Soaking up nature based benefits

Benefit Assessment of nature based stormwater management in a comparative case study on London, Hamburg and Rotterdam

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Abstract

The need for nature-based solutions in urban stormwater management has increased as a result of densification and exacerbated precipitation patterns brought on by climate change. NBS, or nature-based solutions, is one strategy for sustainable urban stormwater management whose remedies are supported by nature. The optimal outcomes of the solutions, known as ecosystem services, include numerous benefits for both society and the environment. Natural swales, retention ponds, and green roofs are just a few examples of NBS stormwater control solutions. But how can the value of ecosystem services in NBS stormwater management be determined and its implementation in practice be improved? To answer this question a benefit analysis on NBS in urban stormwater management has been taken on the tre cases of Rotterdam, Hamburg and London.

London is a forerunner in the monetary estimation of ecosystem services, making NBS a more viable alternative to grey infrastructure in the underserved private sector than the other case study cities of Hamburg and Rotterdam. Because of the important role that the private sector and developers play, this emphasises the importance of including benefit estimates for ecosystem services in decision-making. Hamburg has a strong public water managers sector, with mostly broad but legally binding urban plans. Rotterdam excels in its strategy to integrate stormwater management and urban planning and foster meaningful public participation.

Partnerships that are multidisciplinary and inclusive can encourage the use of NBS as a solution to urban stormwater management. Combining resources, abilities, and information can help to foster and accelerate interactions between various aspects of society. Citizens' participation in urban decision-making can improve livability, reveal NBS implementation options, and foster ownership and stewardship. Innovative technologies, such as natural capital accounts, can help to advance NBS development by facilitating the integration of multiple stakeholder perspectives in urban planning and policymaking.

***Keywords*:** nature-based solutions, sustainable urban stormwater management, climate adaptation, ecosystem services, value of nature

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Abbreviations

NBS - Nature Based Solutions

UGI Urban Green Infrastructure

BI Blue Infrastructure

GI Green Infrastructure

IUCN International Union for Conservation of Nature

SDG Sustainable Development Goals

UK United Kingdom

SUDS Sustainable urban drainage system

GLA Greater London Authority

LES London Environmental Strategy

LP London Plan

UD Urban Development Plan

CP Climate Plan

OO Ontwerp- Omgevingsvisie

RAS Rotterdamse Adaptatie Strategie

UGF Urban Greening Factor

1. Introduction

1.1 Cities and nature

Nowadays, over half of the world's population lives in urban centres. Urban environments house the majority of human assets and serve as the population's economic and institutional hub (de Graaf, 2010). While cities are the primary habitat of humans, they are extremely vulnerable to climate change and environmental threats caused by both anthropogenic and non-anthropogenic origins (Schreider, 2000). Flood severity and frequency in European cities have been steadily increasing as a result of expanding urban density and the resulting soil sealing, resulting in the highest economic losses in Europe over the last decade. Therefore, storm water management has emerged as a critical urban concern. As of 2050, 70% of the world's population will be living in urban city areas, increasing urban vulnerability and flood risk (Langergraber, 2021).

Cities are generally characterised by impermeable surfaces, due to the concrete infrastructure and sealed roads throughout the urban space. Soil sealing reduces infiltration, hinders rainwater run-off and increases ,therefore the risk of flooding during periods of heavy precipitation. When a flood occurs, built-up metropolitan areas have the biggest risk of suffering massive losses, including the loss of life (Hartmann, 2019; Kaspersen et al. 2016). The second factor posing a threat to the cities is climate change. Sea level rise and extreme climatic events are becoming more common as the global atmosphere warms. High precipitation is one of the most common causes of flooding in cities, with heavy localised rainfall accounting for the great bulk of the hazard. As a result, grey infrastructure such as conventional sewers are unable to handle the water from heavy rainfall, causing floods in cities. Places that are experiencing heavy rainfall occurrences are more numerous than cities where rainfall has decreased over time. According to existing literature, the incidence of urban floods is a result of a combination of unplanned urban development, heavy rainfall and drainage system inefficiencies (de Graaf, 2010, Lafortezza et al., 2018).

In western cities, the traditional response to these problems has been 'grey' infrastructure, such as piped drainage systems, which are primarily single-objective oriented designs to deal with rainwater inside the urban landscape. Surface runoff is typically directed to drains and stream discharge as part of traditional stormwater management strategies to lessen the risk of flooding. However, due to climate change and soil sealing, these drainage infrastructures frequently lack the capacity to keep up with ongoing urbanisation and the increasing velocity of stormwater, resulting in greater run-off and a heightened danger of urban flooding (Davis, 2017). Nature-based solutions, as opposed to traditional grey infrastructure and hard engineering, are an alternative approach to dealing with the consequences of climate change (Svendsen, 2012).

