, NBS need to be mainstreamed into key sector policies and investments of the EU and its Member States (United Nations Environment Programme Copenhagen Climate Centre, 2025;

Castelo et al., 2023; Van Eekelen et al., 2021; Tran et al., 2024; Kopsieker et al., 2021). Mainstreaming NBS into key sector policies, such as land use plans and disaster risk management, can help overcome policy barriers as well as enhance the chance that NBS are consistently applied, monitored, and reported (United Nations Environment Programme Copenhagen Climate Centre, 2025). One example of such integration is setting goals on NBS inclusion in infrastructure projects (Van Eekelen et al., 2021). In addition, biodiversity commitments should be integrated into EU climate policy, investment, and its implementation in Member States (Kopsieker et al, 2021). Alignment of long-term national and local policies for NBS should also take place (Sarabi et al., 2020). This consistency is essential for creating a supportive institutional setting for NBS in which short-term local objectives can be created that are aligned with long-term goals. Related to this is the recommendation to downscale and translate implications for NBS from national-level policies to the local level to mainstream NBS into city-level governance (United Nations Environment Programme Copenhagen Climate Centre, 2025). Lastly, a strategy that should be taken into account when implementing the other strategies as well, policy interventions for NBS should be based on a context-specific analysis of the conditions that explain the barriers of NBS adoption (Dorst et al., 2021).

B.3 Legal factors

B.3.1 Legal barriers

The first barrier involves a lack of supportive regulatory and legal NBS frameworks (Sarabi et al., 2020; Linnerooth-Bayer & Scolobig, 2023; United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2021; Tran et al., 2024). This is partly caused by the fact that regulations are typically drafted for existing problems, technologies, and approaches, meaning that innovative approaches like NBS often experience a mismatch or require novel legal paradigms to mitigate their development risks (Dorst et al., 2021). However, the amount of laws specifically designed to mandate the adoption of NBS is limited and the few existing ones are at times incomplete or poorly enforced (United Nations Environment Programme Copenhagen Climate Centre, 2024). Moreover, stakeholders also experience regulatory uncertainty due to regulations often not being updated in view of NBS development, thereby creating inconsistencies and conflicts between municipal, regional, and national regulations (Triodos Investment Management, 2025; Sarabi, 2020).

Furthermore, there are property ownership and use complexities that complicate NBS adoption (Sarabi et al., 2020; Knight et al., 2022; Van Eekelen et al., 2021; Leuven, 2025; Voskamp et al., 2021). Sometimes the property rights are weak or unclear, making it difficult to identify the property owners and negotiate agreements with them (Knight et al., 2022). Moreover, NBS can encompass a large area and, therefore, can cross jurisdictional boundaries, further complicating the establishment of property ownership and use agreements (Van Eekelen et al., 2021). Next to this, cities have limited influence on whether and where NBS can be implemented on privately owned property and private owners are likely to prioritize finances over sustainability (Voskamp et al., 2021; Sarabi et al., 2020). Even if property is publicly owned, there are strict rules on how land can be used (Leuven, 2025).

Lastly, the non-binding nature of relevant policies and implementation delays of binding EU Directives hinder NBS uptake (Kopsieker et al., 2021). There are many policies focused on supporting the implementation of NBS and related approaches, such as the EU Adaptation Strategy and the Green Infrastructure Strategy. However, these policies are non-binding, which has resulted in “shortcomings across sectors in the design and application of policy instruments for the active restoration of ecosystems” (Kopsieker et al., 2021). Moreover, several EU Directives that are focused on nature protection, conservation, and restoration experience implementation delays.

B.3.2 Legal drivers

Businesses are increasingly under legal pressure to address their environmental footprints (Triodos Investment Management, 2025). Even though most companies have made many strides in reducing their footprint, some emissions remain unavoidable. NBS can aid in offsetting these residual emissions as the measures capture carbon and thereby create carbon credits. These credits can be exchanged between NBS projects and the corporate, creating a revenue stream for NBS projects. Furthermore, NBS can help support the achievement of the 2030 EU commitments for sustainable development, climate action, and biodiversity (Kopsieker et al., 2021). As 2030 is approaching and the commitments point towards the urgent need for ecosystem restoration, NBS can provide win-win solutions by not only helping cities with adapting to and mitigating climate change and stimulating biodiversity, but also providing co-benefits like enhanced public health and well-being.

B.3.3 Legal strategies/measures/principles

To begin with, changes in the EU Environmental Impact Assessment (EIA) Directive need to be made (Linnerooth-Bayer & Scolobig, 2023). The EC could extend the directive's scope to include smaller projects and require proposers of grey solutions to also consider NBS as an alternative. Moreover, they could require proposers to formally assess the impacts of their projects over a longer time horizon with a zero or low discount rate. In addition, the EC can exempt selected NBS from lengthy EIA procedures, or apply a more streamlined process to them, thereby helping to break grey path dependency. Next to this, the implementation of key EU legal commitments delivering on NBS through the nature directives should be accelerated and EU legislation for mandatory ecosystem restoration, that builds on and complements these commitments, should be adopted (Kopsieker et al., 2021). The first part of this strategy would require Member States to make higher, and more targeted, investments that meet the public investment needs and would require the EC to invest in operational capacity to actively fulfil its role as guardian of the Treaty. The second part of the strategy refers to establishing mandatory targets and deadlines for achieving favorable conservation statuses of both species and habitats, increasing progress on other current legislation commitments, and setting national nature restoration plans.

Other strategies consider embedding biodiversity and NBS objectives in regulations concerning urban development and infrastructure. One such option is to regulate for no net loss of biodiversity, which the United Kingdom adopted by requiring developers to achieve a net biodiversity gain of 10% (Directorate-General for Environment, 2022). An alternative approach is including NBS in contractual agreements to demand stakeholders to employ NBS in their infrastructure development. A specific measure within this strategy could be the implementation of a regulation that states that new infrastructure projects must contain new green areas (Tran et al., 2024). Furthermore, a more general approach would be for cities to develop NBS strategies as legally binding documents (Hölscher et al., 2023). This would secure political commitment and future funding. Next to this, NBS implementation can be stimulated by integrating NBS into green certification schemes, thereby providing developers recognition for choosing NBS in their infrastructure projects (Directorate-General for Environment, 2022).

In addition, national and municipal regulations need to be upgraded concerning NBS, as most of them are still mainly based on grey solutions (Sarabi et al., 2020). Creating supportive regulations is crucial for reducing investment risks and encouraging collaborative governance arrangements. Finally, approaches need to be identified that can reduce the barriers for NBS in permitting procedures and land ownership and management practices (Van Eekelen et al., 2021; EPA Network & ENCA Network, 2020). At present, NBS often experience more complex permitting procedures (Van Eekelen et al., 2021). Moreover, for NBS developers it can be difficult to identify who legally owns land, negotiate long-term agreements with multiple landowners, and account for the fact that the benefits and costs

of NBS can occur in different locations or sectors as well as that the project can cross jurisdictional boundaries (EPA Network & ENCA Network, 2020). Adaptation of existing regulations or establishment of new ones can reduce the complexity of these processes.

B.4 Clustered overviews

B.4.1 Social and cultural clusters

Table 2 Social and cultural barriers in literature

Theme	***Barriers***
Social and cultural	Resistance to risk, change, and the unknown
	Lack of public awareness, support, and acceptance
	Lack and difficulty of citizen engagement
	Perception that the benefits of NBS are uncertain, inconsistent, or not worthful
	The commodification of NBS
	Perception that NBS are harmful
	Perception that NBS are a distraction from impactful actions
	The current paradigm relies heavily on economic growth, making system change and prioritization of social and ecological benefits over financial benefits seem unattainable
	The proposition of Western civilization that humans and nature are separate

Table 3 Social and cultural drivers in literature

Theme	***Drivers***
Social and cultural	NBS can distribute funds to, create employment opportunities for, and protect the livelihoods of vulnerable and Indigenous populations, people in marginal and economically disadvantaged regions, and people in regions which are particularly vulnerable to climate change, thereby reducing their vulnerability and empowering them (beyond income generation)
	Approximately 3.3 to 3.6 billion people are highly vulnerable to climate change
	NBS can improve mental health and reduce negative mental health outcomes of citizens
	NBS can increase the physical health of citizens
	NBS can increase the quality of life and life expectancy of citizens
	NBS can address the social crises of inequality and public health
	NBS can enhance social cohesion, create new green urban commons, and provide a sense of belonging
	NBS can decrease crime rates
	NBS can help with preserving cultural and natural heritages and with fostering acceptance and appreciation of diverse cultures
	The public is increasingly interested in sustainable urban development and NBS
	NBS support systems change, seen as transformation of the status quo by altering underlying structures and their supporting mechanisms, which is required to address climate change and biodiversity loss
	Most Indigenous people view themselves and nature as a whole (part of the same ecological family) and consider human survival to be dependent on nature
	NBS can connect people to nature
	Investing in NBS offers reputational benefits for corporations
	The discourse surrounding NBS reflects economic growth ideologies

Table 4 Social and cultural strategies/measures/principles in literature

Theme	***Strategies/measures/principles***
Social and cultural	Switch the burden of proof from NBS to grey solutions
	Mobilize and inform communities of the value of NBS (raise awareness)

Ensure the involvement of diverse communities, especially local vulnerable, low-income, and Indigenous communities, in implementing NBS
Ensure community and public ownership, leadership, communication, engagement, empowerment, and self-management during the process of NBS projects
Encourage citizens and social entrepreneurs to be open to collaborate with local governments on NBS
Educate communities on how they can be involved in NBS projects
Implement just transition measures and promote worker rights and inclusiveness in NBS jobs
Consider social cohesion when implementing NBS
Design NBS in an aesthetically appealing way to ensure citizens appreciate and protect them
Bridge the expectation gap between citizens and engineers
Shift the world from an endless growth model and human-centric view to a degrowth model

B.4.2 Governance clusters

Table 5 Governance barriers in literature

Theme	***Barriers***
Governance	Silo mentality (of traditional planning systems and governance structures) and mismatches between the business-as-usual way of working within city governments and the inter- and transdisciplinary collaborations that NBS projects require
	Lack of stakeholder awareness and engagement
	Lack of and difficulty with stakeholder collaboration, coordination, and cooperation
	Lack of clear responsibilities among stakeholders
	Stakeholder opposition and unalignment or conflict between priorities and interests of stakeholders
	A lot of (diverse) stakeholders are involved in NBS projects from inside and outside the municipal organization, especially compared to grey solutions, meaning that many opinions and interests need to be considered and many local considerations as well as public involvement and perception need to be accounted for
	City officials struggle with mobilizing the necessary institutional support, skill sets, and time
	The development, decision-making, and implementation processes for NBS are more precarious and time-consuming
	Few frameworks exist for guiding cross-sectoral project design and implementation
	Grey path dependency

Table 6 Governance drivers in literature

Theme	***Drivers***
Governance	Bringing together stakeholders for the development of policies and projects for NBS is an opportunity for better collaboration between sectors and disciplines and can be a form of intelligent institutional leadership, which can foster resilience and inclusive urban development
	Planning for NBS increasingly recognizes that it is necessary to include a diversity of knowledges
	Urban development stakeholders are organized in networks around urban climate adaptation transitions, which enables mutual understanding and trust among the stakeholders as well as determines the identities and roles of the stakeholders
	Cities are increasingly willing to engage in public-private partnerships (PPPs) for NBS projects

Table 7 Governance strategies/measures/principles in literature

Theme	*Strategies/measures/principles*
Governance	Mobilize and inform stakeholders of the value of NBS (raise awareness) and their role in delivering the organizational objectives (increase acceptance)
	Engage in NBS knowledge and experience exchanges and city-to-city networks to ensure knowledge transfer and peer-to-peer learning on NBS
	Be open to, establish, and utilize inter-disciplinary and cross-sectoral collaborative governance approaches, structures, and partnerships between and across governments, businesses, knowledge institutes, NGOs, and citizens in NBS projects, to increase discussion, engagement, collaboration, co-design, co-creation, and learning processes among stakeholders, integrate the required knowledge and skills (to bridge departmental silos), shift from risk aversion to risk sharing, ensure that the projects are appealing and socially acceptable designs, and connect demands for action with stakeholders responsible for action
	Remove administrative barriers and provide incentives to allow these collaborative governance approaches, structures, and partnerships to emerge
	Embed reflexive learning in collaborative decision-making
	Develop tools for engagement, involvement, and co-creation, to stimulate collaboration between departments instead of working in silos, and ensure that the outputs of these tools are accessible for everyone
	Ensure that stakeholders are committed to utilizing NBS platforms and encourage them to contribute to the platforms
	Municipalities should adopt an action-thinking approach by declaring NBS action as a duty task for municipalities
	Urban planners can link the multiple benefits of NBS to different urban agendas to create a cross-departmental narrative of integration
	Prevent participation fatigue by not constantly involving the same citizens and innovators over and over and view citizens as equals, in terms of knowledge and idea contributions, to experts, scientists, and consultants
	Empower NBS ambassadors that promote NBS as well as engage in a science-community advocacy by communicating the benefits and risks of NBS to citizens and politicians
	Extend the time for decision-making for NBS
	Ensure good governance practices of clarity, legitimacy, transparency, and openness (to opinions, beliefs, aspirations, and frustrations over the wrongs of preceding processes) to develop mutual trust between stakeholders

B.4.3 Informational and technological clusters

Table 8 Informational and technological barriers in literature

Theme	*Barriers*
Informational and technological	Lack of knowledgeable and skilled professionals and knowledge brokers
	Lack of education and training programs and difficulty with workforce training
	Lack of centralized, reliable, and comparable evidence on the effectiveness, efficiency, efficacy, (co-)benefits, and costs of NBS, leading to functionality and performance uncertainties
	There is no clear overview of the costs and benefits of NBS compared to the costs of damage in case of no climate action
	Challenges in quantifying the (co-)benefits and costs of NBS
	Evidence on performance and costs of NBS are difficult to standardize
	Disseminating results of implementation is complex
	Lack of long-term research projects that focus on maintenance and monitoring of NBS
	Few frameworks exist for acknowledging and assessing the value of co-benefits from NBS and existing NBS valuation tools are not used in decision-making processes when deciding between grey and green solutions, leading to NBS being undervalued

	Lack of design standards and guidelines for maintenance and monitoring
	There is uncertainty around how NBS can be best and consistently planned, designed, implemented, maintained, and monitored
	Scientifically validated options and knowledge on NBS are often not available when policy windows are receptive to new NBS projects

Table 9 Informational and technological drivers in literature

Theme	***Drivers***
Informational and technological	Advancements in technology, such as satellite monitoring and AI, make it easier to measure ES, which in turn will make NBS more scalable and cost-efficient
	The potential, benefits, and cost-effectiveness of NBS are increasingly demonstrated in practice and emphasized in scientific assessments and reports
	A large variety of tools has been developed and is being tested to support the adoption of NBS in cities
	Over 60 million people work globally in activities categorized as NBS

Table 10 Informational and technological strategies/measures/principles in literature

Theme	***Strategies/measures/principles***
Informational and technological	Demonstrate the workings, (technical) feasibility, cost-effectiveness, long-term viability, and scalability of NBS to build a solid evidence base for NBS, thereby increasing awareness and willingness to pay
	Improve and apply strong monitoring networks to provide data for the evidence base of NBS and develop strategies and partnerships to collect, maintain, and share this data
	Develop tools and indicators that can provide concrete insights into and output on (the valuation of) the costs and benefits of NBS
	Base the design of NBS projects on evidence of the (co-)benefits of the NBS being adopted and localized systems' knowledge and design the projects in a way and scale so that lessons for their effectiveness can be collected and easily replicated in other locations
	Develop a catalog of applicable and customizable NBS to provide cities with more knowledge on NBS in general and with specific knowledge on NBS for certain challenges
	Provide standards, knowledge tools, and support for the design, development, implementation, and maintenance of NBS
	Identify and quantify the social and natural uncertainties and risks, and develop management options to address them, to manage expectations
	Develop practitioner knowledge, skills, experience, and expertise
	Build (technical) capacity in executing agencies (at the local level) and enhance the productivity of the employees
	Valorize and exploit the existing tacit and expert knowledge of various stakeholders
	Establish a knowledge platform (stewardship community) with a particular focus on cities that adheres to the principles of knowledge sharing and generative learning
	Increase research on the topics of engagement in NBS projects, the role NBS can play in supporting systems change, when and where NBS can help build synergies between climate adaptation and mitigation, and the specific actions that are required and the specific challenges and opportunities that are present in different places and for different ecosystems and species
	Spread information about climate change and extreme weather events to create urgency for NBS
	Establish ULLs that can provide an appropriate and safe environment for stakeholders to learn by doing

B.4.4 Physical and ecological clusters

Table 11 Physical and ecological barriers in literature

Theme	*Barriers*
Physical and ecological	NBS generally occupy a larger, and mostly privately owned, area than grey solutions
	Urban space is scarce and competed over
	Optimization or modernization of grey solutions tends to be favored over complete alteration, which is problematic if NBS have a poor physical fit with the design of grey solutions
	Lack of adequate suitable locations for NBS due to factors like the slope of the roofs, size of the sites, and type of the soil

Table 12 Physical and ecological drivers in literature

Theme	*Drivers*
Physical and ecological	Climate change and its effects combined with the fact that NBS can promote adaptation to climate change, mitigate climate change, and help build climate resilience
	Decline in biodiversity combined with the fact that NBS can help protect, conserve, and restore biodiversity
	The largest share of the population, which is expected to increase significantly by 2050, lives in urban areas and cities that have high exposure to and are particularly vulnerable for climate hazards and other climate change effects
	NBS can address multiple societal challenges (simultaneously) and can deliver multiple benefits or functions (simultaneously)
	NBS their adaptability to uncertainties and the specific socio-ecological context at hand
	NBS are resource-efficient
	NBS are scalable
	The UHI effect is expected to become a more frequent aspect of city life combined with the fact that NBS can help reduce the urban temperature and mitigate the UHI effect
	NBS bring more nature and natural features and processes into cities, landscapes, and seascapes
	NBS can safeguard and increase water availability and quality
	NBS can create fertile soil for agriculture, increase agricultural productivity, contribute to long-term food security, and replace man-made inputs like pesticides and fertilizers
	NBS can mitigate air pollution and increase air quality
	NBS can reduce coastal erosion
	NBS can help with saving energy and promoting sustainable modes of transport

Table 13 Physical and ecological strategies/measures/principles in literature

Theme	*Strategies/measures/principles*
Physical and ecological	Design NBS in a way that they can fulfil multiple functions
	Implement hybrid NBS
	Redesign the car parking infrastructure
	Use abandoned, degraded, or brownfield spaces

B.4.5 Financial clusters

Table 14 Financial barriers in literature

Theme	*Barriers*
Financial	Long lead times combined with the fact that benefits accrue in the long-term
	Benefits are usually not fully captured at the site at which NBS are implemented

(Perceived) high and uncertain costs of NBS
Lack of available public and private financial resources
Lack of adequate financial incentives
Lack of risk sharing and reduction measures, while NBS are high risk investments, and difficulty in calculating risk-adjusted returns
Lack of (knowledge and practical experience in developing) bankable NBS projects
Lack of appropriate business models for NBS
Hard to monetize benefits except for carbon combined with the fact of immature carbon markets
Weak evidence base on financial returns and benefits
Difficulty in coordinating budgets and investments between public and private stakeholders and across various sectors
Difficulty in obtaining funding from the EU, entrepreneurs, or citizens

Table 15 Financial drivers in literature

Theme	***Drivers***
Financial	NBS are cost-effective and often cheaper than grey solutions
	The uptake of NBS can create many jobs (up to 32 million), ranging from low-skill entry level to high-skill jobs
	NBS align with Environmental, Social, and Governance (ESG) goals and can redefine sustainable investing by offering a compelling blend of environmental stewardship and financial returns, thereby attracting investors
	NBS make the cityscape more appealing, thereby attracting and retaining investors, businesses, and talented workforce
	As the climate crisis evolves, extreme weather events will increasingly place substantial financial burdens on urban services and infrastructure, which can be alleviated by NBS
	NBS can reduce the costs and financial burden of several sectors, thereby decreasing costs to governments and individuals
	NBS can generate financial returns
	NBS can increase the productivity of employees and reduce the amount of sick days of employees
	Both the EU and cities themselves are increasingly willing to fund NBS implementation and maintenance
	NBS can increase foot traffic, thereby increasing the amount of economic activities

Table 16 Financial strategies/measures/principles in literature

Theme	***Strategies/measures/principles***
Financial	De-risk NBS and improve their risk-return profile
	Support and stimulate public and private NBS financing
	Promote divestment from nature-negative assets
	Learn from, leverage, and pilot existing revenue-generation NBS models and test them with value-capture arrangements to enhance the attractiveness of NBS for private investors
	Create a shared ambition between public and private sectors by helping them understand and consider the full range of benefits associated with NBS instead of disregarding the positive externalities beyond the scope of the donor or national budget planning
	Create markets for natural capital, create new revenue streams from natural capital, and integrate these revenue streams into NBS projects
	Create multilateral partnerships and build co-finance agreements between and across relevant beneficiaries, including companies, communities, governments, NGOs, donors, development banks, and climate funds, to pool their resources for NBS and unlock new investments

	Improve biodiversity proofing and tracking of relevant EU and national investment to more accurately and regularly assess progress of funding against intermediate needs and objectives and to be able to take additional action where necessary to stay on course for the 2030 commitments
	Increase the use of European Structural and Investment Funds, blue/green bonds, and impact bonds for NBS
	Stimulate the development of bankable projects for the private sector
	Strengthen the business case for NBS and develop tools that can guide stakeholders on how to build such a business case
	Tailor financing structures to local contexts and increase and target investments to contexts with the most potential for NBS

B.4.6 Political clusters

Table 17 Political barriers in literature

Theme	***Barriers***
Political	Lack of political will and support
	Lack of political long-term commitment and continuity
	Lack of awareness and sense of urgency among policymakers and politicians
	Lack of supportive policy
	Lack of coordination between municipal, regional, and national policies and lack of mainstreaming across associated policy realms, leading to inconsistencies and/or conflicts between them
	Difficulty for policymakers to exploit NBS synergies between policy domains with complementary objectives
	Other issues may crowd out NBS on the agenda
	Few frameworks exist for guiding cross-sectoral policy design and implementation

Table 18 Political drivers in literature

Theme	***Drivers***
Political	The Intergovernmental Panel on Climate Change, the UN, the IUCN, and the EC mentioning NBS as a key strategy for climate change and biodiversity action and encouraging cities to implement them
	The adoption of the UN SDGs combined with the fact that NBS support the SDGs
	NBS contribute to the economic policy objectives of the EU and can help achieve the social and environmental (justice) goals on the European agenda
	Countries increasingly include NBS in their Nationally Determined Contributions and international city initiatives on sustainable urban development are increasingly implemented
	Voters in the European election strongly converged on political manifestos that supported bolder EU action to fight planetary degradation and policymakers are increasingly interested in the use of NBS for this
	NBS have many beneficiaries
	The EU having set its agenda to implement NBS research and innovation projects

Table 19 Political strategies/measures/principles in literature

Theme	***Strategies/measures/principles***
Political	Mobilize and inform politicians and policymakers of the value of NBS (raise awareness)
	Mainstream NBS (goals) into key sector policies and investments of the EU and its Member States
	Downscale and translate implications for NBS from national-level policies to the local level when possible