In order to improve runoff quality, encourage evapotranspiration, and decrease surface runoff volume, non-traditional or alternative stormwater runoff management techniques have developed through natural processes involving vegetation and soil (Ahmed, 2022).

Nature-based Solutions are one method that uses or is inspired by nature to handle any of the world's major issues, such as climate change, food security and social and economic development, to name a few. NBS are defined by the European Commission's Directorate-General for Research and Innovation as approaches developed to handle diverse societal difficulties in a resource-efficient and adaptive way while also giving economic, social, and environmental benefits. They are inspired by, continuously sustained by, and utilising nature (European Commission, 2015). NBS is introduced by Kabish et al. (2016) as an umbrella term that encompasses urban green infrastructure (UGI), ecosystem-based adaptation and ecosystem services. In theory, the solutions should provide a variety of benefits to society and the environment. Natural wells, retention ponds and green roofs are all examples of NBS stormwater management strategies. In the face of climate change, nature-based solutions that promote green and blue urban spaces have a huge potential to reduce vulnerability and increase resilience in cities (Kabisch, 2016; Cohen-Shacham et al., 2016).

Although the value of ecosystem services in monetary units is an important instrument for raising awareness and conveying the importance of ecosystems and biodiversity to policymakers, the importance of ecosystems to human society has several dimensions, namely ecological, socio-cultural and economic (Daily, 2008). Information on monetary values allows for more efficient use of limited funds by determining where protection and restoration are most economically important and can be supplied for the least amount of money. The measuring of a wide range of ecosystem service flows and their values in monetary units or other forms is a critical first step toward improving incentives and raising funds for their conservation and long-term use (de Groot, 2012). The difficulty in addressing the full scope of NBS benefits and their ecosystem services highlights the need for additional decision-making tools. This study emphasises the relevance of considering ecosystem services in climate adaptive decision making (Howarth, 2002).

Clear and coordinated principles must be followed in order to effectively apply NBS at the scale required to reverse trends in ecosystem degradation. From these principles, evidence-based standards and recommendations for practitioners and decision-makers can be created. This requires a considerable effort into developing principles, standards or guidelines for global ecosystem-management initiatives that fall within NBS (Lafortezza et al., 2018).

1.2 Problem statement

Numerous studies have explicitly proven that urban flooding is becoming a global concern. However, the reaction to this trend is yet to be determined. Adopting NBS on a larger scale as a potential alternative to grey infrastructure is becoming critical. Nevertheless, the implementation aspects of NBS have not been properly addressed until now (Faivre et al, 2017). Therefore, it's imperative to have a concrete idea about the challenges that affect the implementation of NBS for the reduction of stormwater flooding in urban areas. Activities aimed at improving ecological integrity and human well-being may have unexpected repercussions if there are no clear principles and standards in place (Gann et al., 2018). One will examine the NBS idea in a European environmental policy context in order to improve standards of practice across various urban nature based projects.

The purpose of this study is to address this issue by revealing the limitations and challenges that affect the implementation of nature-based solutions in practice. As a result, this research could aid in deciphering the fact that there are differences between the theoretical approach and the practical implementation of NBS. Furthermore, the study aims to shed light on current practice and the co-benefits offered by NBS in addition to flood reduction. How do planners use nature-based solutions in urban development projects and how is the concept employed in European planning practice? It discusses theoretical developments and demonstrates their application to practical planning problems through the use of case studies.

1.3 Scientific relevance

Stormwater management in metropolitan areas currently does not make use of NBS , resulting in frequent flooding, environmental degradation and human health hazards. Increased urbanisation and climate change necessitate immediate action. Nature-based solutions, or NBS, are an alternative to traditional stormwater management. NBS is described as the use or inspiration of nature to address social concerns. It has the potential to produce robust, adaptable solutions that support biodiversity and human well-being, as well as a solution to these problems. NBS are beset by uncertainties, including performance gaps, maintenance issues, efficiency issues and potential tradeoffs (Oral et al., 2021; Cohen-Shacham, 2016).

Both scientists and policymakers are increasingly interested in the potential for incorporating nature-based approaches into urban planning and policy-making as approaches that provide sustainable and cost-effective solutions for water management, air quality, urban biodiversity and cross-cutting challenges such as biodiversity conservation, public health and well-being Since NBS are still relatively new in academia (Potschin, 2015), there are numerous research gaps in the field. As indicated, a variety of grey and academic literature suggested numerous subjects for additional research. The decision-making process, social innovation and the benefits of NBS are among these domains. This implies that a research gap exists, necessitating additional research into how the concept of building with nature and its implementation in urban systems work.

Biodiversity and ecosystem services have been deemed externalities and free 'goods' since nature or ecosystem services have not put a monetary value on them (de Groot, 2012). The goal of valuing ecosystem services in monetary terms is to convey the importance of ecosystem service production to policymakers planning for the future. Because of the large range of decision-making tools available, the monetary value of ecosystem services could be considered as a supplement to other methods (Daily, 2008; Howarth, 2002).

1.3.1 Expected results

Valuing ecosystem services is a way of displaying and explaining how humans rely on the ecosystems around them by describing the values associated with the services they give (Farber, 2002). The difficulty of valuing all of the benefits provided by ecosystems has made its practice contentious. The integration of ecosystem services and their value has been lacking in contemporary policy and decision-making (Cohen-Shacham, 2019). The goal of assessing benefits of ecosystem services is to convey the value of ecosystem service production for sustainable development and to policymakers.

Expressing ecosystem service benefits could be a more communicative tool in decision-making, allowing for more long-term sustainable decisions (Bateman et al., 2010; Groot et al., 2012). When compared to the utilisation of a traditional sewage network, BGI is frequently associated with higher expenses. A benefit analysis can be used to evaluate the accumulated opportunities worth of various investment options and emphasise the benefits of ecosystem services and encourage the use of more long-term sustainable urban development as a vital step toward mitigating the effects of climate change in the future. In summary, the value of ecosystem services can be highlighted and used as a foundation for future decision-making by identifying both qualitative and quantitative estimations.

1.4 Research objective

This thesis seeks to develop a framework on how theory and practice relate in terms of the benefit analysis of ecosystem services such as sustainable stormwater management by the use of nature based solutions. The benefit assessment serves to explore innovative findings in defining the benefits provided by the implementation of blue-green infrastructure as ecosystem services in stormwater management.

Based on three case study cities the evaluation and implementation of ecosystem services of nature based stormwater management will be conducted. The research hopes to be relevant to other communities interested in integrating NBS by providing real-world experiences from the cities. As a result, it is critical to examine how these NBS interventions in the case study cities might fit into a storm-water management plan, why the three cities decided to include NBS in their storm-water management plans and invest in the intervention based on monetary values to these services and what the benefits/limitations of this services are.

There is one primary research question and three secondary research questions in this thesis for examining the mentioned issue in the objectives. The research questions are:

Primary research question

> ***How can the value of ecosystem services in NBS stormwater management be determined and its implementation in practice be improved?***

The three secondary research questions serve the ambition of answering the more complex primary question in an orderly and structured manner.

> ***Which ecosystem services does nature based urban stormwater management offer?***
>
> ***How prominent is the deployment of sustainable stormwater systems to benefit ecosystem services in the case study cities?***
>
> ***To what extent do nature based stormwater management differ in theory and practice?***

1.5 Societal relevance

The concept of nature based solutions includes a multitude of goals. Not only is the environment and biodiversity being preserved or increased, but flood protection is also being improved, as is collaboration between disciplines, sectors and societal actors (Langergraber, 2021). Nature-based solutions have emerged as viable options for enhancing urban adaptiveness in the face of climate change challenges.

Nature's ecosystem services, such as storm water management, are valued above all other factors. Added recreational value, noise reduction and flood protection are all included. To promote the use of NBS for building urban ecosystem services, tools that demonstrate the long-term value of these types of solutions are required. A performance evaluation system can be used to demonstrate this value while also diagnosing the current state of the city, selecting solutions and tracking their implementation.. This takes cities one step closer to becoming habitable, climate-adaptive and mitigating environments where human existence may thrive (Krauze, 2019).

1.6 Expected results for planning practice

The thesis compares the implementation of nature-based stormwater management solutions in European cities. The comparison elucidates the gap between the theoretical foundation and practical application, as well as the benefits of nature-based solutions. A benefit analysis may aid in persuading decision-makers to incorporate NBS into urban stormwater management by presenting compelling arguments based on the ecosystem service potential associated with NBS stormwater management. Changing mindsets have the potential to generate political momentum, commercial interest and household-level integration initiatives. The political dynamic may lead to more supporting laws, such as legalisation of stormwater management on private property, incentive programs which require a particular amount of nature and water solutions in all new projects. Therefore, initiating motions to establish the basis on which policy instruments to promote and upscale urban nature based solutions can be developed.