	Align NBS across policy goals and programs to showcase them as urban strategic priorities
	Normalize value-based approaches in procurement and contracting processes to challenge the market to propose solutions that maximize co-benefits for society and nature
	Base policy interventions for NBS on a context-specific analysis of the conditions that explain the barriers of NBS adoption
	Align long-term national and local policies for NBS

B.4.7 Legal clusters

Table 20 Legal barriers in literature

Theme	***Barriers***
Legal	Lack of supportive institutional, regulatory, and legal frameworks
	Property ownership and use complexities
	Regulatory uncertainty
	Inconsistencies or conflicts between municipal, regional, and national regulations
	Non-binding nature of relevant policies and implementation delays of binding EU Directives

Table 21 Legal drivers in literature

Theme	***Drivers***
Legal	Businesses are increasingly under pressure to address their environmental footprints, stimulating exchanges between NBS projects and the corporate in the form of carbon credits
	The 2030 EU commitments for sustainable development, climate action, and biodiversity combined with the fact that NBS can support the achievement of these commitments

Table 22 Legal strategies/measures/principles in literature

Theme	***Strategies/measures/principles***
Legal	Extend the scope of the EU Environmental Impact Assessment (EIA) Directive and exempt selected NBS from the EIA
	Accelerate implementation of key EU legal commitments delivering on NBS through the nature directives and adopt EU legislation for mandatory ecosystem restoration that builds on and complements these commitments with the legally binding specific, measurable, attainable, relevant, and time-bound (SMART) targets
	Regulate for no net loss of biodiversity
	Include NBS in contractual agreements and regulations
	Integrate NBS into green certification schemes
	Develop NBS strategies as legally binding documents
	Upgrade national and municipal regulations concerning NBS
	Identify approaches to reduce the barriers for NBS in permitting procedures and land ownership and management practices

B.5 Barriers overview

Table 23 Barriers in literature

Theme	***Barrier***	***Sources***
Financial	Benefits accrue in the long-term	(International Union for Conservation of Nature, 2024; United Nations

	Environment Programme Copenhagen Climate Centre, 2025; López Portillo Purata et al., 2022)
Long lead times	(Knight et al., 2022)
Benefits are usually not fully captured at the site at which NBS are implemented	(International Union for Conservation of Nature, 2024; Knight et al., 2022; United Nations Environment Programme Copenhagen Climate Centre, 2025)
(Perceived) high (upfront) costs	(Sarabi et al., 2020; Knight et al., 2022; Leuven, 2025; Dorst et al., 2021)
Lack of available financial resources (both public and private)	(Sarabi et al., 2020; Knight et al., 2022; Dorst et al., 2022; United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2021; Castelo et al., 2023; Kabisch et al., 2016)
Lack of adequate financial incentives	(Sarabi et al., 2020; López Portillo Purata et al., 2022; United Nations Environment Programme Copenhagen Climate Centre, 2024)
Hard to monetize benefits except for carbon	(Knight et al., 2022; United Nations Environment Programme Copenhagen Climate Centre, 2025)
Poor coordination between public budgets and private financers	(Knight et al., 2022)
Weak evidence base on financial returns and benefits	(Knight et al., 2022; López Portillo Purata et al., 2022)
NBS being a high risk investment	(Knight et al., 2022; López Portillo Purata et al., 2022; Triodos Investment Management, 2025)
Weak bankability of existing deals	(Knight et al., 2022; Linnerooth-Bayer & Scolobig, 2023)
High transaction costs for small-scale projects	(United Nations Environment Programme Copenhagen Climate Centre, 2025)
Fragmentation of smaller investments dispersed across various sectors	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
Lack of knowledge and practical experience in developing bankable NBS projects	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
Lack of bankable NBS projects	(Van Eekelen et al., 2021)
Lack of risk sharing measures	(Van Eekelen et al., 2021)
Lack of risk reduction measures	(Van Eekelen et al., 2021)

	Difficulty in calculating risk-adjusted returns	(Van Eekelen et al., 2021)
	Immature carbon markets	(Triodos Investment Management, 2025)
	On-going maintenance costs are a challenge as the costs can be high and are difficult to estimate	(Tran et al., 2024)
	It is hard to coordinate the limited municipal resources	(Tran et al., 2024)
	EU funding is complicated to apply for and requires co-financing, which many cities cannot afford	(Kabisch et al., 2016)
	Entrepreneurs and citizens are less willing to invest in NBS as they view it as the responsibility of the local government	(Sarabi et al., 2020)
	Entrepreneurs and citizens are often not aware and certain about what is in it for them when investing in NBS, thereby preventing them from investing	(Sarabi et al., 2020)
	Lack of appropriate business models for NBS	(Sarabi et al., 2020)
	Uncertainty surrounding costs	(Van Eekelen et al., 2021)
Political	Lack of political will and support as measures with more immediate and tangible outcomes are often preferred over NBS that have more uncertain outcomes that take longer to produce	(Sarabi et al., 2020; Voskamp et al., 2021)
	Lack of political long-term commitment as long-term thinking is not always in the interest of politicians	(Sarabi et al., 2020; Linnerooth-Bayer & Scolobig, 2023; Voskamp et al., 2021)
	Lack of sense of urgency among policymakers and politicians	(Sarabi et al., 2020; Voskamp et al., 2021)
	Lack of awareness among policymakers and politicians	(Kabisch et al., 2016; Voskamp et al., 2021)
	Lack of supportive policy	(Sarabi et al., 2020; Dorst et al., 2022; Linnerooth-Bayer & Scolobig, 2023; López Portillo Purata et al., 2022; Tran et al., 2024)
	Misalignment between short-term plans and long-term goals	(Sarabi et al., 2020; Van Eekelen et al., 2021; Castelo et al., 2023; Kabisch et al., 2016)
	Lack of coordination between municipal, regional, and national policies, leading to inconsistencies or conflicts between them	(United Nations Environment Programme Copenhagen Climate Centre, 2025; Sarabi et al., 2020)
	Difficulty for policymakers to exploit NBS synergies between policy domains with complementary objectives	(United Nations Environment Programme Copenhagen Climate Centre, 2025)
	Lack of mainstreaming across associated policy realms	(Kopsieker et al., 2021)
	Conflicting policy agendas	(Kopsieker et al., 2021)
	Inadequate biodiversity and climate proofing of national and regional plans	(Kopsieker et al., 2021)
	Housing shortages may crowd out urban sustainability issues like NBS on the agenda	(Dorst et al., 2021)
	Policies are typically drafted for existing problems, technologies, and approaches, which means that innovative approaches like NBS often experience a mismatch or require novel policy paradigms to mitigate their development risks	(Dorst et al., 2021)

	Political continuity is lacking due to local government structural changes and periodic elections	(Voskamp et al., 2021)
	Few frameworks exist for guiding cross-sectoral policy design and implementation	(Kopsieker et al., 2021)
Social and cultural	Risk aversion	(Sarabi et al., 2020; Kabisch et al., 2016)
	Resistance to change	(Sarabi et al., 2020)
	Lack of public awareness	(Sarabi et al., 2020; Kabisch et al., 2016)
	Lack of public support	(Sarabi et al., 2020)
	The public does not commonly participate in NBS projects (insufficient community engagement)	(Leuven, 2025; Tran et al., 2024)
	Difficulty in involving citizens	(Dorst et al., 2022)
	Lack of public acceptance	(Leuven, 2025)
	Perception that the benefits of NBS are uncertain and inconsistent	(Leuven, 2025)
	Skepticism surrounding carbon markets	(Triodos Investment Management, 2025)
	The commodification of NBS	(Dorst et al., 2021; Triodos Investment Management, 2025)
	Narrow value frames around economic efficiency of urban development can prevail over or exclude the social and ecological values that NBS provide	(Dorst et al., 2021)
	Lack of perceived (functional and economic) value of NBS by citizens, leading to them not wanting to pay for NBS	(Tran et al., 2024)
	NBS can lead to disruptions in daily routines and to physical annoyances (unwelcome by citizens)	(Tran et al., 2024)
	Fear of the unknown	(Castelo et al., 2023; Kabisch et al., 2016)
	Grassroot organizations perceive NBS to be a distraction from impactful actions and have manifested resistance to NBS with this belief	(Castelo et al., 2023)
	Humans do not always respect and properly attribute value to non-human nature	(Castelo et al., 2023)
	The current paradigm relies heavily on economic growth, consumerism, and cheap energy, making change in system seem unattainable (even in times of population decline, the amount of urban residential areas increased while the amount of urban green space decreased)	(Castelo et al., 2023; Kabisch et al., 2016)
	Western civilization is built on the proposition that humans and nature are separate	(Castelo et al., 2023)
	Perception that green roofs and walls are harmful	(Kabisch et al., 2016)
	Many entrepreneurs and citizens are not ready to accept the economic valuation of NBS	(Sarabi et al., 2020)
	The majority of real estate and land in cities belongs to private owners, who often prioritize financial benefits over sustainability benefits	(Sarabi et al., 2020)
Governance	Silo mentality of traditional planning systems and governance structures (sectoral and administrative: tasks, responsibilities, and budgets)	(Sarabi et al., 2020; Linnerooth-Bayer & Scolobig, 2023; Dorst et al., 2021; Voskamp et al., 2021; Castelo et al., 2023; Kabisch et al., 2016)
	Lack of (municipal) coordination	(Dorst et al., 2022; United Nations Environment Programme Copenhagen

	Climate Centre, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024)
Lack of collaboration	(Dorst et al., 2022)
Lack of private sector involvement	(Dorst et al., 2022)
Stakeholder opposition	(Linnerooth-Bayer & Scolobig, 2023)
Lack of stakeholder awareness	(United Nations Environment Programme Copenhagen Climate Centre, 2025)
Cooperation between multiple sectors is required, which can be complex	(Wetlands International, 2021)
Lack of clear responsibilities in governance mechanisms	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
Lack of (adequate) stakeholder engagement	(United Nations Environment Programme Copenhagen Climate Centre, 2024; Van Eekelen et al., 2021)
Priorities and interests of stakeholders do not align or conflict	(Van Eekelen et al., 2021)
More diverse stakeholder involvement is required than for grey solutions	(Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023; Kabisch et al., 2016)
Collaboration between different areas of the city council is challenging	(Voskamp et al., 2021)
Lack of openness to collaborative governance	(Voskamp et al., 2021)
As many stakeholders from inside and outside the municipal organization are involved in NBS uptake, many opinions and interests (public and private) need to be considered and many local considerations as well as public involvement and perception need to be accounted for	(Voskamp et al., 2021)
The inter- and transdisciplinary collaborations that NBS require mismatches with the business-as-usual way of working within city governments that involves departmental silos, lacks involvement of the broader public, and is based on rigid funding procedures that prioritize cost-effectiveness over social and ecological benefits	(Hölscher et al., 2023)
City officials struggle with mobilizing the necessary institutional support, skill sets, and time	(Hölscher et al., 2023)
Obtaining agreement from multiple public and private landowners, who have different goals and expectations, is difficult and time consuming	(Tran et al., 2024)
Responsibilities for the maintenance of NBS projects sometimes remains unspecified, which poses risks to the continuity of delivering benefits in the long-term	(Kabisch et al., 2016; Sarabi et al., 2020)
The development, decision-making, and implementation processes for NBS are more precarious and time-	(Voskamp et al., 2021)

	consuming as the responsibility for NBS is shared between multiple departments	
	Few frameworks exist for guiding cross-sectoral project design and implementation	(Kopsieker et al., 2021)
	Grey path dependency	(Linnerooth-Bayer & Scolobig, 2023)
	Challenge of identifying and negotiating long-term agreements with multiple landowners	(EPA Network & ENCA Network, 2020)
Informational and technological	Functionality and performance uncertainties	(Sarabi et al., 2020; Van Eekelen et al., 2021; Kabisch et al., 2016)
	Lack of skilled professionals and knowledge brokers (capacity)	(Sarabi et al., 2020; Linnerooth-Bayer & Scolobig, 2023; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Castelo et al., 2023; Kabisch et al., 2016)
	Lack of education and training programs	(Sarabi et al., 2020; Voskamp et al., 2021)
	Lack of knowledge (at the city council level among urban planners)	(Dorst et al., 2022; Linnerooth-Bayer & Scolobig, 2023; Voskamp et al., 2021; Castelo et al., 2023; Kabisch et al., 2016)
	Lack of evidence on efficacy and (co-)benefits	(Linnerooth-Bayer & Scolobig, 2023; Kabisch et al., 2016; Sarabi et al., 2020)
	NBS being a relatively new concept	(López Portillo Purata et al., 2022)
	Disseminating results of implementation is complex	(López Portillo Purata et al., 2022)
	Lack of evidence on effectiveness and efficiency	(Wetlands International, 2021; Van Eekelen et al., 2021; Voskamp et al., 2021; Kabisch et al., 2016; Sarabi et al., 2020)
	Lack of physical and financial data supporting consistent planning, implementation, and monitoring of NBS investments	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
	Limited evidence base	(Van Eekelen et al., 2021; Sarabi et al., 2020)
	Lack of centralized, reliable, and comparable quantitative data on the costs and benefits of NBS, including biodiversity and ES	(Van Eekelen et al., 2021; Kopsieker et al., 2021; Voskamp et al., 2021; Castelo et al., 2023; Sarabi et al., 2020)
	Uncertain nature returns under climate change	(United Nations Environment Programme Copenhagen Climate Centre, 2025; Van Eekelen et al., 2021; Kabisch et al., 2016)
	Complex valuation of benefits	(United Nations Environment Programme

		Copenhagen Climate Centre, 2025; López Portillo Purata et al., 2022)
	NBS tend to be undervalued due to existing value assessment tools not being able to measure all benefits	(Dorst et al., 2021)
	Evidence on performance and costs are difficult to standardize	(Van Eekelen et al., 2021)
	Lack of design standards and guidelines for maintenance and monitoring	(Sarabi et al., 2020)
	Skill gaps in technical and core competencies	(United Nations Environment Programme, 2024; Voskamp et al., 2021)
	Few frameworks exist for acknowledging and assessing the value of co-benefits from NBS	(Kopsieker et al., 2021)
	Challenges in quantifying ES	(Triodos Investment Management, 2025)
	Uncertainty around how NBS can be best planned, designed, implemented, and maintained	(Sarabi et al., 2020; Voskamp et al., 2021)
	It is challenging to change the way people are used to working	(Voskamp et al., 2021)
	There is no clear overview of the costs and benefits of NBS compared to the costs of damage in case of no climate action	(Voskamp et al., 2021)
	The cause-and-effect mechanisms underlying the costs and benefits of NBS are not well understood, making them difficult to quantify and communicate	(Tran et al., 2024)
	Workforce training is difficult	(Tran et al., 2024)
	Lack of monetary outcomes of implementing NBS	(Castelo et al., 2023)
	Existing NBS valuation tools are not used in decision-making processes when deciding between grey and green solutions	(Castelo et al., 2023)
	Lack of data on long-term benefits of NBS	(Kabisch et al., 2016)
	Lack of long-term research projects that focus on the maintenance and monitoring of NBS	(Kabisch et al., 2016)
	There are few studies of the benefits and costs of NBS in different climate conditions	(Sarabi et al., 2020)
	Grey solutions are easier to calculate and quantify	(Castelo et al., 2023)
	Scientifically validated options and knowledge on NBS are often not available when policy windows are receptive to new NBS projects	(Kabisch et al., 2016)
Legal	Lack of supportive institutional, regulatory, and legal frameworks	(Sarabi et al., 2020; Linnerooth-Bayer & Scolobig, 2023; United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2021; Tran et al., 2024)
	Property ownership complexities	(Sarabi et al., 2020; Knight et al., 2022)
	NBS often cross jurisdictional boundaries (land ownership challenges)	(Van Eekelen et al., 2021)
	The existence of strict rules on how you can use and change land	(Leuven, 2025)
	Implementation delays of EU Directives	(Kopsieker et al., 2021)
	Non-binding nature of several relevant policies	(Kopsieker et al., 2021)

	Regulations are typically drafted for existing problems, technologies, and approaches, which means that innovative approaches like NBS often experience a mismatch or require novel legal paradigms to mitigate their development risks	(Dorst et al., 2021)
	The influence of cities on whether and where NBS can be implemented on privately owned land is limited	(Voskamp et al., 2021)
	Regulatory uncertainty	(Triodos Investment Management, 2025)
	Inconsistencies or conflicts between municipal, regional, and national regulations	(Sarabi et al., 2020)
Physical and ecological	NBS generally occupy a larger, and mostly privately owned, area than grey solutions (space constraints)	(Van Eekelen et al., 2021; Leuven, 2025; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2021; Castelo et al., 2023)
	Competition over urban space (scarcity)	(Dorst et al., 2022; Leuven, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023)
	Challenge of purchasing land	(EPA Network & ENCA Network, 2020)
	Optimization or modernization of grey solutions tends to be favored over complete alteration, which is problematic if NBS have a poor physical fit with the design of grey solutions	(Dorst et al., 2021)
	Other uses of urban land, such as development projects, have a competing advantage for valuable urban land as they tend to have more vested interests behind them	(Castelo et al., 2023)
	Lack of adequate suitable locations for NBS due to factors like the slope of the roofs, size of the sites, and type of the soil	(Castelo et al., 2023; Sarabi et al., 2020)

B.6 Drivers overview

Table 24 Drivers in literature

Theme	***Driver***	***Sources***
Financial	NBS are cost-effective	(European Commission, n.d.-c; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Hölscher et al., 2023; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)
	NBS make areas more attractive to new investors and businesses	(Kopsieker et al., 2021; United Nations Environment

	Programme Copenhagen Climate Centre, 2024)
The uptake of NBS can create many jobs (up to 32 million), ranging from low-skill entry level to high-skill jobs	(United Nations Environment Programme, 2024; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can reduce the financial burden on health services (air pollution and mental health), thereby decreasing costs to governments and individuals	(Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS are often cheaper than grey solutions	(Kopsieker et al., 2021; Sarabi et al., 2020)
NBS can increase the efficiency and circularity of water systems, thereby bringing down water production costs	(Kopsieker et al., 2021)
NBS can generate income (financial returns)	(Triodos Investment Management, 2025)
NBS can redefine sustainable investing, offering a compelling blend of environmental stewardship and financial returns	(Triodos Investment Management, 2025)
NBS their alignment with Environmental, Social, and Governance (ESG) goals helps with attracting investors	(Triodos Investment Management, 2025)
As the climate crisis evolves, extreme weather events will increasingly place substantial financial burdens on urban services and infrastructure, which can be alleviated by NBS	(United Nations Environment Programme Copenhagen Climate Centre, 2025)
The until soon non-monetary outcomes of NBS are increasingly being monetized, making it easier to calculate the benefits of employing NBS	(Castelo et al., 2023)
NBS can increase property value	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can generate tax revenues	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can reduce infrastructure costs	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can increase the sales of carbon, water, and biodiversity credits	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can decrease heating and cooling expenses of buildings	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can reduce the damage costs from extreme weather events	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can increase foot traffic, thereby increasing the amount of economic activities	(United Nations Environment Programme

		Copenhagen Climate Centre, 2024)
	NBS can increase the productivity of employees	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
	NBS can reduce the amount of sick days of employees	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
	NBS make the cityscape more appealing, which can lead to long-term workforce retention and higher talent attraction	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
	The EU is funding some NBS projects	(Voskamp et al., 2021; Tran et al., 2024)
	Cities are increasingly willing to pay for NBS implementation and maintenance	(Tran et al., 2024)
	NBS have lower maintenance costs than technological substitutes	(Castelo et al., 2023)
Political	NBS can help achieve social and environmental (justice) goals on the European agenda	(Kopsieker et al., 2021; Tran et al., 2024)
	NBS contribute to the economic policy objectives of the EU	(Kopsieker et al., 2021)
	Voters in the European election strongly converged on political manifestos that supported bolder EU action to fight planetary degradation	(Kopsieker et al., 2021)
	The Intergovernmental Panel on Climate Change identified NBS as one of the most promising strategies to mitigate climate change while delivering co-benefits for ecosystems and communities	(Triodos Investment Management, 2025)
	NBS have many beneficiaries	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
	The adoption of the UN SDGs	(Voskamp et al., 2021)
	NBS support the SDGs	(Tran et al., 2024)
	The implementation of various international city initiatives on sustainable urban development	(Voskamp et al., 2021)
	The EU having set its agenda to implement NBS research and innovation projects	(Voskamp et al., 2021)
	Policymakers are increasingly interested in NBS as functional and desirable infrastructure, to which NBS contribute, is the basis for civil society	(Tran et al., 2024)
	The UN selecting NBS as one of the nine key action tracks at the 2019 UN Climate Action Summit	(Castelo et al., 2023)
	Countries increasingly include NBS in their Nationally Determined Contributions	(Castelo et al., 2023)
	The IUCN and EC highly encourage cities to implement NBS	(Sarabi et al., 2020)
Social and cultural	NBS can create employment opportunities for vulnerable populations, people in marginal and economically disadvantaged regions, and people in regions which are particularly vulnerable to climate change	(United Nations Environment Programme, 2024; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024)

Approximately 3.3 to 3.6 billion people are highly vulnerable to climate change	(United Nations Environment Programme Copenhagen Climate Centre, 2025)
NBS make areas more attractive to residents and visitors, which has a positive effect on health from the point of scenery	(Kopsieker et al., 2021; Castelo et al., 2023)
NBS can help reduce health inequalities by ensuring a fair distribution of health benefits from green spaces	(Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can encourage citizens to be more physically active, which can reduce obesity, improve mental health, lower the risk of chronic diseases, and increase exposure to microorganisms that strengthen the immune system	(Kopsieker et al., 2021; Castelo et al., 2023)
NBS can improve mental health by reducing anxiety, loneliness, and depression	(Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)
NBS can reduce negative mental health outcomes, such as psychosis, neurosis, dementia, and childhood behavioral disorders	(Kopsieker et al., 2021)
NBS can reduce stress levels, thereby reducing stress-linked conditions	(Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023)
NBS can help distribute new funds to communities living in endangered ecosystems	(Triodos Investment Management, 2025)
NBS can increase the self-perceived physical and mental health of citizens	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can increase the quality of life of citizens	(United Nations Environment Programme Copenhagen Climate Centre, 2024; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016)
NBS can increase the life expectancy of citizens	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can increase the physical health of citizens	(United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)
NBS can enhance social cohesion and provide a sense of belonging	(United Nations Environment Programme Copenhagen Climate Centre, 2024; Tran et al., 2024; Castelo et al., 2023;

		Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019)
	NBS can decrease crime rates	(United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023)
	NBS can help with preserving cultural and natural heritages	(United Nations Environment Programme Copenhagen Climate Centre, 2024; Kabisch et al., 2016)
	The public is increasingly interested in NBS	(Dorst et al., 2021; Voskamp et al., 2021; Castelo et al., 2023)
	Sustainability principles and values have been gaining traction in urban development discourses and can translate into norms for action, thereby creating momentum for the adoption of NBS	(Dorst et al., 2021; Castelo et al., 2023)
	NBS can address the social crises of inequality and public health	(Castelo et al., 2023)
	NBS can promote equality	(Castelo et al., 2023)
	NBS can improve concentration	(Castelo et al., 2023)
	NBS can improve the perceived thermal comfort, beyond the actual temperature reduction	(Castelo et al., 2023)
	NBS can protect livelihoods, thereby addressing poverty alleviation	(Castelo et al., 2023)
	NBS support systems change, seen as transformation of the status quo by altering underlying structures and their supporting mechanisms, which is required to address climate change and biodiversity loss	(Castelo et al., 2023)
	NBS can reduce the vulnerability of local communities and Indigenous people and empower them, beyond income generation, if they actively participate in NBS implementation	(Castelo et al., 2023)
	Most Indigenous people view themselves and nature as a whole (part of the same ecological family) and consider human survival to be dependent on nature	(Castelo et al., 2023)
	NBS can connect people to nature	(Sarabi et al., 2020; Frantzeskaki, 2019)
	NBS can create new green urban commons	(Frantzeskaki, 2019)
	NBS can help citizens with reclaiming public space and self-governance	(Frantzeskaki, 2019)
	NBS can help with fostering acceptance and appreciation of diverse cultures	(Frantzeskaki, 2019)
	Investing in NBS offers reputational benefits for corporations	(Triodos Investment Management, 2025)
	The discourse surrounding NBS reflects economic growth ideologies	(Dorst et al., 2021)
Governance	Working on NBS is an opportunity for better collaboration between sectors and disciplines	(Wetlands International, 2021)
	Planning for NBS increasingly recognizes that it is necessary to include a diversity of knowledges	(Dorst et al., 2021)
	Urban development stakeholders are organized in networks around urban climate adaptation transitions, which enables mutual understanding and trust among the	(Dorst et al., 2021)

	stakeholders as well as determines the identities and roles of the stakeholders	
	Bringing together stakeholders for the development of policies and projects for NBS can be a form of intelligent institutional leadership, which can foster resilience and inclusive urban development	(Frantzeskaki, 2019)
	Cities are increasingly willing to engage in public-private partnerships (PPPs) for NBS projects	(Tran et al., 2024)
Informational and technological	Advancements in technology, such as satellite monitoring and AI, make it easier to measure ES, which in turn will make NBS more scalable and cost-efficient	(Triodos Investment Management, 2025)
	The benefits and cost-effectiveness of NBS are increasingly demonstrated in practice	(Voskamp et al., 2021)
	A large variety of tools has been developed to support the adoption of NBS in cities	(Voskamp et al., 2021)
	The potential of NBS has been increasingly emphasized in scientific assessments and reports	(Castelo et al., 2023)
	New types of assessment and monitoring methods for NBS are being tested	(Castelo et al., 2023)
	Over 60 million people work globally in activities categorized as NBS	(United Nations Environment Programme, 2024)
Legal	Businesses are increasingly under pressure to address their environmental footprints, stimulating exchanges between NBS projects and the corporate in the form of carbon credits	(Triodos Investment Management, 2025)
	NBS can support the achievement of EU's climate and biodiversity objectives, which are legally binding	(Kopsieker et al., 2021)
	The 2030 EU commitments for sustainable development, climate action, and biodiversity	(Kopsieker et al., 2021)
Physical and ecological	Climate change and its effects	(Kopsieker et al., 2021; Triodos Investment Management, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019)
	Decline in biodiversity	(Wetlands International, 2021; Kopsieker et al., 2021; Triodos Investment Management, 2025; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)
	NBS can deliver multiple functions or benefits (simultaneously)	(Wetlands International, 2021; European Commission, n.d.-c; Triodos Investment Management, 2025; United Nations Environment Programme Copenhagen Climate

	Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Hölscher et al., 2023; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019)
NBS can address multiple societal challenges (simultaneously)	(Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2021; Hölscher et al., 2023; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019)
NBS bring more nature and natural features and processes into cities, landscapes, and seascapes	(European Commission, n.d.-c; Voskamp et al., 2021; Hölscher et al., 2023)
NBS promote adaptation to climate change	(Wetlands International, 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)
NBS can aid in mitigating climate change	(United Nations Environment Programme, 2024; Kopsieker et al., 2021; Triodos Investment Management, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)
NBS can reduce the risk (probability and impact) of disasters	(Wetlands International, 2021; Kopsieker et al., 2021; Triodos Investment Management, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; Tran et al., 2024; Castelo et al.,

	2023; Kabisch et al., 2016; Sarabi et al., 2020)
NBS can help protect, conserve, and restore biodiversity	(United Nations Environment Programme, 2024; European Commission, n.d.-c; Kopsieker et al., 2021; Triodos Investment Management, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016)
NBS can help combat land degradation	(United Nations Environment Programme, 2024)
NBS their flexibility in adapting to uncertainties (more flexible than grey solutions)	(Wetlands International, 2021; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS their adaptability to the specific socio-ecological context at hand	(European Commission, n.d.-c; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Voskamp et al., 2021)
NBS are resource-efficient	(European Commission, n.d.-c; Voskamp et al., 2021)
NBS can help build climate resilience	(European Commission, n.d.-c; Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Hölscher et al., 2023; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Frantzeskaki, 2019)
NBS can make cities more habitable in the face of future climate change	(Kopsieker et al., 2021; Frantzeskaki, 2019)
NBS can help reduce urban temperature and mitigate the UHI effect	(Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Kabisch et al., 2016; Sarabi et al., 2020)
NBS are scalable	(United Nations Environment Programme, 2024; United Nations Environment Programme

	Copenhagen Climate Centre, 2024)
NBS can increase water availability	(Kopsieker et al., 2021)
NBS can safeguard and increase water quality	(Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023; Sarabi et al., 2020)
NBS can contribute to long-term food security	(Kopsieker et al., 2021; Castelo et al., 2023; Kabisch et al., 2016)
NBS in agriculture can increase productivity	(Kopsieker et al., 2021; Castelo et al., 2023)
NBS can replace man-made inputs like pesticides and fertilizers	(Kopsieker et al., 2021; Castelo et al., 2023)
NBS can mitigate air pollution (increase air quality), thereby lowering people their exposure to harmful chemicals and preventing respiratory and cardiovascular diseases	(Kopsieker et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)
NBS can reduce coastal erosion	(Triodos Investment Management, 2025)
NBS can create fertile soil for agriculture (increase soil quality)	(Triodos Investment Management, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; Castelo et al., 2023)
Many of the world's growing cities are coastal and the climate crisis will particularly affect urban communities living in low-lying coastal zones	(United Nations Environment Programme Copenhagen Climate Centre, 2025)
The UHI effect is expected to become a more frequent aspect of city life	(United Nations Environment Programme Copenhagen Climate Centre, 2025; Castelo et al., 2023)
NBS can promote sustainable modes of transport like cycling and walking	(United Nations Environment Programme Copenhagen Climate Centre, 2024)
NBS can help buildings with saving energy	(United Nations Environment Programme Copenhagen Climate Centre, 2024; Kabisch et al., 2016)
The largest share of the population lives in urban areas and many cities are located in areas that have a high exposure to climate hazards	(Voskamp et al., 2021; Castelo et al., 2023; Sarabi et al., 2020)
With the built-environment magnifying climate change effects, these effects are expected to be experienced mostly by urban populations	(Voskamp et al., 2021; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)

	The world's population share that is living in urban areas is expected to increase significantly by 2050, which will cause negative environmental impacts	(Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)

B.7 Strategies/measures/principles overview

Table 25 Strategies/measures/principles in literature

Theme	***Strategy***	***Sources***
Financial	De-risk NBS (with public instruments or by stimulating institutional investment)	(Linnerooth-Bayer & Scolobig, 2023; Wetlands International, 2021; Van Eekelen et al., 2021; Directorate-General for Environment, 2022; Sarabi et al., 2020)
	Support and stimulate public and private NBS financing	(Linnerooth-Bayer & Scolobig, 2023; Triodos Investment Management, 2025; Kabisch et al., 2016)
	Promote divestment from nature-negative assets	(Linnerooth-Bayer & Scolobig, 2023; Kabisch et al., 2016)
	Learn from, leverage, and pilot existing revenue-generation NBS models and test them with value-capture arrangements to enhance the attractiveness of NBS for private investors	(United Nations Environment Programme Copenhagen Climate Centre, 2025)
	Employ innovative financial instruments that strategically use public funds to improve the risk-return profiles of NBS	(United Nations Environment Programme Copenhagen Climate Centre, 2025)
	Create a shared ambition between public and private sectors by helping them understand and consider the full range of benefits associated with NBS instead of disregarding the positive externalities beyond the scope of the donor or national budget planning	(Wetlands International, 2021)
	Build co-finance arrangements that can serve as places where relevant beneficiaries pool their resources for a common cause	(Wetlands International, 2021; Directorate-General for Environment, 2022)
	Employ co-financing by donors, multilateral development banks, climate funds, and governments	(Wetlands International, 2021)
	Create new revenue streams from natural capital	(Wetlands International, 2021; Van Eekelen et al., 2021)
	Stimulate coupling of public budgets in multi-purpose projects	(Van Eekelen et al., 2021)
	Establish a dedicated public fund that can be used to support the NBS project development phase and to leverage any additional costs or risks of NBS investments	(Van Eekelen et al., 2021)
	Stimulate the development of bankable projects for the private sector	(Van Eekelen et al., 2021)
	Create markets for natural capital	(Van Eekelen et al., 2021)
	Combine revenue streams in integrated projects	(Van Eekelen et al., 2021)
	Use blue/green bonds or impact bonds	(Van Eekelen et al., 2021)
	Apply innovative procurement or other risk sharing models	(Van Eekelen et al., 2021)

	Create multilateral partnerships between companies, communities, governments, NGOs, finance institutions, and insurance companies	(Van Eekelen et al., 2021; Leuven, 2025)
	Increase the credit profile of NBS projects and/or their sponsor	(Van Eekelen et al., 2021)
	Provide guarantees to cover NBS project risks or emerging country (political) risks	(Van Eekelen et al., 2021)
	Engage the insurance sector to tap into their risk reduction needs and damage cost expertise	(Directorate-General for Environment, 2022)
	Provide subsidies for specific NBS	(Directorate-General for Environment, 2022)
	Increase and target investments to countries with the most potential for NBS	(United Nations Environment Programme, 2024)
	Improve biodiversity proofing and tracking of relevant EU and national investment to more accurately and regularly assess progress of funding against intermediate needs and objectives and to be able to take additional action where necessary to stay on course for the 2030 commitments	(Kopsieker et al., 2021)
	Use public investments as leverage for more and better private investment in NBS	(Kopsieker et al., 2021)
	Increase the prioritization of the use of European Structural and Investment Funds towards biodiversity objectives	(Kopsieker et al., 2021)
	Tailor financing structures to local contexts	(Triodos Investment Management, 2025)
	Develop tools that can guide stakeholders on how to build the business case for NBS and obtain financing	(Voskamp et al., 2021)
	Fund and support local entrepreneurs	(Tran et al., 2024)
	Strengthen the business case for NBS to realize successful PPPs	(Sarabi et al., 2020)
	Establish partnerships between private sector stakeholders and NBS initiatives by linking project-based carbon credit generation to corporate net-zero goals, thereby unlocking private investment for NBS	(Triodos Investment Management, 2025)
Political	Mobilize and inform politicians and policymakers of the value of NBS (raise awareness)	(EPA Network & ENCA Network, 2020; Dorst et al., 2021; Tran et al., 2024; Kabisch et al., 2016; Sarabi et al., 2020)
	Mainstream NBS into key sector policies	(United Nations Environment Programme Copenhagen Climate Centre, 2025; Castelo et al., 2023)
	Downscale and translate implications for NBS from national-level policies to the local level when possible	(United Nations Environment Programme Copenhagen Climate Centre, 2025)
	Set policy goals on NBS inclusion in infrastructure projects	(Van Eekelen et al., 2021; Tran et al., 2024)
	Normalize value-based approaches in procurement and contracting processes to challenge the market to propose solutions that maximize co-benefits for society and nature	(Wetlands International, 2021)
	Align NBS across policy goals and programs	(Hölscher et al., 2023)

	Align NBS with and showcase NBS as urban strategic priorities	(Directorate-General for Environment, 2022; Hölscher et al., 2023)
	Integrate biodiversity commitments into EU climate policy, investment, and its implementation in Member States	(Kopsieker et al., 2021)
	Base policy interventions for NBS on a context-specific analysis of the conditions that explain the barriers of NBS adoption	(Dorst et al., 2021)
	Align long-term national and local policies for NBS	(Sarabi et al., 2020)
Social and cultural	Switch the burden of proof from NBS to grey solutions	(Linnerooth-Bayer & Scolobig, 2023)
	Mobilize and inform communities of the value of NBS (raise awareness)	(EPA Network & ENCA Network, 2020; Leuven, 2025; Dorst et al., 2021; Tran et al., 2024; Kabisch et al., 2016; Sarabi et al., 2020)
	Implement just transition measures to ensure broad support of NBS	(United Nations Environment Programme, 2024; Kabisch et al., 2016)
	Consider social cohesion when implementing NBS	(Kabisch et al., 2016)
	Promote worker rights and inclusiveness in NBS jobs	(United Nations Environment Programme, 2024)
	Ensure community ownership	(Triodos Investment Management, 2025; Tran et al., 2024; Frantzeskaki, 2019)
	Ensure continuous communication with and engagement of local communities	(Hölscher et al., 2023; Tran et al., 2024; Frantzeskaki, 2019)
	Strengthen empowerment and self-management of local communities	(Hölscher et al., 2023; Tran et al., 2024; Frantzeskaki, 2019)
	Involve and consult the public more during the process of policy development and implementation and allow them to take the lead	(Tran et al., 2024; Castelo et al., 2023; Sarabi et al., 2020; Frantzeskaki, 2019)
	Bridge the expectation gap between citizens and engineers	(Tran et al., 2024)
	Expand NBS to communities with lower socioeconomic levels	(Tran et al., 2024)
	Ensure the involvement of local vulnerable, low-income communities in implementing NBS in the short- and long-run	(Castelo et al., 2023)
	Ensure that Indigenous communities play an active role in the implementation of NBS as they have crucial knowledge of the local natural environment	(Castelo et al., 2023)
	Educate communities on how they can be involved in NBS projects	(Castelo et al., 2023)
	Change humankind's relationship with nature as the human-centric view of the world can create dangerous beliefs	(Castelo et al., 2023)
	Shift the world from an endless growth to a degrowth model	(Castelo et al., 2023)
	Design NBS in an aesthetically appealing way to ensure citizens appreciate and protect them	(Frantzeskaki, 2019)

	Encourage citizens and social entrepreneurs to be open to collaborate with local governments on NBS	(Frantzeskaki, 2019)
	Connect with diverse urban communities	(Hölscher et al., 2023)
Governance	Enable greater inter-disciplinary and cross-sectoral working on NBS	(EPA Network & ENCA Network, 2020; Van Eekelen et al., 2021; Directorate-General for Environment, 2022; Triodos Investment Management, 2025; Dorst et al., 2021; Voskamp et al., 2021; Hölscher et al., 2023; Tran et al., 2024; Castelo et al., 2023; Frantzeskaki, 2019)
	Increase the awareness and acceptance of the role of NBS in delivering the organizational objectives	(EPA Network & ENCA Network, 2020; Van Eekelen et al., 2021)
	Mobilize and inform stakeholders of the value of NBS (raise awareness)	(EPA Network & ENCA Network, 2020; Dorst et al., 2021; Tran et al., 2024; Kabisch et al., 2016; Sarabi et al., 2020)
	Engage in NBS knowledge and experience exchanges to ensure knowledge transfer and peer-to-peer learning on NBS	(United Nations Environment Programme Copenhagen Climate Centre, 2025; Kopsieker et al., 2021; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020)
	Develop partnership models for combining the required expertise for implementing NBS	(Van Eekelen et al., 2021; Triodos Investment Management, 2025, Tran et al., 2024; Frantzeskaki, 2019)
	Create more pro-active, integrated stakeholder engagement	(Kopsieker et al., 2021)
	Share experiences from implementing NBS in practice among stakeholders	(Voskamp et al., 2021; Kabisch et al., 2016)
	Extend the time for decision-making for NBS	(Voskamp et al., 2021)
	Develop tools for engagement, involvement, and co-creation to stimulate collaboration between departments instead of working in silos	(Voskamp et al., 2021; Tran et al., 2024)
	Ensure that the outputs of governance tools are accessible for everyone	(Voskamp et al., 2021)
	Involve stakeholders in a participatory process to increase discussion	(Voskamp et al., 2021; Tran et al., 2024; Castelo et al., 2023)
	Integrate knowledge and skills in organizational structures to bridge across departmental silos	(Hölscher et al., 2023)
	Formalize collaborative governance models	(Hölscher et al., 2023)
	Support collaborative (learning) processes	(Hölscher et al., 2023; Tran et al., 2024)
	Establish informal platforms and spaces for engagement to learn from other experiences with NBS	(Hölscher et al., 2023; Sarabi et al., 2020)
	Embed reflexive learning in collaborative decision-making	(Hölscher et al., 2023)
	Develop strong PPPs (transnational, regional, and local)	(Tran et al., 2024; Sarabi et al., 2020)

Increase the amount of private involvement in NBS	(Tran et al., 2024)
Engage in and further extend collaborative networks and communities that have been created by demonstration projects on NBS	(Kabisch et al., 2016)
Empower NBS ambassadors that promote NBS as well as engage in a science-community advocacy by communicating the benefits and risks of NBS to citizens and politicians	(Kabisch et al., 2016)
Establish and utilize collaborative governance approaches between policy officers, citizens, businesses, and civil society by connecting demands for action with stakeholders or partnerships responsible for action	(Kabisch et al., 2016)
Ensure good governance practices of legitimacy, transparency, and openness	(Kabisch et al., 2016)
Use partnerships to shift from risk aversion towards NBS to risk sharing of NBS projects	(Kabisch et al., 2016)
Municipalities should adopt an action-thinking approach by declaring NBS action as a duty task for municipalities	(Kabisch et al., 2016)
Remove administrative barriers and provide incentives to allow partnerships between city governments, businesses, and citizen organizations to emerge	(Kabisch et al., 2016)
Develop mutual trust between stakeholders	(Sarabi et al., 2020)
Ensure that stakeholders are committed to utilizing NBS platforms and encourage them to contribute to the platforms	(Sarabi et al., 2020)
Co-create and co-design with designers, artists, architects, and citizens to ensure NBS projects are appealing and socially acceptable designs	(Frantzeskaki, 2019)
Build trust between the city and citizens by starting relations based on clarity, openness (to opinions, beliefs, aspirations, and frustrations over the wrongs of preceding processes), and transparency	(Frantzeskaki, 2019)
View citizens as equals, in terms of knowledge and idea contributions, to experts, scientists, and consultants	(Frantzeskaki, 2019)
Urban planners should be willing to learn and collaborate across departments and with citizens, beyond regulative and consultative approaches	(Frantzeskaki, 2019)
Municipalities should consider partnerships with social innovators and other social actors to facilitate co-creation processes together	(Frantzeskaki, 2019)
Participate in city-to-city networks and use them as opportunity spaces for learning from peers and for learning by doing	(Frantzeskaki, 2019)
Urban planners can link the multiple benefits of NBS to different urban agendas to create a cross-departmental narrative of integration	(Frantzeskaki, 2019)
Ensure continuous collaborative efforts between municipal staff, citizens, NGOs, and knowledge institutes	(Frantzeskaki, 2019)
Urban planners, together with citizens and local NGOs, need to formulate planning guidelines for shaping the collaborative governance of NBS	(Frantzeskaki, 2019)
Prevent participation fatigue by not constantly involving the same citizens and innovators over and over	(Frantzeskaki, 2019)
Establish different fora for co-creating NBS	(Frantzeskaki, 2019)
Establish cross-organizational structures to overcome the fragmentation of institutional arrangements related to NBS	(United Nations Environment Programme

		Copenhagen Climate Centre, 2025)
Informational and technological	Execute larger-scale case studies to demonstrate that NBS work at scale	(EPA Network & ENCA Network, 2020)
	Demonstrate the long-term viability of the NBS approach	(EPA Network & ENCA Network, 2020)
	Employ a holistic approach to the identification and valuation of benefits and drawbacks of NBS	(EPA Network & ENCA Network, 2020; Van Eekelen et al., 2021)
	Improve the understanding and appreciation of risks and benefits to manage expectations	(EPA Network & ENCA Network, 2020)
	Build a solid evidence base for NBS	(EPA Network & ENCA Network, 2020; Wetlands International, 2021; Van Eekelen et al., 2021; United Nations Environment Programme Copenhagen Climate Centre, 2025; United Nations Environment Programme, 2024; Kabisch et al., 2016)
	Research and demonstrate the (technical) feasibility of NBS	(Van Eekelen et al., 2021; Kabisch et al., 2016)
	Identify social and natural uncertainties and management options to address them	(Van Eekelen et al., 2021)
	Demonstrate the cost-effectiveness of NBS	(Van Eekelen et al., 2021)
	Quantify uncertainty and risk and develop management perspectives	(Van Eekelen et al., 2021)
	Apply strong monitoring networks of NBS to support (cost)effectiveness analysis across cases	(Van Eekelen et al., 2021)
	Provide standards for implementation and maintenance	(Van Eekelen et al., 2021; Triodos Investment Management, 2025)
	Improve data and monitoring to prove the effectiveness of NBS	(Directorate-General for Environment, 2022; United Nations Environment Programme, 2024)
	Execute demonstration projects to showcase the workings of NBS and increase awareness and willingness to pay	(Directorate-General for Environment, 2022; Tran et al., 2024; Castelo et al., 2023)
	Global institutions need to provide knowledge tools and support for the design and development of NBS	(Castelo et al., 2023)
	Develop practitioner expertise	(Directorate-General for Environment, 2022; Tran et al., 2024)
	Invest in skills development	(United Nations Environment Programme, 2024; Tran et al., 2024)
	Build (technical) capacity in executing agencies (at the local level)	(Van Eekelen et al., 2021; Kopsieker et al., 2021; Castelo et al., 2023)
	Educate infrastructure professionals	(Tran et al., 2024)
	Enhance worker productivity	(United Nations Environment Programme, 2024)
	Increase research and development on engagement	(Tran et al., 2024)

	Develop tools that can provide insight into the costs and benefits of NBS, including the expression of benefits as biodiversity and aesthetics in monetary value	(Voskamp et al., 2021)
	Develop a catalog of applicable and customizable NBS to provide cities with more knowledge on NBS in general and with specific knowledge on NBS for certain challenges	(Voskamp et al., 2021)
	Develop tools that can provide concrete output on the effectiveness of NBS (in terms of ES)	(Voskamp et al., 2021; Kabisch et al., 2016)
	Generate systems' knowledge about localized NBS	(Hölscher et al., 2023)
	Develop strategies and partnerships to collect, maintain, and share data	(Hölscher et al., 2023)
	Establish platforms for continuous learning	(Hölscher et al., 2023)
	Spread information about climate change and extreme weather events to create urgency for NBS	(Tran et al., 2024)
	Research the role NBS can play in supporting systems change	(Castelo et al., 2023)
	Research when and where NBS can help build synergies between climate adaptation and mitigation	(Castelo et al., 2023)
	Base the design of NBS projects on evidence of the (co-)benefits of the NBS being adopted	(Castelo et al., 2023)
	Research the specific actions that are required and the specific challenges and opportunities that are present in different places and for different ecosystems and species	(Kabisch et al., 2016)
	Develop indicators to assess and demonstrate the usefulness and effectiveness of NBS, which can also help with systematically evaluating NBS projects, thereby increasing comparability and measurability	(Kabisch et al., 2016)
	Valorize and exploit the existing tacit and expert knowledge of various stakeholders	(Kabisch et al., 2016)
	Establish a knowledge platform (stewardship community) with a particular focus on cities that adheres to the principles of knowledge sharing and generative learning	(Kabisch et al., 2016)
	Provide opportunities for stakeholders to enhance their experience and knowledge with NBS	(Sarabi et al., 2020)
	Establish ULLs that can provide an appropriate and safe environment for stakeholders to learn by doing	(Sarabi et al., 2020)
	Design NBS in a way and scale so that lessons for their effectiveness can be collected and easily replicated in other locations	(Frantzeskaki, 2019)
	Advance valuation models to estimate the cost of NBS projects	(Directorate-General for Environment, 2022)
Legal	Extend the scope of the EU Environmental Impact Assessment (EIA) Directive	(Linnerooth-Bayer & Scolobig, 2023)
	Exempt selected NBS from the EIA	(Linnerooth-Bayer & Scolobig, 2023)
	Reduce barriers for NBS in permitting procedures	(Van Eekelen et al., 2021)
	Regulate for no net loss of biodiversity	(Directorate-General for Environment, 2022)
	Include NBS for biodiversity in contractual agreements	(Directorate-General for Environment, 2022)
	Integrate NBS into green certification schemes	(Directorate-General for Environment, 2022)
	Accelerate implementation of key EU legal commitments delivering on NBS through the nature directives	(Kopsieker et al., 2021)
	Adopt EU legislation for mandatory ecosystem restoration that builds on and complements the above-mentioned commitments with the legally binding specific,	(Kopsieker et al., 2021)

	measurable, attainable, relevant, and time-bound (SMART) targets	
	Develop NBS strategies as legally binding documents	(Hölscher et al., 2023)
	Implement a regulation that states that new infrastructure projects must contain green areas	(Tran et al., 2024)
	Provide a legally binding public mandate for NBS	(Directorate-General for Environment, 2022)
	Upgrade national and municipal regulations concerning NBS	(Sarabi et al., 2020)
	Identify approaches to reduce the barriers of land ownership and management	(EPA Network & ENCA Network, 2020)
Physical and ecological	Design NBS in a way that they can fulfil multiple functions	(Wetlands International, 2021; European Commission, n.d.-c; Triodos Investment Management, 2025; United Nations Environment Programme Copenhagen Climate Centre, 2024; United Nations Environment Programme Copenhagen Climate Centre, 2025; Voskamp et al., 2021; Hölscher et al., 2023; Tran et al., 2024; Castelo et al., 2023; Kabisch et al., 2016; Sarabi et al., 2020; Frantzeskaki, 2019; Kopsieker et al., 2021)
	Implement green roofs and vertical greenery systems	(Hachoumi et al., 2021; World Bank, 2021)
	Redesign the car parking infrastructure	(Croeser et al., 2022)
	Integrate NBS into urban car parks	(Evans & Hardman, 2023)
	Repurpose leftover infrastructure	(Evans & Hardman, 2023)
	Use abandoned, degraded, or brownfield spaces	(Zarei & Shahab, 2025; Mastervich et al., 2024)

Appendix C Interviews

C.1 Interview protocols

C.1.1 Interview protocol academics

Introduction [5’]

(a) Brief personal introductions

(b) Short overview of the research objectives and purpose of the interview

Experience with NBS [5’]

(a) Can you describe the focus of your research endeavors on NBS? Have you also been involved in the planning and implementation phases of NBS projects?