1.7 Methodology overview

This thesis relies on mixed methods in which data will be collected through a literature review interview and policy reports. The literature research on nature-based solutions in view of sustainable urban water management will be conducted in order to offer a foundation for the analytical framework. The aim is to develop a methodology for conducting a benefit analysis for nature based stormwater management, by comparing the three case study cities. Determining the benefits given by the development of blue-green infrastructure as ecosystem services is critical in the benefit assessment.

1.7.1 Case study

The goal of examining cities policy reports is to bridge any gaps between literature-theoretical project stages and processes and what has been implemented in practice and see if there are any additional indicators applicable to NBS for pluvial flood mitigation than those already available in the literature. The NBS projects will offer information on the factors that were considered before, during and after the intervention. NBS effects will also be identified inside and across several sectors (social, economic, environmental). Three case studies are being looked at.

1.7.2 Benefit Assessment

The benefits and ecosystem services of various solutions must be carefully considered when determining the most effective strategies to address climate change, biodiversity loss and development. When developing policies and programs, economic, ecological, social, political gains and costs must all be considered. Benefit analysis is an important tool for NBS policy and project creation and implementation, as it provides input to stakeholders, project implementers and organisational or governmental supervision on the project's benefits in relation to its grey alternatives, which helps with decision-making. It can help identify synergies between climate and biodiversity goals and other objectives, such as economic development, catastrophe risk reduction, public health, social well-being, as well as potential trade-offs (Le Count et al., 2021).

Prior to project implementation, a benefit analysis can be performed to determine whether a project will have a net benefit for the target population and beyond, using expected costs and benefits based on predicted outcomes. Project execution can also be aided by a benefit assessment. A comparison of an intervention's full range of ecological, climate, economic, social and any other positive and negative impacts provides a substantial evidence base that identifies what is and is not working in a project, as well as what positive outcomes are greater than the costs and thus worthy of investment. Preventing damage costs and avoiding economic losses are some of the common benefits discussed. The entire life cycle costing approach, which includes construction, operation, maintenance, opportunity costs and return on investment is one cost–benefit technique for evaluating NBS (Nordman et al., 2018; Martin, 2020).

1.8 Thesis overview

The structure of this thesis is as follows.

Chapter 1 provides an introduction and overview of the identified problem, research questions and study aims, as well as defining the scope and identifying the audience of the report.

Chapter 2, the literature review, outlines the existing definitions of nature-based solutions from the literature, explores their foundation in related concepts such as green and blue infrastructure, ecosystem services and identifies gaps in the literature.

Chapter 3, Methodology and Research Approach, presents the methodology and analytical framework of the thesis. It will explain the rationale and the flow of the research process from data collection to the final strategy recommendation.

Chapter 4, Results, presents the comprehensive findings from the three cities without any comparison. The chapter will provide the empirical results from the data collection process, data coding and policy analysis.

Chapter 5, Discussion and recommendations, address the results in comparison of the three case study cities and inspire to formulate recommendations.

Chapter 6, Conclusion, answers the research questions by summarising key findings. Suggestions for future research, both technical and social, are also provided.

2. Theoretical framework

The review of literature focuses on synthesising existing information about NBS definitions and applications, emphasising benefits and drawbacks and compiling criticisms of the concept. This section outlines the primary incentives for NBS in urban stormwater management in contrast to traditional grey drainage infrastructure, as well as the implementation of various solutions and the additional values that can be provided as ecosystem services. Initial keyword searches and citations were used in a literature study to select relevant material.

2.1 History and definition of NBS

The Nature based Solution (NBS) is a new notion in the debates about creating resilience, adapting to climate change and mitigating its effects (Potschin, 2015). It is a solution that uses or is inspired by nature to address major global concerns such as climate change, food security and social and economic development, among others (IUCN, 2012). It is thought to be able to deliver multiple benefits to the environment, society and economy due to its transdisciplinarity philosophy, which integrates ecosystems with socio-economic dimensions. However, the concept is still relatively new in environmental management discussions and working group definitions are still inconsistent (Potschin, 2015). As a result, the history and definitions of the term "Nature-Based Solutions" will be covered in this section of the literature study.

Nature based solutions are a fuzzy term with numerous interpretations. While the European Commission's definition emphasises all three pillars of sustainability, other scholars and organisations place a greater emphasis on environmental protection and restoration. Ershad-Sarabi et al. (2019) discover that NBS definitions are more typically focused on sustainable development in a systematic literature review. NBS were identified as solutions that jointly achieve environmental, economic and social objectives in around three-quarters of the peer-reviewed studies. The concept was originally employed in 2008 to assist in reducing and adapting to climate change while also delivering sustainable livelihoods and biodiversity advantages (Eggermont et al., 2015). The International Union for Conservation of Nature employed NBS in a study for the United Nations Framework Convention on Climate Change in 2009. Scientists and policymakers quickly embraced the concept after discovering its role to promote green growth in cities while addressing climate change (Eggermont et al., 2015).

Green and blue infrastructure, building with nature, ecosystem-based adaptability and ecosystem services are all concepts related to NBS (Nesshöver et al., 2017). NBS serves as a catch-all name for a variety of ecosystem-related strategies. All of the ideas aim to improve policy-making by taking into account the importance of nature. NBS offer the opportunity to supply co-benefits, such as increased attractiveness of a location, improved health and quality of life and the creation of green jobs. There are few frameworks for recognizing and valuing such NBS co-benefits, as well as for guiding cross-sectoral project and policy design and execution. In order to achieve this, a holistic approach for evaluating the benefits and costs of NBS across elements of socio-cultural and socio-economic systems, biodiversity, ecosystems and climate change will be devised (Kabisch et al., 2017; Hartmann, 2019).

There is increasing recognition that nature-based solutions can help shield humanity from the effects of climate change while also delaying future warming, preserving biodiversity and securing ecosystem services. However, the ability of NBS to deliver the desired benefits has not been thoroughly evaluated (Seddon et al., 2019). The similarities between an NBS and its sister concepts Green infrastructure and Blue- Green infrastructure (GI, BGI) are that they use nature to enhance adaptive capacity, reduce the risk of pluvial flooding, strengthen resilience, improve water quality, add recreational opportunities, improve human well-being and health, enhance vegetation growth and connect habitat and biodiversity (Ruangpan, 2019; Hartmann, 2019).

The focus of NBS is one of the most contentious issues. Is it possible to include more technical ways for their use in NBS, or should it just represent natural systems and practices? Furthermore, concerns arise about where NBS should fit into the environmental methods used to affect urban development and how this influences the decisions made by built environment experts (Pontee et al., 2016). This is a critical debate, with Nesshöver et al. (2016) promoting NBS as a challenge to existing "grey" infrastructure, arguing that NBS are needed to facilitate a transition to a more ecologically sensitive approach to urban management, while Liquete et al. (2016) see NBS as a complement to engineered solutions rather than a replacement.

The gradual shift in focus placing 'nature' at the centre of development arguments has been a major component of the debates supporting NBS. This goes beyond the GI's inherent examination of human-environmental interactions and is a significant departure from the 'green space' literature's larger policy/practice evaluations. The NBS literature emphasises the relevance of nature in its broadest meaning, emphasising its ecological value with socioeconomic benefits (Kabisch et al., 2016). Although GI became widely recognized in landscape debates, it emphasised the broader links between people, location, policy and the landscape, rather than a present nature-centric approach to investment, which has transformed the framing of landscape design. This does not diminish the need of considering social and economic gains, but rather emphasises nature as a major development paradigm. Furthermore, there is a case to be made for extending current green space talks by utilising NBS to achieve green infrastructure ideals like accessibility and multi-functionality (Cohen-Shacham et al., 2016; Eggermont et al., 2015).

The promotion of nature based solutions as a supplementary strategy to urban development is an important part of this process. This partly reflects the breadth of investment options available with NBS, but it also supports Fan et al. (2017) claim that NBS are more responsive and capable of addressing the climatic, physical and socio-economic issues that come with urban expansion. As a result, NBS are seen as more adaptable than traditional investing strategies. Fink (2016) further contends that NBS assists the development of a developing equilibrium between people, technology and environmental policy in order to create a long-term balance between societal requirements, natural systems and economic progress. Fink (2016) does add, however, that green technology in the shape of green walls, roofs and ecologically sensitive structures, in addition to natural resource management, can play a vital part in achieving sustainability.

2.3 Urban Stormwater management

The most visible and concerning repercussions of growing and unregulated urbanisation are land take and soil sealing. Due to the insufficient capacity of traditional drainage systems, climate change has resulted in an increase in the number of flooding occurrences in metropolitan areas, as well as an increase in the frequency of intense meteoric events. Rainwater drainage systems in cities are necessary infrastructure for collecting and transporting rainwater away. Traditional stormwater management systems, also known as grey infrastructures, are systems that are primarily focused on a single goal: water quantity control (Barbosa, 2012).