(b) Could you give one or two recent examples (in the last 5 years) of NBS (research) projects you’ve been involved in?

(c) How would you define NBS in your own words?

(d) What types of NBS are you most familiar with?

Barriers and drivers of NBS implementation and strategies and measures to address them [40’]

For each of the following themes — social and cultural, governance, informational and technological, physical and ecological (if time allows) — have a discussion about:

(a) Specific factors that might be barriers and drivers of NBS implementation

(b) Specific strategies and measures that can help overcome these barriers and leverage the drivers or can help in general with successfully implementing NBS

(c) Are there any additional key factors that have not yet been addressed but are important to consider?

Looking ahead [5’]

(a) Assuming you would desire NBS to be adopted at scale in Dutch cities, what would be needed to realize this?

(b) If you were to develop support tools for NBS planning and implementation for practitioners, what features or characteristics would you include in these tools?

(c) Can you name one or two specific NBS projects, perhaps one successful one and one less successful one, you believe offer important lessons for future implementation?

Wrapping up [5’]

(a) Do you have anything else you would like me to consider?

(b) Are there other experts you recommend I speak to?

C.1.2 Interview protocol practitioners

Introduction [5’]

(a) Brief personal introductions

(b) Short overview of the research objectives and purpose of the interview

Experience with NBS [10']

(a) Can you describe your role(s) in the planning and/or implementation phases of NBS projects?

(b) Could you give one or two recent examples (in the last 5 years) of NBS projects you've been involved in?

(c) How would you define NBS in your own words?

(d) What types of NBS are you most familiar with?

Barriers and drivers of NBS implementation and strategies and measures to address them [40']

For each of the following themes — social and cultural, governance, informational and technological, physical and ecological (if time allows) — have a discussion about:

(a) Specific factors that might be barriers and drivers of NBS implementation

(b) Specific strategies and measures that can help overcome these barriers and leverage the drivers or can help in general with successfully implementing NBS

(c) Are there any additional key factors that have not yet been addressed but are important to consider?

Looking ahead [10']

(a) Assuming you would desire NBS to be adopted at scale in Dutch cities, what would be needed to realize this?

(b) If support tools for NBS planning and implementation were to be developed for practitioners, what features or characteristics should these tools include to be useful to you?

(c) Can you name one or two specific NBS projects, perhaps one successful one and one less successful one, you believe offer important lessons for future implementation?

Wrapping up [5']

(a) Do you have anything else you would like me to consider?

(b) Are there other experts you recommend I speak to?

C.2 Informed consent form template

Informed consent form

You are being invited to participate in a research study titled 'Factors influencing the implementation of Nature-Based Solutions in Dutch cities'. This study is being done by Julia Klapwijk from the TU Delft.

The purpose of this research study is to identify which barriers and drivers experts experience when implementing Nature-Based Solutions in Dutch cities and which strategies need to be adopted to overcome these barriers and leverage the drivers. The interview will take approximately 60 minutes and will be used in the student's Master thesis. We will be asking you about your experience with Nature-Based Solutions projects and/or research and which

factors you think are drivers or barriers for the implementation of Nature-Based Solutions. Moreover, we will ask what you think is needed to overcome these barriers and leverage the drivers for the further roll out of Nature-Based Solutions in Dutch cities. The identified barriers, drivers, and strategies will be incorporated in an implementation framework that can support the adoption of Nature-Based Solutions.

We collect your name and e-mail address for administrative purposes (personally identifiable information) and write down your (generic) job role (personally identifiable research data) in the research approach and methodology section of the thesis. The interview will be audio and video recorded and transcribed. We will analyze the transcripts (with ATLAS.ti) to identify barriers, drivers, and strategies. To explain and support these factors, your anonymous quotes and opinions (personally identifiable research data) can be used throughout the thesis and will be linked to your (generic) job role. An anonymous summary of your interview will be included in the appendix of the thesis and linked to your (generic) job role. Even though you will be anonymous in the thesis, you should be aware that there is always a risk of re-identification, meaning that your quotes and opinions could be traced back to you (by members of the Nature-Based Solutions community).

After the interview has taken place (about a week later) the interview transcript will be sent to you, so you have the opportunity to ask for modifications of the transcript. Both the anonymous summary (included in the appendix of the thesis) and your anonymous quotes and opinions (used throughout the thesis) will be sent to you before concluding and publishing the thesis.

The thesis will be published in the TU Delft Repository, which has open access. Publishment is expected to take place in October 2025.

The audiovisual recording of the interview will be deleted after concluding and publishing the thesis. All other data collected during the project will be preserved at TU Delft for up to 2.5 years. The data may be reused for future scientific and education activities on the topic of Nature-Based Solutions. You will be anonymous in any and all outputs. After that time, the data will be deleted (approx. date: October 2027).

As with any (online) activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by storing all personal data in a secure TU Delft OneDrive, which can only be accessed by the TU Delft project team consisting of the principal investigator Julia Klapwijk and her graduation committee, consisting of Martijn Warnier, Nazli Yonca Aydin, and Lisa Scholten.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions.

In case of any questions or complaints, please contact the corresponding and responsible researcher:

Julia Klapwijk – corresponding researcher

E-mail address of corresponding researcher

Nazli Yonca Aydin – responsible researcher

E-mail address of responsible researcher

I agree that my responses, views or other input can be quoted anonymously in research outputs. Therefore, I understand that the remarks I make during the interview should not be professionally sensitive or confidential. I understand that the interview transcript will be sent to me after the interview (about a week later) and that the anonymous summary as well as my anonymous quotes and opinions that will be included in the thesis will be shown to me before concluding and publishing the thesis. I understand that this gives me the opportunity to rectify any information I have provided.

Please tick the appropriate box: Yes □ | No □

I have read and understood the study information above and I consent to participate in the study and to the data processing described above.

_____ _____ _____

Name of participant [printed] Signature Date

C.3 Interview details

Table 26 Interview details

Number	Job role	Themes	Meeting type	Date	Duration
P1	Senior advisor (Practitioner)	All	Online (Teams)	02-07-2025	65 minutes
PA1	Researcher and advisor (Practitioner/academic)	All	Online (Teams)	03-07-2025	63 minutes
A1	Professor (Academic)	All except governance (limited discussion on that theme)	Online (Teams)	08-07-2025	49 minutes
A2	Senior researcher (Academic)	All except governance (limited discussion on that theme)	Online (Teams)	29-07-2025	56 minutes
A3	Senior researcher (Academic)	All	Online (Teams)	31-07-2025	68 minutes
P2	Advisor (Practitioner)	All	Online (Teams)	20-08-2025	58 minutes
P3	Strategic advisor (Practitioner)	All except informational and technological (limited discussion on that theme)	Online (Teams)	22-08-2025	70 minutes
A4	Professor (Academic)	All except informational and technological	Online (Teams)	28-08-2025	59 minutes
A5	Researcher (Academic)	All	Online (Teams)	02-09-2025	49 minutes
PA2	Senior researcher and advisor (Practitioner/academic)	All	Online (Teams)	05-09-2025	62 minutes

C.4 Interview summaries

C.4.1 Summaries academics

C.4.1.1 Summary A1

NBS are measures that address, prevent, or mitigate societal problems like circularity, sustainability and climate issues, by working with nature rather than against it. While inspired by nature, they do not necessarily have to be nature in the literal sense, and they deliver a wide range of Ecosystem Services. Crucially, NBS always involve a reciprocal relationship between society and nature, as humans need to maintain and manage NBS. They have known a niche for a long time, but a look needs to be taken at the possibilities to scale them up.

From a social and cultural perspective, citizens generally perceive NBS as positive measures and value their contribution to, among other things, physical and mental health, and therefore tend to accept them when they are implemented in their neighborhood. However, public awareness of what NBS exactly entail and provide often remains limited. In particular, the broader implications of NBS are not always recognized, as they are not self-sustaining systems and require ongoing maintenance and management in which local citizens are actively involved. To ensure this long-term care, co-creation is essential, with communities engaged early in the planning and design processes. Despite general support, citizens may still prioritize personal habits and conveniences, such as parking availability, over the introduction of NBS. Furthermore, the diverse cultural backgrounds within cities shape differing perspectives on nature, which should be taken into account when implementing NBS projects.

Within the governance domain, an integrated approach to NBS projects is vital. While governmental organizations strive for such a perspective, it rarely occurs in practice. They are often stuck in traditional ways of working and dependent on existing systems (path dependency). Next to this, departments can have conflicting opinions on NBS projects and can, sometimes, even work against each other. This is partly due to their concerns surrounding precedent effects, meaning that if exceptions to regulations or policies are granted for NBS, this could be exploited in other projects. Furthermore, stakeholders often prioritize different benefits that NBS can offer. The final selection of NBS is therefore the result of a multi-criteria decision-making process, heavily influenced by the preferences of the stakeholders involved.

On the informational and technological front, there are gaps in data on NBS due to several reasons. You cannot capture all nature in data, as many variables exist. Next to this, NBS are customized solutions, meaning that the data will be different for each case. Therefore, you need to recognize patterns to be able to draw a conclusion, which can be very complex. Moreover, the benefits often go beyond the economic realm, making them hard to quantify. The most effective way to demonstrate the potential of NBS is to combine modeling and GIS (using climate data and maps) with survey insights from local citizens, thereby linking objective data with subjective experiences. Numerous websites provide relevant data, and a growing range of tools, both existing and in development, can help visualize and assess the effects of NBS. However, ULLs can also provide data for the modeling studies as well as help to discover how stakeholders respond to NBS and how co-creation and citizen management and maintenance can be shaped. A catalog with example NBS projects can be very helpful and inspiring, but also has its dangers as many variables and conditions of the projects are not explained, meaning that it will not necessarily work for a different city.

When it comes to physical and ecological aspects, there is a lack of space within cities. This while NBS have a lower density and thus require more surface area to be implemented. This together with the presence of existing systems resulted in many NBS being hybrid solutions, such as vertical greenery or green roofs, instead of full blue-green solutions. In terms of multifunctional space use, much is still

being developed and experimented with. The multifunctionality of NBS is one of their greatest strengths, as they can deliver a wide range of Ecosystem Services alongside co-benefits. Depending on the specific challenges a city faces, NBS can be assigned multiple functions and tailored to address heat stress, lower hydrological risks, and increase air quality. NBS require intensive maintenance on which should be focused.

If a tool for practitioners were to be developed, it needs to be emphasized that activating social capital is of utmost importance for successfully realizing NBS projects. Local citizens and communities are necessary for co-creation, maintenance, and management, thereby creating an infrastructure of care to ensure the long-term existence of NBS and provision of their benefits.

C.4.1.2 Summary A2

Depending on the person the expert is speaking to, a slightly different term is used. When employing NBS, you are working with nature to address a problem, such as climate change, as NBS can deliver multiple Ecosystem Services and benefits simultaneously. This is powerful and not only beneficial for humans, but also for nature itself and for protecting and improving biodiversity.

On the social and cultural front, most citizens are not fully aware of what NBS are or the benefits they can provide, and often need to be reminded of the value of nature. The connection between NBS and human health remains underemphasized and should be strengthened. However, society does feel a sense of urgency to address climate change. Awareness can be increased by using posters and videos that highlight nature's close relationship to human well-being as well as by encouraging hands-on engagement and direct contact with nature. Support is more easily gained when citizens understand the specific personal benefits NBS offer. However, acceptance tends to drop when NBS replace parking spaces, and they can sometimes be perceived as greenwashing. Creating spaces where citizens can meet, exchange views, and discuss these matters can help strengthen community understanding and support. Citizens should also have an active role in co-creation and maintenance, while being assured that the government will provide support where needed. Designing aesthetically pleasing is important considering citizens are likely to see NBS on a daily basis, although a shift in perspective on aesthetics is also required to understand that sometimes a more biodiverse solution that may be less aesthetically pleasing might be a better option. Finally, NBS should be the default before turning to grey solutions, with the burden of proof placed on both approaches equally.

When it comes to governance, there is a silo mentality in both the academic and practitioner world, although sometimes there is exchange of knowledge and data between knowledge institutes. This can be changed by one person in the municipality standing open for a broader view and feeling the space to do so, but this is not yet standard practice. Next to this, a Community of Practice was used for a while in which stakeholders from different ‘worlds’ came together to discuss NBS projects. However, it must be noted that there is often a language barrier between the different stakeholders, which requires time to overcome. Co-governance structures and PPPs between multiple stakeholders are often the most successful in practice, so there needs to be thought about who should be involved and what collaboration should look like. The national government should take the lead in honoring and governing the transition to NBS and provide direction and vision, but ultimately all stakeholders, including citizens, municipalities, and companies, are needed. Moreover, a shift in stakeholder thinking when making decisions about public space in cities should take place, placing nature and NBS more on the forefront of their discussions. Next to this, municipalities often lack knowledge on ecology within cities, so hiring a city ecologist can help with this.

From the informational and technological point of view, a lot of data is available, but not all data is open access or is available on every desired scale level. Next to this, some effects of NBS are difficult

to quantify or cannot be quantified, which is especially the case for social values, meaning proxies need to be used. Although people recognize the power of a number and are thus working on creating models that also include these social benefits, it remains the question whether you can and want to quantify everything, as combining qualitative and quantitative methods is also considered powerful. In line with this, using varied methods and units in calculations is considered best practice, as it exposes differences, reveals their causes, and provides working margins. If everyone used the same assumptions, results could appear misleadingly definitive. Moreover, it is difficult to attach economic value to social aspects, making cost-benefit comparisons challenging. Data on the long-term performance of NBS is not really available yet, since many tools offer snapshots. Therefore, scenario modeling can be used to indicate the global trends. Knowledge and data on NBS are spread across different disciplines, so they must be consolidated. Many tools are available for showing the effects of NBS, but this abundance can be overwhelming for practitioners and academics alike. The tools should be compared to see what results they can deliver, and if they can provide the results that are needed, and what tools are still missing. Using catalogs works well for identifying core elements of NBS projects and to get inspired and learn from other cities, considering many cities face similar problems.

Within the physical and ecological domain, multifunctionality of NBS allows the measures to address several challenges simultaneously. This characteristic should be leveraged and the specific benefits should be tailored to each case, however, the baseline should always be that they support nature and biodiversity before considering other issues. Although urban space is limited, it ultimately comes down to making conscious choices about how space is used, which calls for more open discussions and deliberate trade-offs. In addition, hybrid NBS can be employed to overcome spatial constraints, such as adapting green roof designs to match the weight-bearing capacity of different buildings.

When developing a tool for practitioners, including a checklist of key principles or characteristics for NBS projects can greatly support successful design. The checklist could pose guiding questions, for instance: How can we make NBS multifunctional and how can we guarantee that planning and implementation processes promote inclusion and equity? Next to this, it is important to be aware of the underlying drivers of declining nature, meaning that looking beyond NBS is required to address climate change and biodiversity loss. This raises another question: How can we foster more nature-inclusive behavior in society at large?

C.4.1.3 Summary A3

NBS are based on the functioning of nature and follow three core principles. To begin with, they sustain themselves by capturing energy that is provided by the sun on-site and converting it into the energy that is needed to survive. Second, they capture and use water locally, meeting their own needs before releasing any surplus to the surrounding environment. Lastly, they mimic nature's way of handling materials, where matter continuously circulates through the ecosystem, for example, a fallen leaf is broken down by fungi and its nutrients are absorbed by nearby plants or trees. These principles of How does nature use energy?, How does nature use water? and How does nature use materials? form the foundation for NBS. Additionally, because NBS are inherently multifunctional, their design should always consider the full range of functions they can provide.

From a social and cultural point of view, many citizens remain unaware of what NBS are and can mean. Awareness and support can be enhanced through visual and experiential methods, such as before-and-after images, immersive 3D experiences, or real-life demonstrations that allow citizens to compare environments with and without NBS. However, past projects have shown that citizens sometimes still prefer ‘standard neighborhoods’ over nature-inclusive designs. Another measure that can help is letting academics make simple videos that explain the results of NBS projects to citizens, as many citizens are not inclined to read research papers. Moreover, NBS can be linked to current issues people

are dealing with, however, it must always be noted that the benefits of NBS extend beyond these immediate topics. In general, many citizens accept and, to a lesser extent, support NBS. Strong resistance is uncommon unless projects directly impact the immediate surroundings of residents, such as reducing parking availability. Although NBS are not inherently green or aesthetically appealing, designs should aim for visual attractiveness to maintain public acceptance. Citizens' perspectives on NBS should be integrated early in the planning process, with opportunities for co-creation. However, full-scale participatory processes will take too long with climate change moving at a rapid pace. When it comes to maintenance of NBS, public involvement is often limited by a lack of time or interest, partly reflecting a broader decline in gardening practices over recent decades. This indicates the need for a societal shift in attitudes toward nature.

From a governance perspective, stakeholders often operate in silos, whereas NBS projects require cross-departmental and cross-sectoral collaboration. Therefore, interdisciplinary construction teams in which all relevant stakeholders are involved should be established early in the project process. While dedicated networks uniting stakeholders around NBS are largely absent, several professional associations do increasingly focus on climate change and NBS. The responsibility for initiating action should lie with the national government, which can develop harmonized regulations to guide NBS implementation. Leaving this responsibility solely to society risks suboptimal outcomes, as citizens and companies tend to prioritize cost-efficiency and rapid results over long-term climate resilience and nature inclusiveness. Next to this, governmental organizations should work on expanding their knowledge on NBS, as they often lack in-depth professional knowledge on the matter due to frequent changes in personnel. Moreover, stakeholders need to be made aware that NBS cannot only be beneficial for their department or sector, but that the benefits extend beyond their individual interests, thus can be linked to several urban agendas. High-ambition demonstration projects can help show stakeholders what is possible with NBS.

When it comes to informational and technological aspects, it is crucial to quantify the benefits and services that NBS can deliver as early as possible, in order to clarify the differences between solutions and enable stakeholders to determine which NBS are most suitable for addressing specific site-related challenges. A key limitation of existing data is that they often consist of enumerations, while essential numerical values for calculations remain unavailable. Determining such values is complex due to the large number of variables involved, making it more practical to provide indicative ranges rather than exact figures. However, selecting a single representative value can be sufficient in most cases, as the primary aim is often to evaluate design alternatives for a particular site rather than to produce an absolute outcome. Quantifying social values remains particularly challenging, as the number of underlying assumptions often undermines the interpretive value of the resulting figures. Although there are already many tools available to aid in quantification of NBS effects, there is still progress made in improving and expanding this toolkit. ULLs are valuable for gathering data as well as discovering how citizens view NBS and how co-creation processes can be shaped. Moreover, they are essential for their power of demonstration, which can be more persuasive than data alone; but research is still crucial for showing the effects. Furthermore, catalogs with examples of NBS projects, policies, or regulations from different cities can serve as inspiration for stakeholders.

Within the physical and ecological domain, it is crucial to fully leverage the multifunctionality that NBS can provide. Considering there is limited space in cities, each space should ideally serve at least three functions to ‘justify’ its use. Nature flourishes due to its multifunctionality, so NBS should be approached in this manner. This means avoiding a single-function mindset and consistently exploring what additional functions can be integrated. Designers should think in terms of ‘and–and’ rather than ‘either–or’, making use of existing techniques and products to combine purposes. For example, NBS

can be incorporated into parking spaces, cycling paths, or building structures, thereby creating hybrid solutions. Ultimately, the choice of which NBS to implement is context-dependent and should be guided by the specific conditions and challenges of the site.

When developing a tool for practitioners, minimize text and try to focus on visual elements like images, flow charts, funnel charts, graphs, yes/no diagrams, and maps. This makes it easier to convey the message and helps practitioners understand better what is meant.

C.4.1.4 Summary A4

The Nature-Based part of the term NBS refers to focusing on the use of nature, drawing on nature, and imitating nature, but the Solutions part is a bit unclear sometimes in the sense of to what it exactly is a solution. Moreover, it is more a policy marketing term used by the EC to market itself as an innovator, but by now a lot of measures are called NBS even though they might not qualify as NBS. Therefore, the term urban green and blue infrastructure is preferred by the interviewee. When using the term NBS, it is important to realize that they are systemic and transformative measures that address multiple social, environmental, and economic goals and challenges at the same time.