Traditional stormwater and wastewater management systems face difficulties despite ongoing investments due to problems that are shared with many developed nations. These include shifting operational conditions, most notably demographic change and a rise in the frequency and severity of storm events (Nickel at al., 2014).

Climate change is causing more unpredictable rainfall patterns, as well as an increase in the number of intense storms, which leads to frequent drainage system overflow. Floods are becoming increasingly frequent as a result, particularly in central metropolitan areas with large impervious surfaces. Urban floods happen when surface runoff exceeds drainage capacity, which happens a lot during high-intensity, short-duration rainfall events (Berland, 2017). Urbanisation exacerbates pluvial floods by increasing impervious surface areas and altering flow pathways. Many metropolitan areas will become more vulnerable to pluvial floods due to heavy rainfall events as land cover changes in the future.

Pluvial floods may wreak havoc on cities and have serious consequences for individuals, the economy and the environment. Mitigating flood damages and losses requires careful management of pluvial flood risks. The likelihood of a flood event of a certain magnitude and with a specific loss is defined as flood risk (Hartmann, 2019). Long periods without precipitation, on the other hand, are leading cities to have functional issues, as previously indicated. As a result, the shortage of stored rainfall increases the demand for irrigation systems to water urban green spaces. Such strategies necessitate both natural resources and financial support, making them unsustainable (Enzi et al., 2017). Next to the risk of flooding, discharge pollution is a great threat in urban stormwater management. Stormwater is regarded as the primary source of heavy metals, while wastewater is the primary source of organic and nitrogenous contamination (Bavor et al. 2001; Eriksson et al. 2007).

Separate sewer network systems are common in many nations and most rainfall networks release rainwater directly into receiving waterways without any treatment, posing a major threat to the water's quality. This is especially harmful for smaller watercourses running through towns, when rapid discharge from rainfall drainage systems exceeds hydraulic capacity, posing a major contamination threat. To protect downstream freshwaters from contamination and eutrophication, urban water pollution control is mostly done as a "end of the pipe" approach with highly intensified wastewater treatment facilities (Finger et al. 2013). However, in addition to the benefits outlined in the previous sections for stormwater management, flood protection and resource efficiency, NBS presents an unexplored potential for urban water pollution control (Enzi et al., 2017).

2.4 Sustainable Stormwater management by NBS

In many cases, present water management systems are insufficient and there is a need to address the issue of water quantity and quality in order to execute the concept of an urban circular economy. The combination of ever-expanding metropolitan areas with impermeable surfaces and pollution from human activities, as well as climate change and a rising number of climatic extremes, necessitates a new approach for cities to become more robust to socio-environmental stresses (Oral et al., 2020).

Figure 1: Illustration NBS stormwater management (Stahre, 2008)

Therefore, based on the mentioned issues, it is critical to promote the implementation of NBS in cities in order to help cities adapt to climate change by lowering their sensitivity to environmental risks. As a result, NBS has become a critical component of urban resilience, helping to manage stormwater, contribute to urban cooling through evapotranspiration and reduce urban heat island effects while promoting urban green with local water resources (Bavor, 2001). Rain gardens, green roofs, natural swales, city parks, wetlands and even urban trees are examples of NBS for urban stormwater. Apart from stormwater management, these technologies could give other benefits to the city. The multi benefits include, but are not limited to, improved air quality, microclimate management, increased urban biodiversity, improved citizen health, increased urban aesthetic and recreational space.

According to hydrological processes, there are three different types of water techniques for BGI. Small-scale methods like green roofs, rain gardens, and permeable pavement are used to accomplish onsite control. All of these techniques strive to retain as much stormwater locally as feasible. Stormwater is retained, or absorbed locally by infiltration, evapotranspiration, and other processes. (Liu et al., 2019). Process control or slow transport uses swales and ditches to move stormwater downstream slowly. These processes, in addition to reducing floods by increasing concentration time, can improve water quality and local water balance through infiltration. Downstream control or controlled discharge is achieved by using larger facilities, such as dry basins, ponds and wetlands, for temporary detention and slow discharge to recipients or downstream urban drainage systems.Through sedimentation, downstream detention helps to reduce flooding and enhance water quality, but it has little effect on the local water balance (Brears, 2018, Liao et al., 2017).

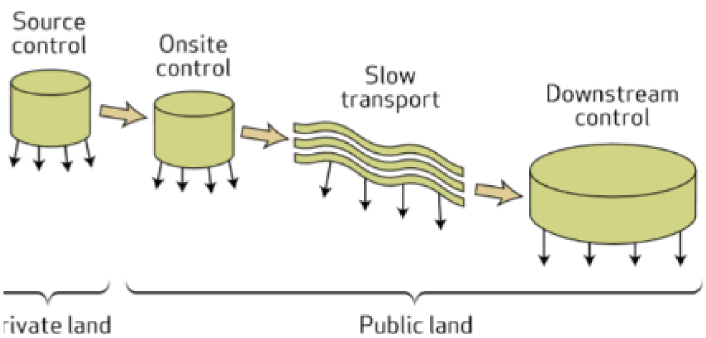

Figure 2: The four control categories (Stahre, 2008)

2.5 Strengths of NBS

The Sustainable Development Goals (SDGs), EU Biodiversity Strategy and EU Water Framework Directive (WFD) (EC, 2020; Seddon et al., 2020) all support NBS as a sustainable strategy. The main attribute in overcoming environmental, social and economic concerns is protecting and preserving biodiversity and providing ecosystem services (Pauleit et al., 2017). By delivering robust and adaptive solutions that enhance biodiversity and mitigate climate change, NBS can address all elements of sustainability.

The focus on provisioning and enhancing availability of urban green area benefits of NBS will become increasingly recognized in urban environments. Improved quality of life, mental and physical health and reinforced cultural identities, which foster a sense of belonging and place, are just a few of the advantages (Keniger et al. 2013, Hartig et al. 2014). NBS are often seen as more efficient and cost-effective solutions to climate change threats than more traditional approaches, such as conventional sewage or air conditioning systems, when this aspect of multifunctionality is taken into account, as well as the plethora of co benefits produced (European Commission, 2015).

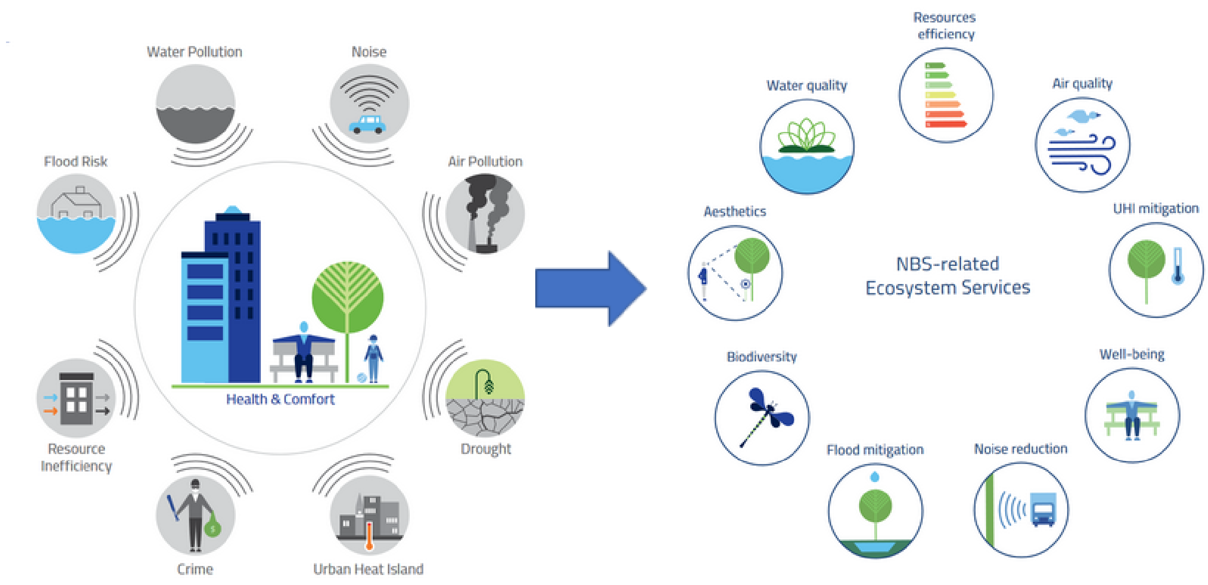

Figure 3: urban pressures and mitigation options by the application of NBS (Blue green solution, 2017)

NBS can be used to fulfil numerous sustainable development goals which the UN members have pledged to attain (UN, 2019). At least 14 of these SDGs can be linked to NBS. The Nature Conservancy, the International Union for Conservation of Nature and the World Bank all put NBS in a policy context, offering both a structure and funding for its implementation (Faivre et al., 2017).