From a social and cultural point of view, citizens are typically not aware of the term NBS and the benefits they can deliver. Using the general term nature makes it easier for citizens to understand what is meant, and they might be more aware of its value due to heatwaves in the past years and noticing that it helps with cooling. However, there is still a group that is not aware and does not really care. Although there is generally no resistance when NBS are implemented in public spaces, it is problematic for citizens if NBS take away parking spaces. Facilitating citizen experiences, such as blocking of the street for mobility, helps citizens realize how much room becomes available and that it might be more important to use that for nature than for parking. Moreover, NBS can create a sense of place for citizens and make them feel connected to an area. Co-creation is also important, as it can help with creating support for NBS and helps citizens understand the benefits. For this, it is of essence to make the participatory processes as locally relevant and tangible as possible as well as to know which people need to be involved and which engagement format to use. Especially older people and people that are interested in nature tend to participate, so it is hard to engage diverse citizens groups. Involving neighborhood managers can help with including more vulnerable or marginalized groups. However, co-creation needs to be seen as a long-term term process and investment and, therefore, needs to be embedded. Furthermore, citizens could also be involved in maintenance, but it should not be seen as a transfer of responsibility so the government can cut back on costs. In theory, aesthetic appeal of NBS is important, but it is not one of citizens' main concerns. For them it is mostly about how nature makes them feel and what they can do in nature.

When it comes to governance, silos can be observed, with each department working in different ways and having their own financing structures, priorities, and mandates. It is considered difficult to create organizational structures as NBS require systemic approaches, meaning that not always the same departments are involved. This makes it hard to create synergies across departments in practice. Even if a municipality is putting out a tender for companies, most tenders do not have space to integrate all departments, different financing streams, and co-creation. However, they often tend to find a way to make it work. For this, personal relations are crucial as there are not many networks in which stakeholders who are working on NBS can find each other, although they are sometimes created during the project itself. Moreover, there exist some (international) city networks in which stakeholders can meet and exchange knowledge. Depending on the city, businesses, consultancies, and knowledge institutes are also involved in them, especially as most projects are implemented by a city government together with a company. Nevertheless, networks within governmental organizations themselves remain relatively small. For them it is important to integrate NBS projects in the urban agenda of other

departments by identifying possibilities for synergies and collaboration. This requires training programs for employees within governments to create awareness that they need to connect with each other as well as other stakeholders. Moreover, there needs to be invested in organizational slack time for learning new things and talking to stakeholders. When it comes to responsibility for upscaling NBS, a strong government is vital for ensuring that citizens and businesses are engaged. It is good that the EU is working on more NBS regulations and initiatives, as it is the responsibility of these higher governmental levels to set goals. This then needs to be trickled down to national support and regulations.

Within the informational and technological realm, there is a lot of data available already, but it remains difficult to quantify the costs and benefits, especially the qualitative benefits. It is also challenging to find suitable monitoring frameworks for all benefits. Employing ULLs can help with improving co-creation processes, during which should also be focused on achieving heterogeneity among participants. Moreover, ULLs can provide institutional flexibility, create a safe space for innovation, and stimulate stakeholders' creativity. However, they need to think more long-term about ULLs than currently, as it is now seen as a project-based form that is done when the project ends.

From a physical and ecological perspective, there is competition for space, especially in dense cities. It is difficult to integrate all the different functions, and especially the housing and mobility sectors take up a lot of space. Moreover, ownership of land is an issue as lots of land is privately owned and there is a trend among private parties to pave their terrain for ease of maintenance, which is creating the opposite effect of what the NBS community is trying to achieve. In order to deal with the lack of space, hybrid NBS like green roofs and vertical greenery can be implemented. The multifunctional nature of NBS means they can tackle multiple goals and challenges at the same time, such as creating a connection between people and nature and aiding in climate adaptation. This trait can be leveraged by assigning multiple functions to a NBS design. A final important remark is that the right species need to be selected for the climate in which they are being implemented, as a lot of first generation NBS are currently dying.

If a tool for practitioners is being developed, the more practical, concrete, and zoomed in the tool is the better. The Connecting Nature Framework is a good framework to take inspiration from, as it shows a meta-level perspective on the processes that are required for planning and implementing NBS.

C.4.1.5 Summary A5

NBS entail using natural processes and Ecosystem Services to address urban challenges. So this can vary from green roofs and rain gardens to permeable pavements and community gardens.

From a social and cultural point of view, citizens are often not really aware of what NBS entail, apart from communities with greater access to information and resources. However, most citizens, generally speaking, do understand the importance of green spaces for their community, but are not necessarily interested in the more complicated benefits. They are mainly interested in how NBS improve their quality of life, such as parks for walking or measures that can reduce flooding in their neighborhood. If NBS are framed in such a way, acceptance increases. Next to this, the Dutch culture of living with and managing water generally increases acceptance as well. However, resistance can be observed when parking spaces are taken away or when NBS alter the familiar neighborhood, which citizens like to look at, too much. Attention should also be paid to implementing NBS in a just manner, as they typically get introduced first in wealthier neighborhoods that do not particularly profit greatly from the health benefits of the solutions. Urban planners can actively counterbalance these inequities by prioritizing underserved areas when implementing NBS. In addition, in order to scale up NBS in cities, more citizen engagement and co-creation and participation processes are required and are already

taking place. This engagement in design and stewardship improves the acceptance of NBS as well. Citizens can also be involved in maintenance of NBS. Bigger parks can be managed by cities, but smaller initiatives require community interest. Lastly, the aesthetic appeal of NBS is important, although there is no single consensus on what's considered beautiful and biodiversity value does not always align with aesthetic preference. That tension is itself a governance and communication challenge. However, regarding aesthetics, maintenance is perhaps most important since NBS only look as good as well as they are maintained over time. This means that resistance against wetlands for instance is not because they are not aesthetically pleasing, but because there might be breeding of insects due to poor maintenance.

When it comes to governance, there are knowledge gaps within municipalities as not all employees understand the importance or benefits of integrating NBS in urban planning. This results in only a few departments, mainly within bigger municipalities, really working on it, while scaling up NBS requires cooperation of different stakeholders. Within municipalities there is not as much coordination between departments as there should be. Everyone works on their own tasks and cooperation only takes place selectively and depends on who is leading. Generally speaking, bringing everyone together has not often been achieved in a successful manner. In order to improve collaboration, a look should be taken at the broader metropolitan region as many solutions also go across municipalities and neighborhoods. With each municipality having its own strategy and needing to match it to that of other municipalities within the region, they are forced to work together. Moreover, a committee is often looking over these administrative units to ensure that everyone collaborates. Next to this, some networks, established by knowledge institutes or municipalities for example, do exist and stakeholders can find each other there when they want to implement a NBS project or exchange knowledge. Regarding responsibility, national governments and municipalities within metropolitan regions should play a leadership role and ensure collaboration. In addition, mayors hold a lot of power and should also speak out about NBS, as this can lead to municipal departments taking it more seriously. However, businesses, citizens, universities, and knowledge institutes should play a role as well, with the latter two already actively helping by conducting crucial research.

From an informational and technological perspective, NBS are considered a specific thing to model, meaning that NBS first need to be classified and categorized in order for a model to understand what NBS mean. Modeling broader green interventions, such as corridors and recreation areas, is already possible, but to model NBS specifically, a standardized classification system that defines what counts as NBS in the Dutch context is needed. For example, modeling all green spaces does not automatically indicate which part of it is a designed intervention, like a rain garden or water square, versus an incidental green area. So a clear, agreed dataset that classifies interventions as NBS categories and contains attributes describing their functions is essential for training models to simulate or compare NBS outcomes. Although there have been emerging efforts that are helping build this classification base and could now support more precise modeling, there is still work to do. Moreover, mainly GIS and land-use models can be used for modeling NBS, as they work on the same base data. But again, a data set of the different types of NBS and the benefits they provide needs to be made in order for the model to recognize NBS and model their effects. Moreover, researchers are working at the financial quantification of the costs and benefits of NBS, but it will take some time before this becomes widely accepted. Especially the long-term benefits NBS provide for biodiversity and health are hard to quantify. Regarding actual implementation of NBS, a case study compendium (catalog) can help cities to see what is possible and which benefits can be generated.

Within the physical and ecological system, a lack of space can be observed in cities. They are compact and there is competition for land use, especially given the housing crisis. Other sectors can be given

priority over NBS, so there is not enough space for urban planners to freely implement NBS. Next to this, there are issues with the groundwater levels and soil conditions, which also influences the feasibility of certain NBS. Maintenance is an important aspect of NBS and needs to be ensured by the municipality, for instance by dedicating a budget to it and putting specific policies into practice, as breeding of bad plants or insects can occur when it is not kept up. The multifunctionality of NBS is a nice characteristic and should be strived for whenever possible by assigning multiple functions to a NBS design. However, it cannot always be implemented, for instance, a wetland cannot always be made public and serve a recreational purpose as well.

When developing a tool for practitioners who are working on NBS projects, it is important that the tool is user-friendly and communicates well to the intended target group. Make it very visual and clarify for them or give them ideas on different ways that can help with implementing NBS.

C.4.2 Summaries practitioners

C.4.2.1 Summary P1

The concept of NBS is based on looking at nature and learning how it can be used to improve cities. At their core, NBS are about increasing the amount of greenery in cities, improving their biodiversity, and enhancing cities' climate adaptivity. The transition starts with removing bricks and adding greenery and transforms into creating biodiverse areas with native species and water storage solutions. The focus should thus not only be on taking care of existing green spaces and creating new ones, NBS also require a new way of maintenance and management to guarantee their benefits.

Within the social and cultural domain it can be noted that NBS are increasingly appreciated by citizens, yet remain a sensitive topic, especially when water remains stagnant or when there is a fear or pests. Therefore, it is important to listen to citizens' concerns and design NBS smartly to ensure public support. Moreover, NBS should be framed in a manner that resonates with citizens or shows how they can personally benefit from their implementation. This can for example be done by explaining how the solutions contribute to their quality of life. Visualizing the solutions can also aid in showing their impact, thereby fostering acceptance. Next to this, citizens should be involved in the planning and implementation process of NBS as well as during maintenance. However, formal agreements are essential for the latter to prevent it from becoming too noncommittal. It can also be observed that the way of thinking about designing public space and implementing greenery is shifting favorably, although designing according to old style still occasionally occurs. While aesthetic appeal of NBS is important, the solutions must first and foremost be selected based on their compatibility with the implementation site.

When it comes to governance, municipalities should play a leading role in initiating projects and involving citizens. There is already a lot of collaboration with various municipal departments to ensure alignment in policies and regulations. Even though these projects require a balance of give-and-take, most departments manage to integrate them into their own agendas. Knowledge institutes are occasionally involved and companies are increasingly engaged through municipal competitions for NBS-related projects. Various networks are available for stakeholders to collaborate, though the abundance of such networks can be overwhelming, making it challenging for practitioners to establish mutually beneficial partnerships. Categorizing municipalities based on their stage in the transition towards NBS could help tailor collaboration more effectively.

On the informational and technological front there are many tools available to support practitioners with, for instance, selecting the most suitable NBS design or location. However, this abundance can make it challenging to locate the most relevant information, highlighting the need for a similar categorization approach as suggested for governance. Within municipalities themselves, there is often

sufficient design capacity and expertise to realize NBS projects. ULLs can help cities with demonstrating what is possible, gathering data, and fostering collaboration and citizen engagement. However, certain effects of NBS remain difficult to measure, especially in the short term or if the project is small in scale. While a few international databases exist for practitioners, the information they contain can be complex and time-consuming to unravel. Developing or adopting a catalog of applicable NBS for cities could greatly enhance implementation, as a good example inspires others to follow.

From a physical and ecological perspective, many cities lack space for NBS. Transport and mobility are considered the main culprits and should take on a new role and spatial form within cities, such as by reducing or replacing parking spaces. Another aspect that needs to be accounted for is the soil, as it is not always suited for (all types of) NBS. Next to this, it is important to design NBS with native species and to select NBS that fit well with the location in which you are trying to implement them. The multifunctional nature of the solutions can drive their adoption and can be leveraged by assigning multiple functions to a NBS design.

Regarding the development of a tool for practitioners, it is important to make visually explicit what NBS can do for cities, for example by means of before and after pictures. Give concrete examples of NBS projects to show what is meant with the content of the framework. Next to this, sorting the content of the framework based on practitioners' experience can also help; in this case distinguishing which barriers and drivers can be faced by practitioners who are just starting to implement NBS versus practitioners that have already implemented several NBS projects.

C.4.2.2 Summary P2

The concept of NBS entails using the principles of nature in a smart way, which can go from systemic approaches to, for example, copying or adapting processes of evapotranspiration into materials to reduce the impact from heat on indoor temperatures. The expert looks at the world with a systemic understanding, meaning that climate has no boundaries and that a look beyond the implementation site is taken to understand, for instance, wind flow and solar radiation. NBS themselves consider the use of plants and the way they can occur in nature in combination with the type of land cover. So from using trees in dense urban areas for cooling to depaving solutions to improve the urban water cycle. It is about creating a network of green and blue spaces.

When it comes to the social and cultural domain, the degree of public acceptance varies, but, generally speaking, it is increasing due to the concept of NBS leaving the academic world and the fact that more NBS projects are being realized. However, there are still citizens that are not aware and do not really care as well as citizens that are aware but are afraid to leave their comfort zone. They can, for instance, be worried about NBS attracting insects or causing the removal of parking spaces. Moreover, citizens are often aware about the benefits NBS can provide for physical health, but not so much about the positive impacts on mental health. In addition, NBS projects should be co-created with citizens, but participatory processes should be shaped wisely to avoid participation fatigue. Make sure to actively listen to citizens' feedback and to build on it and think about more engaging models of participation in which stakeholders start with citizens instead of the design. Designers, and society at large, should be more patient and flexible in this regard, as it can be more valuable to first understand the wishes of citizens before designing, and urban change does not happen overnight. Citizens can also be involved in maintaining the projects, to provide them with a sense of co-ownership, but the municipality still needs to be responsible for the bigger solutions from a safety point of view. It is vital to design NBS in an aesthetically pleasing manner, but society should also change their perspective on what is beautiful as dried out wadis are also natural processes.

Within the governance realm, the amount of collaboration between stakeholders depends on the stakeholders at the table, not on the types of organizations or sectors involved. When stakeholders are more rigid and closed, a silo mentality can be observed, but there are also instances in which stakeholders are more open and flexible. When establishing collaborative governance arrangements, start with the municipality and see which standard stakeholders, like citizens and water boards, need to be involved and then think about whether specialized stakeholders, for example academic partners or modeling experts, are required. It can also help to make a stakeholder engagement plan. Next to this, try to link the project to their urban agendas to make clear what is in it for them. There are Community of Practice networks in which stakeholders can find and learn from each other as well as matchmaking platforms in which stakeholders that are interested in a project can team up with each other. The responsibility for scaling up NBS in urban areas should be shared, so a combination of bottom-up and top-down, spontaneous and non-spontaneous, and citizen-led and government-led initiatives. Sometimes citizens wait too long for governments to take the lead and to form policy, while citizens and companies can often make more impact as the majority of urban space is privately owned.

From an informational and technological perspective, there are many tools available to calculate the outcomes of implementing NBS. However, the most complete tools are often very complex and take a long time to run, while the lighter and faster tools are not able to provide output on all relevant variables. Therefore, efforts need to be made to connect and integrate these tools. Implementing ULLs is very helpful for revealing barriers that could not have been anticipated as well as demonstrating NBS to citizens and directly seeing their reaction to the project. This is vital as augmented reality still needs to be developed further to provide stakeholders with a more immersive reality of what NBS can look like and provide. Moreover, the results can also be integrated back into practice and feed future projects with better insights. When it comes to informing municipalities themselves, using catalogs with example NBS projects can be inspiring. Some of the information might be generalizable, but other matters will be more context-dependent. Therefore, the principles and guidelines should always be checked with the local context.

On the physical and ecological front, there is limited space within urban areas. The presence of existing structures and needs of other sectors, such as mobility, can act as barriers. However, this can be tackled by, for example, using hybrid NBS like green roofs and green facades or by implementing artificial structures that mimic nature, so biophilic design. With regard to hybrid NBS, it must be noted that green wall solutions are costly, despite ongoing technological improvements, and they do not contribute that much to cooling buildings; but they do improve biodiversity and mental health. When it comes to maintenance, an option is to opt for zero or spontaneous maintenance solutions, meaning that they still look and perform well without maintenance. Finally, the multifunctionality of NBS should be fully leveraged by assigning multiple functions and ensuring they deliver at least three core benefits: climate adaptation, biodiversity enhancement, and improved public health.

When developing a tool for practitioners, try to base it on the KISS framework. The framework stands for Keep It Short and Simple, so stick to short sentences, avoid jargon, and keep it concise. During the development process, involve practitioners every now and then to check if the framework is fulfilling their expectations and could be useful to them.

C.4.2.3 Summary P3

The term NBS should be distinguished from the term nature-inclusive. While NBS also encompass geo-engineering solutions, meaning the use of natural and physical mechanisms to generate desired outcomes, the term nature-inclusive solely focuses on designing and building green-blue interventions that deliver various benefits, such as supporting climate adaptation and creating habitats for fauna

and flora, with the overarching aim of improving quality of life for all species. Therefore, the interviewee prefers the use of the term nature-inclusive.

Within the social and cultural domain, citizens are generally aware of NBS and supportive of their implementation. For example, simple interventions, such as adding plants as stepping stones, are widely accepted. Issues like declining biodiversity and climate change are often perceived as negative, so measures like NBS that address these challenges are seen as positive initiatives. Citizens feel a sense of contributing to a good cause and can observe the benefits in action. However, awareness is often limited to visible effects, such as cooling and aesthetics, while less tangible benefits, like supporting ecosystems or improving quality of life, are less recognized. When asked carefully framed questions about NBS, citizens become more aware of these broader benefits. Initial resistance may occur, for instance if NBS are perceived as a threat to parking spaces, but acceptance usually grows once projects are implemented. Despite this, NBS are not yet fully integrated into everyday thinking, which remains a gap to address. Engaging citizens during implementation is essential. They should have opportunities to provide input and help co-create projects, but questions must be realistic to avoid disappointment if their preferences cannot be accommodated. It is also important to involve citizens at the right time, as creating interconnected networks of green and blue infrastructure is often better managed by professionals. Citizens can, however, participate meaningfully by choosing between designs or providing feedback on new proposals. Finally, citizens can also be involved in maintenance and stewardship of NBS projects, as this enhances support, reduces municipal workload, fosters social cohesion, and increases the overall success of the project.

From a governance perspective, awareness of and support for NBS have grown over the years. Urban planners and architects increasingly recognize that certain design choices may not be optimal for incorporating NBS and that collaboration with other stakeholders, such as city ecologists, is often necessary. Similarly, project developers are becoming aware of the fact that NBS can enhance property values. Governmental organizations are also introducing mechanisms to promote NBS. Within municipalities, departmental silos exist, but these can be overcome by demonstrating that slight design adjustments can align a project with the agendas of other departments, such as mobility or housing. Experiencing this in practice helps build trust and understanding, making stakeholder education a key aspect of governance. Although networks of NBS professionals are limited, increasing their number is not necessarily required. Many separate initiatives occur that often generate temporary networks, for instance, project teams within the Board of Government Advisors. Additionally, study programs, annual congresses, and expert pools within some municipalities provide opportunities for meeting other experts and exchanging knowledge. Project developers have also established the KAN platform to support NBS initiatives. The responsibility for upscaling urban NBS lies with both governments and companies. As NBS have many advantages for society, for which the government is responsible, and the introduction of national policies is more effective than that of municipal ones, the national government should play a leading role. Moreover, companies should also bear responsibility, not only for societal benefits but also for self-interest, as the current workforce increasingly prefers employers with sustainable visions.

For the informational and technological aspects, it is important to have a better picture of the data, especially on (co-)benefits and costs, that currently exists. As more data is becoming available, such an overview can help understand the status quo. Moreover, knowledge on NBS should be made more accessible and actively integrated into education. In addition, a catalog of example NBS projects could provide valuable inspiration for municipalities. While designs will need to be adapted to local contexts, underlying principles, policies, and models can often be transferred.

Within the physical and ecological domain, it can be noted that there often is a lack of space within cities, with the main competitor being the mobility sector. When (public) space is limited, NBS can also be implemented on buildings, for example on rooftops or facades of houses and office complexes (hybrid NBS), thereby expanding the usable surface area beyond the footprint alone. Furthermore, NBS are multifunctional in nature, so they can support climate adaptation and water retention as well as enhance biodiversity and quality of life. Two other principles that should be kept in mind while designing NBS are focusing on connection and porosity. The first refers to linking blue and green solutions to create a coherent and robust NBS network, while the latter concerns the use of pores in spaces and structures to allow the integration of grass, trees, and other vegetation. To ensure a robust system, it is equally important to avoid reliance on a single species. Lastly, when selecting NBS, keep in mind the trophic pyramids and consider desired species composition.

When it comes to the development of a tool for practitioners, pay attention to making it user-friendly, manageable and suitable for short attention spans. Incorporate images, make use of colors, provide references for inspiration, and include summaries. Also choose and specify for which practitioners you are designing the framework and select the right format for this target group.

C.4.3 Summaries practitioners/academics

C.4.3.1 Summary PA1

NBS is an umbrella term encompassing many aspects and related concepts, such as Green Infrastructure, nature-inclusive design, and Nature+. The solutions are based on living nature, must retain its characteristics, and are designed to deliver a range of benefits. NBS can be seen as taking a utilitarian perspective on nature as the framing of NBS emphasizes an intentional use of nature to achieve specific goals, although they do serve ‘nature for nature’ purposes.

On the social and cultural front, many citizens are not aware of what NBS exactly are and what they implicate. Next to this, citizens often do not view themselves as part of the climate problem or as a key to the solution and tend to have other priorities. Early education, co-creation of NBS projects, and framing NBS in terms of personal benefits can build awareness, a sense of ownership, and broad support. Furthermore, letting citizens experience scenarios with and without NBS can further highlight their effects and importance. However, the unpredictable and ‘messy’ nature of NBS can remain concerning for citizens as well as their novelty, meaning that one misstep could lead to a loss in public acceptance. Next to involvement in the planning and implementation process, citizens should also be involved in maintenance of NBS. However, not all citizens will have the interest and time for this and there are issues of continuity. A final important remark is that shifting the burden of proof from NBS alone to both grey solutions and NBS allows for a better and fairer comparison between the two, in which the damage of grey solutions is also taken into account.

From a governance point of view, the main challenge is that NBS require a cross-departmental and cross-sectoral approach, which often results in no single party taking full responsibility. While frontrunners know how to connect, collaboration remains difficult for most stakeholders. Establishing thematic groups that unite stakeholders from different departments and sectors around a specific implementation area could help, but these groups must also declare leadership and commit to a shared narrative that explicitly frames NBS as a solution. Moreover, NBS must be raised higher on the urban agenda, as other priorities still tend to take precedence. This is reflected in the lack of optimal coordination between stakeholders who shape public space, where NBS are not automatically considered during reorganization projects. It is thus important that NBS are linked to various urban agendas. Municipalities should take the lead in NBS implementation, as they have the best understanding of local conditions and are responsible for urban green, yet they cannot do this alone. Collaboration across governmental levels and national borders is essential to ensure interconnected

NBS. Finally, trade-offs between NBS benefits must be made, with outcomes dependent on the stakeholders involved. These decisions can be challenging, as grey solutions may sometimes offer greater safety but lack the multiple co-benefits that NBS provide.

Within the informational and technological domain, most Ecosystem Services can be measured well, but it can be hard to capture social values, like social cohesion, in data. Furthermore, it remains difficult to convert data into monetary terms as (1) you cannot monetize everything, (2) numbers often do not tell the full story, and (3) some matters are very subjective. These challenges also make data standardization difficult and often result in tools that cover economic and ecological values, but overlook social ones. Although new tools are emerging that include all relevant effects of NBS, the question remains: how much can a number really reveal? The abundance of tools also makes it difficult for practitioners to choose which to use. Moreover, there is a gap between tool knowledge and their practical application, since many practitioners do not have the expertise to interpret them immediately and integration into daily workflows takes time. Using a catalog can be inspiring for practitioners to see what aspects other NBS projects have and their potential for their own problem. Next to this, ULLs are not only valuable for collecting data, but also enable cross-site comparisons, helping to uncover differences and whether these are due to institutional conditions or physical factors.

From the physical and ecological perspective, great strength of NBS lies in their multifunctional nature. In order to maximize these various benefits, the creation of interconnected blue and green areas is required. However, fragmented land ownership and diverse land uses make this challenging. Next to this, limited space in cities calls for hybrid NBS as other sectors also require space. Nevertheless, opportunities exist to reduce or redesign space currently dedicated to parking and streets, thereby freeing up room for NBS. Finally, NBS typically require more maintenance than grey solutions, and it remains uncertain what long-term upkeep should look like, as the evolution of natural systems is difficult to predict.

When developing a NBS planning and implementation tool, it is important to mention who is involved when as well as picture what the decision-making timeline looks like. Next to this, it needs to be clear which problem you are trying to address and which NBS would be suitable for this purpose.

C.4.3.2 Summary PA2

For the term NBS it is useful to look at the definition the IUCN has provided. NBS are measures that use Ecosystem Services and functions to deliver various benefits to nature and humans. The measures themselves can be implemented in spatial plans and infrastructure plans.

From a social and cultural perspective, citizens are generally not familiar with the term NBS. However, they are aware that they like to live close to nature and that greenery helps with providing shade and lowering the urban temperature as well as reduces stress. Nevertheless, awareness of the fact that NBS can provide safety, health, and climate resilience is a far from my bed show for many. Acceptance among citizens varies, some citizens are enthusiastic and want to improve their street with greenery, but others are attached to the current situation. Increasing acceptance requires openness of society to (some) levels of uncertainty and dynamic systems. Next to this, reasoning from the problems that citizens have can increase their acceptance. Indicate that heat stress will reduce and flooding will occur less frequently. The openness of people to less concrete benefits, like nature and biodiversity, as well as to the fact that NBS can improve their mental health and quality of life varies. Citizen initiatives and co-creation can be very powerful tools to stimulate NBS implementation, meaning that citizens should be involved and asked about their needs, which, if possible, should be taken into consideration and included. The aesthetic appeal of NBS also plays a part, but is subjective and should never be the end goal of NBS implementation. Citizens can also be involved in maintenance, however, this requires

flexibility in allowing alternative forms of maintenance as well as informing and instructing citizens on how it should be done.

On the governance front, siloed structures within municipalities, as well as within provinces and the national government, remain a barrier. However, the interest in multifunctional use of space is rising, thereby forcing collaboration between departments, which is sometimes successful and other times not. In order to improve this, employees as well as financing streams need to be brought together and single-assignments need to be changed into multi-assignments, thus linking NBS to the urban agenda of various stakeholders, as NBS are able to tackle multiple issues simultaneously. Next to this, windows of opportunity that arise if, for instance, an area is being redeveloped or requires new safety measures, should be used. There are currently few centralized networks for NBS that bring stakeholders together. Nevertheless, knowledge exchange takes place through broader European networks, Communities of Practice exist at various levels, and some networks emerge organically through long-term initiatives. However, in practice, stakeholders often rely on their own professional networks, typically re-engaging with individuals they have collaborated with in the past. When it comes to responsibility, the national government should play an important role in scaling NBS up and deep by creating a vision, policy, and regulations. However, ultimately, society as a whole should be responsible for NBS becoming part of the way of thinking, working, and talking, thus creating awareness and shaping behavior in such a way that natural aspects are by standard taken into account or are even a priority. Scaling out, especially in the short-term, requires an effort from citizens in the form of citizen initiatives. Even though the current political landscape is not necessarily pro NBS, they like to collaborate in such initiatives together with organizations like consultancies and engineering firms that can deliver the right knowledge and tools.

Within the informational and technological domain, key figures are important, such as X m^2 NBS has X retention capacity. Such key figures are known, but they are location-specific and perhaps too generic, so they also rely on many assumptions. The numbers on infiltration capacity are relatively solid, for air quality more numbers could be used, and biodiversity and carbon sequestration are difficult benefits to assign numbers too. Moreover, there is too little data on the potential negative effects of NBS, such as insect plagues. It is also important to note that the key figures should always be used with considerable caution, because NBS are highly dynamic, extremely context-specific, and not perfectly controllable. But it's certainly necessary to provide better insight into the potential. Social matters are hard to capture in data as well. The most important thing is proving qualitatively that NBS improve social cohesion, safety, and living comfort, which has been shown in several demonstration projects. However, there are research efforts to quantify this as well. The costs and more concrete benefits can be quantified increasingly well due to the availability of more data points as a consequence of increased NBS implementation. Although assumptions, information, and calculation rules can be derived from this, there remains quite a bit of uncertainty around the exact cost-effectiveness. There exist many tools that support the development, design, and implementation of NBS, ranging from tools that can compare different NBS to tools that look at vulnerabilities within neighborhoods and indicate areas of action. However, some tools are not maintained over time or differ slightly in the way they work, meaning that outputs of various tools can be difficult to compare. ULLs take place often and are valuable, but there is not always enough money for or interest in measuring and monitoring. This while it is important for showing the (cost-)effectiveness of NBS and to verify assumptions of models with actual data. Lastly, a catalog with examples of cities can be helpful, but should come with a disclaimer that states that application in a different city requires an understanding of the context in which it will be implemented. Alternatively, frontrunners can give a masterclass to other municipalities to show that NBS work, what is possible, what issues and barriers they ran into, and how they dealt with it. Lastly, education is important to consider as well, since integrating NBS in courses within study

programs can aid in changing the way people think of nature inclusiveness beneficially and integrating this into their way of working, because ultimately these students will end up making the difference in practice.

When it comes to the physical and ecological system, there is a lack of space in cities. Though, smaller NBS contribute less to matters like biodiversity and air quality than larger projects, consisting of several connected NBS, in which a look has been taken beyond the city, meaning that the broader landscape is taken into account as well. However, such projects require more space and for densely built-up and densely populated cities this means a different use of space, that integrates different functions. In order to deal with the limited amount of available space, space should be used in a multifunctional way and attention should be paid to using the soil in an optimal way. Furthermore, NBS should be connected with each other to create a network, which also indicates connecting public and private terrain, for instance by greening up private gardens with the Tegelwippen initiative. Additionally, the multifunctionality that NBS have to offer should be made good use of by looking at the problems in a city, and looking beyond the usual suspects, to identify how you can use NBS to address these different challenges simultaneously. This requires a close look at the entire area and all its uses to gain an understanding of what systems are in place, what their challenges are, and what bottlenecks and opportunities are present.

When developing a tool for practitioners, the practitioners themselves as well as their problems should be seen as the starting point. It helps to establish a Theory of Change, so ask who should change things and what they need to make this change happen. What type of information do they need and in which format should this information be delivered. To achieve this, engaging practitioners about their needs and preferences is crucial.

C.5 Coding scheme

Table 27 Free codes

Codes	Description
NBS definition	Characteristics or features that make something a NBS or description of what the concept of NBS details.
Most critical factors	Factors that are considered the most critical for scaling up NBS in Dutch cities in the upcoming years.
Tool requirements	Requirements that the framework that will be developed must have to be useful for practitioners.
Example projects	Projects that could be useful as illustrative cases for framework application.

Table 28 Social and cultural codes

Themes	Codes
Barriers/drivers	*Acceptance and support*
	Awareness and understanding
	Interests and priorities
	Perspective on urban space
	Quality of life
	Reputational benefits
	Sense of ownership
	Sense of place

Strategies/measures	*Account for citizen perspectives*
	Co-create with citizens
	Communicate via videos/posters
	Design aesthetically pleasing
	Design smartly
	Embed NBS thinking
	Facilitate citizen experiences
	Frame smartly
	Inform citizens
	Involve citizens in maintenance
	Make participation locally relevant
	Shift burden of proof
	Use engaging participatory models
Principles	Adapt to social/cultural context
	Ensure just implementation
	Involve all relevant citizen groups
	Involve community/neighborhood managers
	Keep participation realistic
	Prioritize underserved areas

Table 29 Governance codes

Themes	**Codes**
Barriers/drivers	Acceptance and support
	Amount of stakeholders
	Awareness and understanding
	Collaboration between departments
	Collaboration between organizations/sectors
	Departmental assignment structures
	Interests and priorities
	Language
	Leadership/responsibility
	Networks
	Personal relationships
	Precedent effects
	Time
Strategies/measures	Declare all governmental levels responsible
	Declare all stakeholders responsible
	Declare citizens responsible
	Declare companies responsible
	Declare municipalities responsible
	Declare stakeholders responsible
	Declare the metropolitan regions responsible
	Declare the national government responsible
	Develop/use 3D/AR/VR tools
	Develop/use co-creation tools
	Develop/use communication tools
	Develop/use serious games
	Develop/use visualization tools
	Embed NBS thinking
	Embed new governance models

	Embed patience and flexibility
	Establish construction/thematic groups
	Install committee for collaboration
	Link to urban agendas
	Organize NBS competitions
	Stimulate citizen initiatives
	Stimulate collaboration between stakeholders
	Use windows of opportunity
Principles	Make a stakeholder engagement plan

Table 30 Informational and technological codes

Themes	**Codes**
Barriers/drivers	Capacity
	Conferences
	Data availability
	Data expressibility
	Data measurability/predictability
	Definition
	Education/training programs
	Knowledge
	Research
	Technological advancements
	Tool availability/use
Strategies/measures	Build capacity
	Classify NBS and attributes
	Combine qualitative and quantitative methods
	Combine objective and subjective methods
	Create data overviews
	Create nature overviews
	Create tool overviews
	Develop/use catalogs
	Develop/use NBS selection tools
	Educate practitioners
	Employ (scenario) modeling studies
	Employ GIS studies
	Employ survey studies
	Establish a NBS definition
	Establish ULLs
	Execute demonstration projects
	Integrate models
	Integrate NBS into education/training programs
	Map frontrunners and beginners
	Organize masterclasses
	Quantify costs and (co-)benefits
	Research link with health
	Synthesize essential NBS theory
	Use averages in calculations
	Use proxies in calculations
Principles	Check with local context
	Compare model outputs

	Ensure monitoring
	Practice problem-solution alignment

Table 31 Physical and ecological codes

Themes	Codes
Barriers/drivers	Adaptability
	Aesthetic appeal
	Air quality
	Biodiversity
	Climate adaptation/mitigation
	Cooling/UHI effect
	Existing systems
	Maintenance requirements
	Multifunctionality
	Recreational space
	Space availability
	Suitable locations
	Water infiltration/hydrological risks
Strategies/measures	*Assign multiple functions*
	Create pores in structures/spaces
	Implement hybrid NBS
	Implement single plants
	Optimize soil use
	Reshape transport/mobility
	Use biophilic/biomimicry design
	Use private space
	Use zero maintenance species
Principles	Account for climate conditions
	Account for trophic pyramids
	Balance maintenance and natural processes
	Create interconnected green and blue areas
	Ensure contribution to biodiversity
	Ensure maintenance and management
	Ensure robustness
	Implement native plant species
	Look beyond city scale
	Select site-compatible NBS
	Use multiple species

Table 32 Financial codes

Themes	Codes
Barriers/drivers	(Maintenance) costs
	Business case
	Departmental financing structures
	Entrepreneurship
	Financing
	Property value
Strategies/measures	Combine departmental financing streams
	Compare costs and benefits NBS vs grey

	Establish co-financing models
	Use NBS subsidies
Principles	Dedicate budget towards maintenance

Table 33 Political codes

Themes	Codes
Barriers/drivers	Amount of beneficiaries
	Interests and priorities
	Policies
Strategies/measures	Embed NBS in planning frameworks
	Implement coherent supportive policies
Principles	Implement NBS maintenance policy

Table 34 Legal codes

Themes	Codes
Barriers/drivers	Land ownership/use
	Regulations
Strategies/measures	Allow flexibility in regulations
	Implement biodiversity net gain regulation
	Implement coherent supportive regulations
	Implement NBS point system
	Implement no loss regulation
	Mandate greenery/water storage inclusion
	Mandate pavement removal
Principles	Use maintenance agreements

Appendix D Seeds of Change Framework

A Pathway to Dutch Nature-Based Cities

Seeds of Change (SoC) Framework

Image from Teoh (2020)

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CHAPTER 1
INTRODUCTION

1.1 Background

Trees for All (2023)

Need for change

Dutch cities are increasingly grappling with environmental challenges, with two of the most significant issues being **climate change** and a **decline in biodiversity** (United Nations, n.d.-a; Generation Climate Europe, 2024). Climate change has led to an increase in the probability and magnitude of extreme weather events, more health risks, a loss of species, and decreasing water availability and crop yield (United Nations, n.d.-a). With climate change heavily impacting cities and their basic services, housing, infrastructure, health, and human livelihoods, they need to play a key role in **climate mitigation and adaptation measures** (United Nations, n.d.-b; European Commission, n.d.-a; United Nations, 2024). The Netherlands' low elevation levels and densely populated cities make the country **particularly vulnerable to flooding and the UHI effect** (Netherlands Environmental Assessment Agency, n.d.; Steeneveld et al., 2011; Mohajerani et al., 2017; Ritchie & Mathieu, 2019). Moreover, biodiversity loss is accelerating at an unprecedented rate, thereby threatening the delivery of various Ecosystem Services, including the provision of fresh water, clean air, food security, fuel sources, and natural medicines as well as the regulation of diseases, crop pests, and the quality of air, water and soil (Connop, 2016; World Health Organization, 2025). The Netherlands is **one of the world's leaders in biodiversity loss** (Soons et al., 2022).

Nature-Based Solutions as promising measures

These conditions necessitate innovative **urban strategies** to **combat climate change and stimulate biodiversity**. Moreover, the measures must be **adaptable** and **multifunctional** in nature because of uncertain local climate impacts and biodiversity issues as well as the manifold of spatial needs within the urban environment, linked with the social, economic, and environmental components of cities (Voskamp et al., 2021). This combination of requirements has led to the appeal of using **Nature-Based Solutions** (NBS), which are multi-purpose solutions that aim to address **societal challenges** by protecting, sustainably managing, and restoring natural and modified ecosystems (International Union for Conservation of Nature, n.d.). The solutions are **supported and inspired by nature**, allowing them to bring more, and more diverse, nature and natural topographies and processes into cities (European Union, n.d.). Due to their multifaceted character, they are able to adapt to local needs and can simultaneously provide a **range of social, environmental, and economic benefits**. Thereby, they help build **resilience** while being **resource-efficient** and **cost-effective**.

1.2 Why do we need the SoC Framework?

Despite the recognized potential of NBS and the growing acknowledgment that action is urgently needed, their **implementation in Dutch cities remains limited** (PBL Netherlands Environmental Assessment Agency, 2023). As adoption is determined by a **complex and context-dependent system of factors**, there is a pressing need for a better understanding of what influences (successful) realization of NBS projects and what is required to achieve it. Projects are shaped by an interplay of **barriers** and **drivers**, making awareness of these factors critical. At the same time, knowledge of the **strategies** and **measures** that can overcome barriers, leverage drivers, and serve as broader enablers of successful execution is equally important. In addition, certain **principles** can be taken into account that further contribute to more effective implementation. The **Seeds of Change Framework** developed in this booklet brings these elements together, providing guidance for practitioners on how to approach NBS in practice from a **common understanding of the challenges and opportunities** involved. By systematically capturing barriers, drivers, strategies, measures, and principles, the framework aims to strengthen the conditions for NBS adoption in Dutch cities and contribute to **unlocking their full potential**.

University of Minnesota Extension (n.d.)

Optigroen (n.d.)

1.3 What does the SoC Framework do?

The Seeds of Change Framework is an implementation framework with a guiding nature that enables users to systematically identify the barriers and drivers that influence their NBS projects, as well as select the strategies and measures that can be applied to address these factors or to generally stimulate implementation. In addition, it highlights the principles that should be followed to ensure sound NBS practice. The primary application of the framework is prospective, **guiding decision-making and design during the planning and implementation phases of NBS projects**. The framework enables stakeholders to understand which factors influence their NBS project and how to address them, while also serving as a tool to compare competing NBS projects. It can also be applied retrospectively to **evaluate what went well, identify areas for improvement, and draw lessons for future projects**. The framework's content is **grounded in insights from interviews with experts** in the field of NBS, including both academics and practitioners. Its characteristics were shaped by the requirements identified by these experts, complemented by a close analysis of existing frameworks for NBS planning and implementation.

1.4 Who can use the SoC Framework?

The Seeds of Change Framework is mainly intended for stakeholders directly engaged in the planning and implementation of NBS projects in Dutch cities, or alternatively, for those responsible for evaluating projects after their completion. It is envisioned that **various governmental levels** (i.e. the national government, the provinces, the municipalities, and the regional water authorities), **urban planners**, **businesses**, **knowledge institutes**, **universities**, **financial institutions**, and **non-profit organizations** will all be primary users of the framework.

1.5 What does the SoC Framework look like?

het Park (n.d.)

This information booklet consists of two chapters, following this introductory chapter, designed to enhance the user's understanding of their NBS project(s) and thereby support their (successful) realization.

Chapter 2 presents an overview of the framework by outlining **seven themes of influencing factors**: (1) social and cultural (SC), (2) governance (G), (3) informational and technological (IT), (4) physical and ecological (PE), (5) financial (F), (6) political (P), and (7) legal (L). This chapter enables practitioners to systematically identify the barriers and drivers influencing their project(s), determine and select which strategies and measures can be implemented to address these factors or generally support their project(s), and recognize the principles that constitute good practice.

The first table lists influencing factors for which stakeholders must **identify whether they function as a barrier, driver, or both**. Next, the framework asks stakeholders to **assess the relevance of each factor**, classified as none, low, medium, or high. The following column refers to **numbered strategies and measures that can be selected to address each factor** (e.g., to overcome a barrier or leverage a driver). Commas indicate that one or several approaches may be selected, while plus signs (+) denote combinations of approaches that must be applied together. Typically, strategies and measures correspond to the same theme as the factor (e.g., political approaches address political factors). However, in some cases, strategies or measures from another theme can be applied. In those cases, the first letter of the relevant theme is indicated in parentheses after the number (e.g., (G) for governance). Separate **tables list the strategies and measures as well as the principles**, each with a unique number. If strategies or measures fall under a broader approach, they are sub-numbered and written in *italics* (e.g., *1.1 X*). While strategies and measures can be used to address specific barriers or drivers, they may also be applied more generally to stimulate NBS implementation. Principles, on the other hand, can always be taken into account. All tables are made for each theme separately.

Chapter 3 provides **one-line definitions for each factor** as well as **expert commentary and illustrative cases for selected factors** within each theme. This chapter offers additional context and demonstrates the practical application and value of the Seeds of Change Framework. The order of the factor definitions corresponds to their order in the tables in Chapter 2.

1.6 How can the SoC Framework be used?

START

STEP 1:
The workshop or meeting during which the framework is used should be facilitated by an expert on NBS. This expert should introduce the concept of NBS, clarify which project(s) are under assessment, and explain how the framework works.

STEP 2:
The stakeholders involved in the NBS project(s) should be divided across the different themes, ensuring that users apply the parts of the framework that align with their expertise.

STEP 3:
The stakeholder groups should apply the framework by identifying barriers and drivers, assessing their relevance, selecting appropriate strategies and measures, and noting relevant principles.

STEP 4:
The different groups should share their findings with all stakeholders to enable an open discussion, after which the final content of the framework should be determined.

Tuindingen (n.d.)

CHAPTER 2
FRAMEWORK OVERVIEW

2.1 Social/cultural (SC) factors

This theme considers how society perceives, values, and engages with NBS.

Identify barriers and drivers			
Barriers/drivers	**Type**	**Relevance**	**Strategies/measures**
Acceptance and support	Barrier / driver / both	None / low / medium / high	1+10+13, 2+10+13, 3+8, 4, 5+8, 6, 7, 8, 8.1, 9, 12, 14 (IT), 15 (IT)
Awareness and understanding	Barrier / driver / both	None / low / medium / high	1+10+13, 2+10+13, 5+8, 6, 8, 8.1, 9, 12, 14 (IT), 15 (IT)
Interests and priorities	Barrier / driver / both	None / low / medium / high	1+10+13, 2+10+13, 5+8, 6, 8, 8.1, 9, 11, 12, 14 (IT), 15 (IT)
Perspective on urban space	Barrier / driver / both	None / low / medium / high	1+10+13, 2+10+13, 5+8, 6, 8, 8.1, 9, 11, 12
Quality of life	Barrier / driver / both	None / low / medium / high	7
Reputational benefits	Barrier / driver / both	None / low / medium / high	6 (G), 7
Sense of ownership	Barrier / driver / both	None / low / medium / high	1+10+13, 2+10+13, 9, 12
Sense of place	Barrier / driver / both	None / low / medium / high	1+10+13, 2+10+13, 9, 12

2.1 Social/cultural (SC) factors

Select strategies and measures
1. Account for citizens' perspectives
2. Co-create with citizens
3. Design aesthetically pleasing
4. Design smartly
5. Embed NBS thinking
6. Facilitate citizen experiences
7. Frame smartly
8. Inform citizens
8.1 Communicate via videos/posters
9. Involve citizens in maintenance
10. Make participation locally relevant
11. Shift burden of proof
12. Stimulate citizen initiatives
13. Use engaging participatory models

Be aware of principles
1. Adapt to social/cultural context
2. Ensure just implementation
3. Involve all relevant citizen groups
4. Involve community/neighborhood managers
5. Keep participation realistic
6. Prioritize underserved areas

2.2 Governance (G) factors

This theme concerns how stakeholders collaborate, coordinate, and cooperate, as well as how decision-making processes are organized and implemented.

Identify barriers and drivers			
Barriers/drivers	**Type**	**Relevance**	**Strategies/measures**
Acceptance and support	Barrier / driver / both	None / low / medium / high	2, 3, 4, 6, 7.3, 14 (IT), 15 (IT)
Amount of stakeholders	Barrier / driver / both	None / low / medium / high	-
Awareness and understanding	Barrier / driver / both	None / low / medium / high	2, 3, 4, 6, 7.3, 14 (IT), 15 (IT)
Collaboration between departments	Barrier / driver / both	None / low / medium / high	7, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 8
Collaboration between organizations/sectors	Barrier / driver / both	None / low / medium / high	7, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 8
Departmental assignment structures	Barrier / driver / both	None / low / medium / high	7.7, 8
Interests and priorities	Barrier / driver / both	None / low / medium / high	2, 3, 4, 6, 7.3, 14 (IT), 15 (IT)
Leadership/responsibility	Barrier / driver / both	None / low / medium / high	1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7
Networks	Barrier / driver / both	None / low / medium / high	-
Personal relationships	Barrier / driver / both	None / low / medium / high	-
Precedent effects	Barrier / driver / both	None / low / medium / high	5
Time	Barrier / driver / both	None / low / medium / high	5

2.2 Governance (G) factors

Select strategies and measures
1. Declare stakeholders responsible
1.1 Declare all governmental levels responsible
1.2 Declare all stakeholders responsible
1.3 Declare citizens responsible
1.4 Declare companies responsible
1.5 Declare municipalities reponsible
1.6 Declare the metropolitan regions responsible
1.7 Declare the national government responsible
2. Develop/use 3D/AR/VR tools
3. Develop/use visualization tools
4. Embed NBS thinking

Select strategies and measures
5. Embed patience and flexibility
6. Organize NBS competitions
7. Stimulate collaboration between stakeholders
7.1 Develop/use co-creation tools
7.2 Develop/use communication tools
7.3 Develop/use serious games
7.4 Embed new governance models
7.5 Establish construction/thematic groups
7.6 Install committee for collaboration
7.7 Link to urban agendas
8. Use windows of opportunity

Be aware of principles
1. Make a stakeholder engagement plan

2.3 Informational/technological (IT) factors

This theme focuses on the role of knowledge, data, and tools in supporting decision-making for NBS.

Identify barriers and drivers			
Barriers/drivers	**Type**	**Relevance**	**Strategies/measures**
Capacity	Barrier / driver / both	None / low / medium / high	1
Conferences	Barrier / driver / both	None / low / medium / high	-
Data availability	Barrier / driver / both	None / low / medium / high	2, 5, 11, 11.1, 12, 14, 15, 16, 17
Data expressibility	Barrier / driver / both	None / low / medium / high	3, 4, 12, 17, 20, 21
Data measurability/predictability	Barrier / driver / both	None / low / medium / high	11, 11.1, 14, 15
Definition	Barrier / driver / both	None / low / medium / high	13
Education/training programs	Barrier / driver / both	None / low / medium / high	10.1
Knowledge	Barrier / driver / both	None / low / medium / high	6, 8, 10, 10.1, 10.2, 10.3, 14, 15, 19
Research	Barrier / driver / both	None / low / medium / high	14, 15, 18, 19
Technological advancements	Barrier / driver / both	None / low / medium / high	-
Tool availability/use	Barrier / driver / both	None / low / medium / high	7, 9, 10.1, 11, 11.1, 12, 16

2.3 Informational/technological (IT) factors

Select strategies and measures
1. Build capacity
2. Classify NBS and attributes
3. Combine objective and subjective methods
4. Combine qualitative and quantitative methods
5. Create data overviews
6. Create nature overviews
7. Create tool overviews
8. Develop/use catalogs
9. Develop/use NBS selection tools
10. Educate practitioners
10.1 Integrate NBS into eduction/training programs
10.2 Map frontrunners and beginners
10.3 Organize masterclasses

Select strategies and measures
11. Employ (scenario) modeling studies
11.1 Employ GIS studies
12. Employ survey studies
13. Establish a NBS definition
14. Establish ULLs
15. Execute demonstration projects
16. Integrate models
17. Quantify costs and (co-)benefits
18. Research link with health
19. Synthesize essential NBS theory
20. Use averages in calculations
21. Use proxies in calculations

Be aware of principles
1. Check with local context
2. Compare model outputs
3. Ensure monitoring
4. Practice problem-solution alignment

2.4 Physical/ecological (PE) factors

This theme concerns the biophysical and ecological conditions that influence the feasibility of NBS.

Identify barriers and drivers			
Barriers/drivers	**Type**	**Relevance**	**Strategies/measures**
Adaptability	Barrier / driver / both	None / low / medium / high	-
Aesthetic appeal	Barrier / driver / both	None / low / medium / high	3 (SC)
Air quality	Barrier / driver / both	None / low / medium / high	-
Biodiversity	Barrier / driver / both	None / low / medium / high	-
Climate adaptation/mitigation	Barrier / driver / both	None / low / medium / high	-
Cooling/UHI effect	Barrier / driver / both	None / low / medium / high	-
Existing systems	Barrier / driver / both	None / low / medium / high	3
Maintenance requirements	Barrier / driver / both	None / low / medium / high	9, 9 (SC)
Multifunctionality	Barrier / driver / both	None / low / medium / high	1
Recreational space	Barrier / driver / both	None / low / medium / high	-
Space availability	Barrier / driver / both	None / low / medium / high	1, 2, 3, 4, 6, 7, 8
Suitable locations	Barrier / driver / both	None / low / medium / high	5
Water infiltration/hydrological risks	Barrier / driver / both	None / low / medium / high	-

2.4 Physical/ecological (PE) factors

Select strategies and measures
1. Assign multiple functions
2. Create pores in structures/spaces
3. Implement hybrid NBS
4. Implement single plants
5. Optimize soil use
6. Reshape transport/mobility
7. Use biophilic/biomimicry design
8. Use private space
9. Use zero maintenance species

Be aware of principles
1. Account for climate conditions
2. Account for trophic pyramids
3. Balance maintenance and natural processes
4. Create interconnected green and blue areas
5. Ensure contribution to biodiversity
6. Ensure maintenance and management
7. Ensure robustness
8. Implement native plant species
9. Look beyond city scale
10. Select site-compatible NBS
11. Use multiple species

2.5 Financial (F) factors

This theme focuses on NBS their costs and benefits expressed in monetary terms, the mechanisms through which they are financed, and the ways in which they can be embedded within broader financial systems.

Identify barriers and drivers			
Barriers/drivers	**Type**	**Relevance**	**Strategies/measures**
(Maintenance) costs	Barrier / driver / both	None / low / medium / high	2, 4, 9 (SC)
Business case	Barrier / driver / both	None / low / medium / high	1, 1 (PE), 2, 17 (IT)
Departmental financing structures	Barrier / driver / both	None / low / medium / high	1
Entrepreneurship	Barrier / driver / both	None / low / medium / high	-
Financing	Barrier / driver / both	None / low / medium / high	3, 4
Property value	Barrier / driver / both	None / low / medium / high	-

Select strategies and measures
1. Combine departmental financing streams
2. Compare costs and benefits NBS vs grey solutions
3. Establish co-financing models
4. Use NBS subsidies

Be aware of principles
1. Dedicate budget towards maintenance

2.6 Political (P) factors

This theme addresses both the political dynamics surrounding NBS and the ways in which policymakers perceive and integrate NBS into their policy frameworks.

Identify barriers and drivers			
Barriers/drivers	**Type**	**Relevance**	**Strategies/measures**
Amount of beneficiaries	Barrier / driver / both	None / low / medium / high	-
Interests and priorities	Barrier / driver / both	None / low / medium / high	1, 14 (IT), 15 (IT)
Policies	Barrier / driver / both	None / low / medium / high	2

Select strategies and measures
1. Embed NBS in planning frameworks
2. Implement coherent supportive policies

Be aware of principles
1. Implement NBS maintenance policy

2.7 Legal (L) factors

This theme concerns the laws and regulations that shape the space in which NBS can be developed.

Identify barriers and drivers			
Barriers/drivers	**Type**	**Relevance**	**Strategies/measures**
Land ownership/use	Barrier / driver / both	None / low / medium / high	2, 2.1, 2.2, 2.3, 2.4, 6 (G), 12 (SC)
Regulations	Barrier / driver / both	None / low / medium / high	1, 2, 2.1, 2.2, 2.3, 2.4, 2.5

Select strategies and measures
1. Allow flexibility in regulations
2. Implement coherent supportive regulations
2.1 Implement biodiversity net gain regulation
2.2 Implement NBS point system
2.3 Implement no loss regulation
2.4 Mandate greenery/water storage inclusion
2.5 Mandate pavement removal

Be aware of principles
1. Use maintenance agreements

CHAPTER 3
FACTOR DEFINITIONS, EXPERT COMMENTS AND ILLUSTRATIVE CASES

3.1 Social/cultural factors - Definitions

Understand factors	
Factors	**Definitions**
Acceptance and support	The extent to which citizens accept and support NBS implementation (in their neighborhood).
Awareness and understanding	The extent to which citizens are aware of (the need for) NBS and understand what they entail.
Interests and priorities	The existence or absence of public interest in NBS and whether or not NBS are considered a priority by citizens.
Perspective on urban space	The societal view on the shaping, design, and management of (public) urban space.
Quality of life	The contribution NBS can have to the quality of life of citizens (e.g. mental and physical health, living comfort, neighborhood safety).
Reputational benefits	The influence of NBS on the societal reputation of adopting companies.
Sense of ownership	The role of NBS in fostering a sense of ownership among neighborhood citizens.
Sense of place	The role of NBS in fostering a sense of place among neighborhood citizens.
Account for citizens' perspectives	Actively seek citizens' perspectives and incorporate them into the design and implementation of NBS projects.
Co-create with citizens	Use a collaborative, participatory process to design and implement NBS projects together with local citizens.
Design aesthetically pleasing	Design NBS in an aesthetically pleasing to enhance public acceptance and support.
Design smartly	Design NBS smartly to reduce resistance: avoid allergens, stagnant water, or pest-attracting features, and provide paths for engagement.
Embed NBS thinking	Encourage society to approach projects and everyday life from the perspective of how nature and NBS can be integrated.
Facilitate citizen experiences	Enable citizens to experience NBS (e.g. nature walks, Tegelwippen, experience difference between areas with grey solutions and NBS).

3.1 Social/cultural factors - Definitions

Understand factors	
Factors	**Definitions**
Frame smartly	Frame NBS and their benefits around stakeholder interests/priorities (e.g., health for citizens, climate adaptation for governments).
Inform citizens	Inform citizens about what NBS are and the range of benefits they can deliver.
Communicate via videos/posters	Communicate information about NBS via videos and posters as citizens are typically not inclined to read (scientific) articles.
Involve citizens in maintenance	Involve citizens in the maintenance of parts of NBS projects (e.g., weeding and watering of plants).
Make participation locally relevant	Make citizen participation locally relevant and tangible to motivate citizens to get on board of participatory sessions on NBS.
Shift burden of proof	Shift the burden of proof from NBS to grey solutions (or share the burden), thus first think of NBS before thinking about grey solutions.
Stimulate citizen initiatives	Stimulate citizens to initiate and design their own NBS projects.
Use engaging participatory models	Use engaging participatory formats (e.g., bike tour, draw your vision) to motivate citizens to get on board of participatory sessions on NBS.
Adapt to social/cultural context	Adapt NBS designs to the social and cultural context of the neigborhood in which they are being implemented.
Ensure just implementation	Ensure just implementation of NBS by including less wealthy neighborhoods and preventing social displacement in these areas.
Involve all relevant citizen groups	Involve all citizen groups that will be affected by the implementation of NBS projects (in their neighborhood).
Involve community/neighborhood managers	Involve community/neighborhood managers to reach out to different populations for participatory sessions on NBS.
Keep participation realistic	Keep citizen participation realistic (e.g., value their input without false promises, they shape details while experts set overall requirements).
Prioritize underserved areas	Prioritize neighborhoods with limited NBS when deciding where to implement them to support just and socially fair outcomes.

3.1 Social/cultural factors - Expert comments

Real life comments
"I think there are more and more people being aware, then there are people that are aware but they don't really want to leave their comfort zones, and then there are people that are not aware and don't give a damn. Of course this depends on the country. Different countries have different perceptions of the urgency of climate adaptation and what Nature-Based Solutions mean in general and for them and for their daily lives and the future generations." *"I do think that involving them [citizens] helps to create support and understanding of the values of the benefits. Also because they're actively being asked like, OK, what do you want here?"* *"Well, those are six videos that basically show the scientific research results of that project in a very basic way. And those videos are very simplified and explain why nature in the city is important and what you should do in a growing area or with water or whatever. Scientists should learn to communicate with residents in this way."* *"You need to connect with pressing issues that concern the owner or residents themselves. If you are talking about Nature-Based Solutions in industrial areas, link that to the energy transition, because that is what the area is currently focused on. If you are talking about housing and neighborhoods, link it to climate adaptation. So, initially, water storage, because that allows you to reduce damage caused by flooding. Link it to heat. Heat doesn't cost people money, but they do experience it and find it unpleasant. So link it to current themes, but not only to the current theme. Just keep emphasizing that it will simply make the neighborhood more pleasant and livable overall."*

3.1 Social/cultural factors - Illustrative case

Illustrative case
The Community Garden Emma's Hof in The Hague was co-created with citizens between 2007 and 2011 on the site of an abandoned building (Urban Nature Atlas, 2021a). The project was initiated by a group of 8 citizens. A continuous effort was made to inform citizens about both nature and the project to enhance awareness, understanding, support, and acceptance as well as to increase participation. While citizens came up with the general plan and goals for the park, engineering consultant Arcadis developed the exact design of the park, and various other public, private, and NGO stakeholders also participated. Co-planning and consultation took place in the beginning of the project through use of engaging participatory formats, such as workshops, focus groups, surveys, participatory mapping, and community meetings. Implementation was joint, and after completion citizens founded Stichting Emma's Hof, which now owns the land and organizes maintenance with volunteers and a nearby primary school. Beyond ecological benefits, the garden's main aim was to increase the quality of life of neighborhood citizens. Emma's Hof contributes to social interaction and cohesion, promotes cultural diversity by reducing social isolation of cultural minorities and elderly, puts children in contact with nature, increases health and well-being, provides a sense of ownership and management, and improves livability. This case highlights the value of encouraging citizen initiatives, layered citizen participation (planning, co-creation, maintenance, management), the drivers quality of life, sense of ownership, and sense of place, and the importance of making participation locally relevant, tangible, and engaging. The NK Tegelwippen is an annual competition between Dutch municipalities that encourages citizens to replace pavement tiles from their gardens with greenery (NK Tegelwippen, n.d.). Municipalities facilitate participation to not only raise awareness and understanding of NBS by letting citizens experience nature, but also to build support, acceptance, and a greater appreciation of nature as a priority. In 2024 alone, over 5.5 million tiles were replaced, with almost 60% of the Dutch municipalities taking part and realizing a range of greening projects: from mini gardens to green schoolyards and from private garden transformations to large neighborhood projects (Kennisportaal Klimaatadaptatie, 2024). This case demonstrates how citizen experiences can foster a nature-oriented mindset among citizens and drive NBS adoption. Non-participating cities could follow this example or organize alternative initiatives such as guided nature walks.

3.2 Governance factors - Definitions

Understand factors	
Factors	**Definitions**
Acceptance and support	The extent to which stakeholders accept and support NBS implementation.
Amount of stakeholders	The amount of stakeholders that are involved in NBS projects.
Awareness and understanding	The extent to which stakeholders are aware of (the need for) NBS and understand what they entail.
Collaboration between departments	The degree of collaboration between different departments within governmental organizations on NBS projects.
Collaboration between organizations/sectors	The degree of collaboration between different organizations and sectors on NBS projects.
Departmental assignment structures	The way in which assignments of different deppartments within governmental organizations are structured.
Interests and priorities	The existence or absence of stakeholders' interest in NBS and whether or not NBS are considered a priority by stakeholders.
Leadership/responsibility	The extent to which stakeholders demonstrate leadership and responsibility for NBS implementation.
Networks	The existence or absence of networks in which stakeholders can meet, exchange knowledge, and team up for NBS projects.
Personal relationships	The presence or absence of personal relationships with stakeholders that are needed for NBS projects.
Precedent effects	Whether stakeholders are concerned that granting rule exemptions for NBS could set precedents and be misused.
Time	Whether stakeholders are concerned with the time it takes to implement NBS projects.

3.2 Governance factors - Definitions

Understand factors	
Factors	**Definitions**
Declare stakeholders responsible	Declare stakeholder(s) (groups) responsible for implementing and upscaling NBS.
Declare all governmental levels responsible	Declare all governmental levels (i.e. EU, national, provincial, metropolitan, municipal) responsible for implementing and upscaling NBS.
Declare all stakeholders responsible	Declare all stakeholders (i.e. all governmental levels, citizens, and companies) responsible for implementing and upscaling NBS.
Declare citizens responsible	Declare citizens responsible for implementing and upscaling NBS.
Declare companies responsible	Declare companies responsible for implementing and upscaling NBS.
Declare municipalities responsible	Declare municipalities responsible for implementing and upscaling NBS.
Declare the metropolitan regions responsible	Declare the metropolitan regions responsible for implementing and upscaling NBS.
Declare the national government responsible	Declare the national government responsible for implementing and upscaling NBS.
Develop/use 3D/AR/VR tools	Develop or use 3D/AR/VR tools to show stakeholders the difference between the current situation and a situation with NBS.
Develop/use visualization tools	Develop or use visualization tools to show stakeholders the difference between the current situation and a situation with NBS.
Embed NBS thinking	Encourage stakeholders to approach projects from the perspective of how nature and NBS can be integrated.
Embed patience and flexibility	Embed slack time and flexibility within governmental organizations to support NBS projects.

3.2 Governance factors - Definitions

Understand factors	
Factors	**Definitions**
Organize NBS competitions	Organize competitions for businesses to incorporate NBS (e.g., on company grounds) to get them interested in the concept.
Stimulate collaboration between stakeholders	Stimulate collaboration between various stakeholder(s) (groups) (i.e. businesses, governments, citizens, NGOs) in NBS projects.
Develop/use co-creation tools	Develop or use tools for co-creating NBS projects with various stakeholder(s) (groups) to support collaboration.
Develop/use communication tools	Develop or use communication tools for NBS projects with various stakeholder(s) (groups) to support collaboration.
Develop/use serious games	Develop or use serious games to see what stakeholders consider to be important, thereby supporting collaboration.
Embed new governance models	Institutionalize new governance models to secure sustained collaboration on NBS.
Establish construction/thematic groups	Establish construction/thematic groups at the start of NBS projects including stakeholders aligned with key points.
Install committee for collaboration	Install a committee that oversees collaboration to ensure that everyone works together; to serve as a big stick.
Link to urban agendas	Link NBS (projects) to the urban agendas of stakeholder(s) groups.
Use windows of opportunity	Make use of windows of opportunity for NBS that present itself (e.g., road or building reconstruction, need for temperature reduction).
Make a stakeholder engagement plan	Make a stakeholder plan to clarify who should be involved and how, when, and why they are participating.

3.2 Governance factors - Expert comments

Real life comments
"In my experience with the interviews, I think the argument that we got over and over again for the Dutch context, is that there is still not as much coordination between departments as there should be. Everyone still works on the topic that is given to them and there is a siloed approach even now."
"There is no single party willing to take up the gauntlet, especially if it involves costs. So it brings many advantages for many different parties, but it falls somewhat between responsibilities."
"There are many organizations and institutes that have the CoP, the Community of Practice, and these are very good platforms for people to meet each other, to know that they exist, and to team up. You also have organizations that have people like me [practitioner], but also from the governments, and there they can meet each other and team up for projects and do researches and this type of initiatives. And then it happens also very often, mostly when it's an open call or when it's a subsidy from the European Union, for example for funds, that there are these matchmaking platforms where you come listening to or reading who's there, who's interested in applying to that project, to that goal, and then you can team up with those parties. So basically there are different platforms with different objectives, but all of them are committed to engaging stakeholders."
"Things are being redeveloped, the street is being opened up for maintenance work on the road surface, things are being built or redesigned, and sometimes there is simply an absolute necessity to increase safety in an area. So take advantage of the windows of opportunity that exist, where action is taken or a change is made, and then look for solutions or design solutions."

3.2 Governance factors - Illustrative case

Illustrative case
The City Island (Park Tour) is an ongoing project in the municipality of Utrecht that concerns the creation of a climate-proof city island of 45 acres that includes multiple NBS along two canals with a cycling/walking tour of 12 kilometers around it, thereby forming a large city park (Urban Nature Atlas, 2021c; Gemeente Utrecht, 2024). The project has been linked to the urban agendas of several stakeholders by integrating elements relevant to them, which stimulated multi-stakeholder collaboration and enabled the realization of NBS on a large scale. For example, attention to water management attracted Rijkswaterstaat, a focus on climate adaptation and mitigation engaged the Coalition Spatial Adaptation Utrecht, and the recreational features, including the cycling/walking tour, led to the involvement of architecture firms, designers, and sport associations (Urban Nature Atlas, 2021c). The project is led by a central committee, RSE, that oversees the collaboration, but smaller construction or thematic groups work on the various subprojects, including spatial interventions and area developments (Gemeente Utrecht, 2024). Visualization tools are used to generate renders of the park, making NBS designs more tangible for stakeholders. This case shows how using such tools, linking NBS (projects) to the urban agendas of multiple stakeholders, installing a central committee, and establishing construction or thematic groups can strengthen collaboration among stakeholders. Haskoning recently developed the serious game Engreeneering to support multi-stakeholder decision-making for NBS (Haskoning, n.d.). The game is based on the fictional 'Valley Town', where the demand for housing has increased, and requires stakeholders to make choices about the development of a greenfield site near a nature reserve and river. Stakeholders can base their decisions on three criteria, being costs, citizen satisfaction, and nature, meaning that their decisions show where their interests and priorities lie. They can directly see the impact of each decision on the short-term and long-term on citizens, budgets, and ecosystems as well as the benefits of NBS and ROI. By earning points for improved decisions, stakeholders learn to balance trade-offs. The game is designed to raise awareness of NBS, highlight their value for cities, and foster collaboration among stakeholders. This case shows how tools for collaboration, in this case a serious game, can create awareness, shed light on and shift stakeholders' interests and priorities, and can help with encouraging collaborative approaches.

3.3 Informational/technological factors - Definitions

Understand factors	
Factors	**Definitions**
Capacity	The amount of employees within executing agencies with knowledge, skills, and experience in implementing NBS.
Conferences	The presence of conferences on the topic of NBS or related measures.
Data availability	Whether data on variables of interest is available (e.g., open access, desired scale).
Data expressibility	Whether variables of interest can be quantified in a meaningful way (e.g., quantifying social benefits, expressing co-benefits in money).
Data measurability/predictability	Whether variables of interest can be measured (e.g., monitoring) or predicted (e.g., modeling).
Definition	Whether a clear, agreed-upon definition for NBS exists.
Education/training programs	The amount and type of education and training programs that are centered on NBS or include NBS.
Knowledge	The amount of in-depth professional knowledge on NBS and urban ecology within executing agencies.
Research	The amount and type of research that has been done on NBS.
Technological advancements	Whether technological advancements have been made in the field of NBS, or in another field, that can influence NBS implementation.

3.3 Informational/technological factors - Definitions

Understand factors	
Factors	**Definitions**
Tool availability/use	The availability of tools that can support NBS implementation and whether they are/can be used by practitioners.
Build capacity	Hire more employees, within executing agencies, with knowledge, skills, and experience in implementing NBS.
Classify NBS and attributes	Develop a dataset that classifies NBS, such as pocket parks, and contains attributes describing their functions, such as shading effect.
Combine objective and subjective methods	Combine objective (e.g., modeling) and subjective (e.g., survey) methods to provide output on variables of interest.
Combine qualitative and quantitative methods	Combine qualitative (e.g., interviews) and quantitative (e.g., modeling) methods to provide output on variables of interest.
Create data overviews	Create an overview of the available data on NBS to help practitioners with finding data and to see which data is missing.
Create nature overviews	Create an overview of the plant, shrub, and tree species that are beneficial for biodiversity, and thus can be used in NBS projects.
Create tool overviews	Create an overview of the available tools that can support NBS implementation to help practitioners with finding tools.
Develop/use catalogs	Develop or use a catalog with examples of implemented NBS projects as inspiration; see what is possible and how it is achieved.
Develop/use NBS selection tools	Develop or use tools that can help with selecting NBS for a specific location based on the context as well as the costs and benefits.

3.3 Informational/technological factors - Definitions

Understand factors	
Factors	**Definitions**
Educate practitioners	Educate practitioners on NBS, their benefits, and their applications.
Integrate NBS into education/training programs	Incorporate NBS into education and training programs within early and higher education as well as professional organizations.
Map frontrunners and beginners	Map frontrunner and beginner stakeholders to enhance knowledge exchange among practitioners.
Organize masterclasses	Organize masterclasses to exchange knowledge (e.g., show what is possible, how problems and obstacles are dealt with).
Employ (scenario) modeling studies	Employ (scenario) modeling studies to gather data on variables of interest (under different scenarios).
Employ GIS studies	Employ GIS studies to gather data on variables of interest.
Employ survey studies	Employ survey studies to gather data on how citizens perceive NBS (projects).
Establish a NBS definition	Establish a clear, agreed-upon definition for NBS.
Establish ULLs	Establish ULLs to provide a safe environment for stakeholders to experiment with NBS and learn by doing as well as to gather data.
Execute demonstration projects	Execute demonstration projects to show feasibility and functionality of NBS as well as to gather data on variables of interest.

3.3 Informational/technological factors - Definitions

Understand factors	
Factors	**Definitions**
Integrate models	Integrate models to conduct studies that generate outputs for all variables of interest.
Quantify costs and (co-)benefits	Quantify the costs and (co-)benefits of NBS, both in monetary and non-monetary terms.
Research link with health	Research the influence of NBS on citizens' (mental and physical) health.
Synthesize essential NBS theory	Synthesize essential NBS theory into a guide to provide practitioners with a status quo and basic understanding of the concept.
Use averages in calculations	Use averages to represent NBS key figures that vary across a range of performance.
Use proxies in calculations	Use proxies to express variables of interest that are difficult to quantify.
Check with local context	Check NBS data and case examples in relation to the local context before transfer; don't copy-paste directly.
Compare model outputs	Compare model outputs to help make uncertainties more transparent and provide margins within which the solutions are likely to work.
Ensure monitoring	Ensure that NBS projects are monitored to gather data.
Practice problem-solution alignment	Practice alignment of problems with NBS designs by learning which NBS best deliver specific benefits and address particular challenges.

3.3 Informational/technological factors - Expert comments

Real life comments
"There are certainly key figures, but these are quite location-specific and perhaps still too generic. So we have certainly made assumptions in this regard."
"We have tools that look at system understanding, i.e., the system works in a certain way, these are the ecosystem services that a particular system can provide, and how can you make optimal use of them? There are tools that look at what the challenges are in a particular area, what the vulnerabilities are in an area, and what measures are needed. There are tools that look at possible solutions and how you could apply them in this, this, and this way. And there are tools that tell you that if you want to implement this measure, you have to take XYZ into account."
"I made a very simple booklet where I show what the situation was and what it has become. Then you immediately get a feeling of, OK, so that's achievable, and that's what it looked like before."

3.3 Informational/technological factors - Illustrative case

Illustrative case
TKI Eco-System-City was an Urban Living Lab project that consisted of several pilot projects in Alphen a/d Rijn, Arnhem, Rotterdam, and Utrecht (TKI Eco-Systeem-Stad, n.d.). Its aim was to generate knowledge and NBS designs for challenges concerning drought, heat, flooding, and opportunities for biodiversity in the cities. The central research questions focused on the urban water balance for greenery, the types of greenery suitable for future cities, and how considering these factors affects the social costs and benefits of urban green. The project taught stakeholders extensively about NBS and led to demonstration projects, data generation through monitoring, and the creation of models, nature overviews, and catalogs. Results were published in journals, shared through videos, and presented at conferences. This case shows the value of Urban Living Labs in generating and disseminating knowledge, data, and tools, while also increasing awareness, understanding, acceptance, support, and the perceived importance and priority of NBS among policymakers, stakeholders, and society. The municipality of Eindhoven developed an inspiration booklet for NBS that can be seen as a combination between a synthesization of essential NBS theory and a catalog of example NBS projects (Roijackers, 2018). The first part of the booklet focuses on defining the concept, identifying which challenges can be addressed with NBS, describing the types of NBS available, and how these NBS can address the issues. While this section already introduces several examples of NBS, the second part provides more in-depth examples of realized NBS projects. This case highlights the importance of establishing a clear and shared definition of NBS, as well as the value of providing accessible theoretical foundations and practical examples. Such resources help disseminate knowledge, inspire practitioners, and enhance their awareness and understanding of NBS. In June 2025 two experts from Wageningen University & Research and Deltares gave a masterclass on NBS for practitioners working in governmental organizations (Natuur en Milieufederaties, 2025). They presented a climate- and future-proof vision for the Netherlands in 2120, built around five guiding principles in which NBS play a central role. This vision was translated into practice by demonstrating how NBS are already being implemented at numerous locations, both in the Netherlands and abroad, and it was emphasized that nearly every street in the Netherlands requires modifications with NBS to achieve the 2050 goals for heat, flooding, and drought resilience. The session also addressed questions on how to build acceptance and support among policymakers, society, and other stakeholders, how regulations can facilitate NBS adoption, and which tools can be used to make the societal and economic value of NBS visible. The masterclass led to a working visit in September, where participants explored local NBS projects and learned from on-the-ground experiences. This case illustrates the importance of organizing masterclasses to help practitioners exchange knowledge, share perspectives, and bridge the gap between vision and practical implementation.

3.4 Physical/ecological factors - Definitions

Understand factors	
Factors	**Definitions**
Adaptability	The potential of the NBS to adapt to the specific conditions of the neighborhood where it is implemented.
Aesthetic appeal	The aesthetic appeal of a neighborhood and the contribution that NBS can make to it.
Air quality	The air quality in a neighborhood and the effect that NBS can have on it.
Biodiversity	The biodiversity in a neighborhood and the ability of NBS to help with protecting, restoring, and conserving it.
Climate adaptation/mitigation	The need for climate adaptation and mitigation measures in a neighborhood and the role NBS can play in addressing it.
Cooling/UHI effect	The presence of the urban heat island (UHI) effect in a neighborhood and the potential of NBS to provide cooling and mitigate it.
Existing systems	The presence of current infrastructure and the potential for integration with NBS.
Maintenance requirements	The intensity of maintenance requirements for NBS, including time, cost, and labor.
Multifunctionality	The need for multifunctional solutions in a neighborhood (given the multiple challenges present) and the ability of NBS to fulfill this need.
Recreational space	The availability of recreational spaces within a neighborhood and the ability of NBS to create or enhance such spaces.
Space availability	The availability of space for implementing NBS.

3.4 Physical/ecological factors - Definitions

Understand factors	
Factors	**Definitions**
Suitable locations	The availability of locations suitable for hosting NBS (e.g., soil conditions, slope of roofs).
Water infiltration/hydrological risks	The hydrological risks in a neighborhood and the capacity of NBS to enhance water infiltration and reduce flood risk.
Assign multiple functions	Design NBS with multiple functions (e.g., biodiversity, parking, water infiltration) to address space limits and leverage multifunctionality.
Create pores in structures/spaces	Incorporate vegetation like grass and trees into (small) openings within structures/spaces.
Implement hybrid NBS	Implement hybrid NBS integrating natural features with grey infrastructure, for example, green roofs and living walls.
Implement single plants	Implement one plant (e.g., pergolas with plants or trellises between the facades with a small wisteria) to deal with a lack of space.
Optimize soil use	Optimize the way in which soil can be used for NBS.
Reshape transport/mobility	Reshape the transport/mobility sector with measures (e.g., promoting shared mobility or reducing parking spaces) to make room for NBS.
Use biophilic/biomimicry design	Implement nature-inspired designs that mimic nature while including artificial materials/construction methods and architectural elements.
Use private space	Implement NBS on private terrain (of citizens and businesses) as a supplement to NBS in public spaces.
Use zero maintenance species	Use species that require no or spontaneous maintenance, meaning that the NBS look well even without maintenance.

3.4 Physical/ecological factors - Definitions

Understand factors	
Factors	**Definitions**
Account for climate conditions	Account for climate conditions in species selection for NBS to enhance resilience and survival.
Account for trophic pyramids	Use trophic pyramids to guide the composition and abundance of fauna, informing which species to select to sustain the ecosystem.
Balance maintenance and natural processes	Balance NBS maintenance with the space for natural processes to unfold.
Create interconnected green and blue areas	Develop a network of interconnected NBS to uphold the ecosystemic approach and maximize the delivery of benefits.
Ensure contribution to biodiversity	Ensure that implemented NBS enhance biodiversity, at minimum, given their multifunctional character.
Ensure maintenance and management	Ensure that implemented NBS are being maintained and managed.
Ensure robustness	Ensure that the system of NBS is robust, thus can handle changing (climate) conditions and keeps functioning if a part of it is interrupted.
Implement native plant species	Use mostly species that are native to the site where they are implemented.
Look beyond city scale	Adopt a holistic perspective by considering nearby rural areas and nature reserves to create a NBS network and maximize benefits.
Select site-compatible NBS	Select NBS that are compatible with the biophysical conditions of the site at which they are being implemented.
Use multiple species	Incorporate multiple species into NBS design to increase biodiversity richness and ensure higher survival rates.

3.4 Physical/ecological factors - Expert comments

Real life comments
"Well, those hybrid solutions mainly arise because in the Netherlands, but also in many other countries, you are already part of an existing system. You don't start from scratch, right? And very often it's an existing system that you have to connect to, so you're actually talking about a transition. First, you have to keep both systems intact, and only when you can completely replace the system do you have a system redesign. But in practice, this is almost never the case, even in other countries where it is very nature-oriented." *"That is a requirement because, in the design world, we are currently very stuck in the mindset that something is either a place for a tree to grow or a parking space, but we no longer have room for that, and climate adaptation no longer allows us that option. Something in the city must have at least three functions. It must be a place where you can manage your rainwater, a place where tree roots can grow well without damage, and it must be a parking space."* *"There are also some nice examples of underground parking lots with a hole in them, where two parking spaces are removed and replaced by a tree that grows all the way up above the parking garage. But that can also be done on a very small scale, like that beautiful school in Boulanger Billancourt, which is a part of Paris where the facades are slightly staggered, creating gaps where all kinds of moss and grass can grow."*

3.4 Physical/ecological factors - Illustrative case

Illustrative case
The Willem Alexander Park is a roof park in Utrecht that is built on the A2 highway tunnel (Urban Nature Atlas, 2021b). As Utrecht is densely built and populated, there is a lack of space within the city. By making use of an existing system, in this case a highway tunnel, a hybrid NBS was created by implementing a park of 80,000 m2 on the tunnel's roof (Gemeente Utrecht, n.d.). The park consists of prairie plantings for which various species have been used. While the park is maintained, natural processes are allowed to unfold, thereby constantly expanding the amount and variety of plants. However, actions were taken to protect certain species, especially native and valued kinds (Urban Nature Atlas, 2021b). Moreover, the soil has been optimized by addition of minerals and fibers to make it stable for NBS and to improve the water retention capacity (Gemeente Utrecht, n.d.). The park was designed to deliver multiple benefits and to serve several functions (Urban Nature Atlas, 2021b). One of the main goals was the creation of a connecting ecological green zone, connected to other green zones in the city, to promote the mobility of species. The park contributes to biodiversity by preserving and strengthening existing habitats and ecosystems as well as providing new habitats for various species, including butterflies, bees, and birds. In addition, it manages stormwater and rainfall by providing storage, improves air and soil quality, and enhances waste management. Furthermore, the park serves as a recreational space for citizens, offering walking paths, gardening, and urban agriculture, which also increases citizens' access to healthy and affordable food. The aesthetic appreciation of the park is also recognized as a benefit. Beyond ecological gains, the park delivers several benefits in the social and cultural domain: it provides opportunities for social interaction and physical activity, fosters social cohesion, and contributes to citizen's overall health and well-being. All these functions are deliberately assigned to the park, which is also reflected in its design consisting of five segments with a thematic program: (1) connect & meet, (2) art & culture, (3) sports & games, (4) nature & education, and (5) food & drinks. This case illustrates how space limitations can be overcome by creating hybrid NBS with existing infrastructure. Moreover, it demonstrates how the various (ecological) drivers and multifunctionality characteristic of NBS are leveraged by assigning multiple functions to the park. Also, it shows the importance of optimizing soil use, balancing maintenance and natural processes, creating a network of connected NBS, and implementing multiple species.

3.5 Financial factors - Definitions

Understand factors	
Factors	**Definitions**
(Maintenance) costs	The costs of NBS projects (i.e. costs for planning, designing, implementing, maintaining, managing, and monitoring).
Business case	Whether a formal justification for a NBS project, considering options, costs, benefits, and risks, can be provided to support its progression.
Departmental financing structures	The way in which financing streams of different deppartments within governmental organizations are structured.
Entrepreneurship	The contribution of NBS to enterprises and entrepreneurship (in the sustainability domain).
Financing	The availability of financial resources for NBS projects.
Property value	The change in property value when NBS are implemented in close proximity to the property.
Combine departmental financing streams	Combine financial resources across governmental departments to enable joint financing and collaboration.
Compare costs and benefits NBS vs grey solutions	Compare the costs and benefits of NBS with those of grey solutions.
Establish co-financing models	Establish financial models that allow multiple stakeholders to contribute funds to a project, thereby pooling resources.
Use NBS subsidies	Make use of subsidies that governmental organizations provide for NBS projects to reduce costs and simplify the financing process.
Dedicate budget towards maintenance	Ensure there is budget allocated for maintenance to ensure long-term performance of the solutions and prevent issues from arising.

3.5 Financial factors - Expert comments

Real life comments
"That booklet X contains a table comparing the costs of green space maintenance with the costs of road maintenance, based on the costs provided by my colleagues in Management. It shows that green space maintenance is cheaper than the maintenance of paved spaces if you do it smartly, which immediately convinced the alderman, who said, "Let's do it!"."
"For street trees and urban trees, you can use the i-Tree model to calculate the monetary value that urban trees deliver to the city. The only problem is that these values do not end up in the city council's bank account, because they belong to everyone."
"The point is that if you have pillarized financing structures and assign them to single tasks and give them a budget for that, you are not promoting cooperation. You are ensuring that certain parties work towards achieving and ticking off: I have achieved my task and this is my money and this is what I am going to spend it on."

3.5 Financial factors - Illustrative case

Illustrative case
The RESILIO project aimed to address several climate challenges, including flooding, heat, energy consumption, water supply, and urban livability, by implementing smart blue-green roofs on social housing complexes in climate-vulnerable neighborhoods in Amsterdam (Urban Innovative Actions, n.d.). The project installed these systems on 12,683 m2 of rooftop space on four different building complexes in Amsterdam neighborhoods as well as the Tropenmuseum (RESILIO, n.d.). The green roofs have enhanced water retention, allowing for storage of extra water under the green plant layer (Urban Innovative Actions, n.d.). This way, the roofs reduce the impacts of heavy rain, increase the cooling effect as well as the survival rate of the plant layer in case of drought, improve building insulation, and contribute to biodiversity and quality of life. A large part of the project's financing, almost €5 million, came from the European Regional Development Fund (ERDF) subsidy of the EU, which can be used for, among other things, green initiatives (that reduce disparities) (European Commission, n.d.-b). This case shows how making use of subsidies can enable the realization of NBS. Moreover, during the project the value proposition of these roofs was assessed by means of the Total Economic Value (TEV) framework to demonstrate that NBS can result in (higher) net benefits (than grey solutions) as well as to indicate how a business case for NBS can be built in the future (RESILIO, 2022). When assessing the business case, assigning numbers to (co-)benefits can be difficult. The RESILIO project used a combination of revealed preference methods for valuing the costs and stated preference methods, including shadow/direct pricing for avoided damage costs and estimation of the Willingness-To-Pay (WTP) by means of surveys, for valuing the (co-)benefits. The results showed that while the technology used in the RESILIO project is still under development, there is potential for a positive cost-benefit analysis. A reduction in maintenance costs, use of the roofs in a multi-functional manner, and achievement of economies of scale can tip the scale to cost-effectiveness under all scenarios. The disconnect in benefits and costs that typically hampers the business case for NBS was mitigated by introducing transfer mechanisms for costs and benefits. Attention was also paid to including all benefits of NBS, such as option value which cannot be provided by grey systems. This case shows how a proper comparison of the costs and benefits of NBS and grey solutions can lead to a positive business case for NBS as well as how the factors maintenance costs and business case can influence the realization of NBS.

3.6 Political factors - Definitions

Understand factors	
Factors	**Definitions**
Amount of beneficiaries	The amount of stakeholders or stakeholder groups that benefit from NBS implementation.
Interests and priorities	The existence or absence of political interest in NBS and the question of whether or not NBS are considered a political priority.
Policies	The presence of policies that hinder or support NBS implementation.
Embed NBS in planning frameworks	Embed NBS in urban planning frameworks to ensure continuity of NBS adoption in a fluctuating political climate.
Implement coherent supportive policies	Implement policies that support NBS adoption and are coherent across governmental levels (i.e. EU, national, provincial, municipal).
Implement NBS maintenance policy	Implement a maintenance policy for NBS to ensure long-term performance of the solutions and prevent issues from arising.

3.6 Political factors - Expert comments

Real life comments
"By definition, Nature-Based Solutions benefit all groups, because they are valuable for health, water management, building energy management, building value, and biodiversity."
"Without political will, you can't do anything. And I'm quoting a teacher that really inspired me many years ago when he said: "You can have the most brilliant ideas, but if your client and/or a decisionmaker does not want them, forget about it, it is not going to happen". So I think if we want to accelerate the pace with which we are implementing Nature-Based Solutions and develop knowledge about Nature-Based Solutions in practice, which we should, then we really need politicians and policymakers to give us room and investment to do it."
"I think it is necessary to embed NBS in long-term planning frameworks to reduce vulnerability to political cycles."

3.6 Political factors - Illustrative case

Illustrative case
To gain insight into the role of policies as an influencing factor, a useful approach is to analyze existing policies across different governmental levels in the Netherlands to identify both challenges (barriers) and opportunities (drivers) for NBS implementation. At the highest level, the European Green Deal provides a broad policy framework that aims, among other things, to make Europe climate-neutral and to protect biodiversity and ecosystems (European Commission, n.d.-d). On the national level, the Delta Program on Spatial Adaptation (DPRA) focuses on making the Netherlands climate-proof and water-resilient by 2050, seeking to mitigate the impacts of heat, drought, flooding, and inundation (Kennisportaal Klimaatadaptatie, n.d.). Moving to the provincial level, the Province of Utrecht has adopted the Implementation Program on Climate Adaptation, which outlines how the province aims to strengthen the resilience of its cities, rural areas, and citizens against the effects of climate change (Provincie Utrecht, 2024). This program is aligned with the DPRA and also serves to set direction for lower governmental levels. In the southwest of the province, fourteen municipalities, the Province of Utrecht itself, the De Stichtse Rijnlanden Water Board, the GGD Utrecht, and the Utrecht Safety Region collaborate through a Regional Adaptation Strategy (RAS), which focuses on maintaining water resilience and climate robustness (Gemeente Utrecht, 2022). The RAS is further linked to the DPRA through annual consultations, ensuring coherence between regional and national agendas. Finally, at the municipal level, the City of Utrecht has implemented its Vision on Climate Adaptation. This strategy is closely aligned with the aforementioned RAS as well as other national, provincial, and municipal plans and visions. This multi-level policy alignment illustrates how the existence of supportive policies and coherence across governance levels can act as a strong driver for NBS adoption.

3.7 Legal factors - Definitions

Understand factors	
Factors	**Definitions**
Land ownership/use	Land ownership distribution (public vs private) and applicable land-use regulations.
Regulations	The presence of regulations that hinder or support NBS implementation.
Allow flexibility in regulations	Adopt a flexible approach to regulatory frameworks, thus allow room to adapt existing regulations in favor of NBS.
Implement coherent supportive regulations	Implement regulations that support NBS adoption and are coherent across governmental levels (i.e. EU, national, provincial, municipal).
Implement biodiversity net gain regulation	Implement a regulation requiring all new and renovation projects to deliver X% more biodiversity than was present at project start.
Implement NBS point system	Implement a regulation requiring new construction projects to achieve at least X points for NBS integration.
Implement no loss regulation	Implement a regulation requiring that every square meter of greenery removed be replaced with greenery within or on the building.
Mandate greenery/water storage inclusion	Implement a regulation requiring all new construction to include X m^2 of greenery and X mm of water storage capacity.
Mandate pavement removal	Implement a regulation requiring the removal of X% of pavement as part of all road reconstruction projects.
Use maintenance agreements	Implement standard contracts between citizens and the municipality to secure reliable maintenance and prevent lack of commitment.

3.7 Legal factors - Expert comments

Real life comments

"We investigated this in urban areas, but land ownership and land use are also very fragmented there. So the government does not even have that much influence on all parts of the city."

"At the same time, in the Netherlands, things are pretty much laid down in guidelines and objectives, and the rules for how things should be done in a certain way are quite strict. So for that reason, it is also necessary for us to introduce some flexibility."

"For every apartment added to the city, X m² of green space must be added and X millimeters of water storage space must be created. And the greener and higher quality it is, the smaller your task becomes. So if you do something that greatly benefits biodiversity, you don't have to create the full X m². The same applies to water: if you do it in a high-quality and green way, then you don't have to provide as many millimeters of storage space as we specify."

3.7 Legal factors - Illustrative case

Illustrative case
The municipality of The Hague wanted to stimulate green and nature-inclusive construction to enhance biodiversity, reduce heat stress and flooding, contribute to opportunities for experiencing nature in the city, and improve citizens' well-being and health (Gemeente Den Haag, 2022; Klasberg & Mulder, 2018). Therefore, they decided in 2016 to become the first city in the Netherlands to implement a point system for Green and Nature-Inclusive Construction to stimulate NBS adoption in new development projects. This system requires building developers of large-scale new construction projects to comply with this system and to guarantee sufficient greenery on and around the construction site by meeting a certain number of points. Although the system is not yet mandatory for small- and medium-sized projects, it provides a useful starting point for achieving nature-inclusive construction for these projects too. The system can also be applied when renovating buildings, but as there are more restrictions when it comes to renovations, large-scale renovation projects are assessed on a case-by-case basis to see which measures are feasible. Construction projects must earn a required number of points by selecting from a range of measures. These measures fall into three categories: (1) facade and roof installations, such as facade gardens and green roofs, (2) accommodations for animals, such as nesting sites, and (3) green interventions in the surrounding environment, including pocket parks, wadis, or clusters of trees and shrubs. Previously, the required number of points depended on the urban zone of the construction project, with distinctions made between the historic center/old city districts, residential areas, large-scale developments and high-rise buildings, and industrial estates (Klasberg & Mulder, 2018). Currently, a single point system applies uniformly across the entire city (Gemeente Den Haag, 2022). Other municipalities can adopt a similar point system, but as it is custom-made, it must be adapted to their local context (De Groot, 2021). Some municipalities, including Amsterdam and Zaanstad, have recently done this (Schreurs & Van der Wal, 2021; Gemeente Zaanstad, n.d.). This case shows how enforcing NBS implementation through regulations, for which the point system was selected in this example, can significantly contribute to scaling up the solutions.

CHAPTER 4
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