NBS may have a higher impact than traditional drainage systems, influencing a broader range of stakeholders. Because the project has the potential to give various advantages, it should be planned, designed and implemented with a large number of stakeholders (Somarakis et al., 2019). Involving a large number of stakeholders offers numerous advantages, including better understanding of the plans and processes, gaining acceptability, incorporating knowledge from various viewpoints, working as a kind of knowledge exchange and strengthening the democratic process (Innes, 2000). In order to address the issues caused by the prior methodologies, new concepts and paradigms for managing stormwater through more sustainable and integrated methods then arose. Beyond the conventional field of urban water engineers and specialists, this integration includes an increasing number of disciplines and concerns. The paper makes an effort to justify the necessity of this evolution, which has increased the complexity of urban stormwater management by dealing and interacting with ecology, biodiversity, bioinspiration, architecture, landscape values and water values, as well as the well-being of citizens, history, culture and socioeconomic factors.

2.6 Weaknesses of NBS

Despite its enormous potential, NBS is not well-known in urban settings. Natural areas are dwindling in cities and natural resources are deteriorating (Cohen-Shacham et al., 2019). NBS is a broad and encompassing phrase but it is also ambiguous and has a fuzzy relationship to the terms it encompasses (Nesshöver et al., 2017).
Nesshöver et al. (2017) note that the term "nature" is not well defined, which is essential in determining what should be included in an NBS. Furthermore, it is uncertain to what extent biodiversity conservation should be included in the NBS, raising concerns about its long-term viability. Finally, solutions can result in trade-offs, most likely between sustainability characteristics, emphasising the significance of knowing the solution in order to achieve the desired, long-term development. One example is urban green space, which has the potential to raise property values, prices and rents, significantly impacting social cohesiveness (Kabisch et al., 2016).

One of the most significant flaws of nature-based solutions in the urgent climate adaptation debate is that they are frequently slower in developing and effective implementation in comparison to grey alternatives. It takes a relatively long time to restore or develop a habitat. Plants develop according to nature's schedule; while planners can occasionally select plants that grow quicker, they may not provide the same benefits as slower-growing plants. A short-term technical solution may offer direct and quicker results than a long-term but more sustainable solution based on nature (Balian et al, 2014).

NBS projects continue to face numerous challenges, including design, implementation and maintenance. The benefits and co-benefits of their ecosystem services are not well understood (Kabisch et al., 2017). At various stages of NBS project development, there is a lack of deep understanding among key stakeholders, as well as a scarcity of skills and experience. Decision-makers and practitioners frequently lack the knowledge and skills required to handle potential trade-offs effectively and make the best use of available technical solutions. There is also a scarcity of evidence on NBS effectiveness, as well as measurement of environmental, economic and social advantages (Kabisch et al., 2017; Balian et al, 2014). Inadequate or in most cases absent follow-up monitoring of deployed NBS obstructs the evaluation of their effectiveness, depriving decision-makers and practitioners of vital insights into the cost-benefit analysis, performance and long-term viability of NBS. The construction of an uniform and holistic framework for the assessment of NBS impacts, as well as the monitoring of multiple scales of NBS impacts in both spatial and temporal dimensions, are essential objectives for future research. If the benefits of NBS are to be maximised, it is necessary to understand the complete spectrum of benefits that NBS can deliver by recognizing the many types of NBS accessible and their respective usefulness within a specific context (UK Green Building Council, 2020).

In order to achieve an NBS's sustainability goals, the framework and solutions must be implemented at all spatial scales. Small-scale solutions, for example, are unlikely to reach global goals on their own, highlighting the necessity for a larger-scale approach (Nelson et al., 2020). This also implies that for a comprehensive NBS implementation, all sectors must be involved.

2.5 The value of nature based solutions

Nature-based solutions have a high potential for dealing with the serious issues of climate change and urbanisation. As a result, they serve many purposes and assist a multitude of urban stakeholders. The concept of ecosystem services is a popular approach of defining and explaining the benefits that society obtains from nature (European Commission 2015).
Ecosystem services are defined as “the benefits human populations derive, directly or indirectly, from ecosystem functions” by Costanza et al. (1997). A number of these ecological services are not directly used by humans, but are required to keep ecosystems alive. Plant pollination and nutrient cycling are examples of indirect services, however the classification is not clear. Another feature of ecosystem services is that they cover a wide range of spatial areas. According to the breadth of the problem they are tied to and the possibility of transporting the service from where it is generated to the city where humans benefit from it, services might be provided on a local or global scale (Bolund & Hunhammar, 1999). By utilising NBS in urban areas, additional services are generated besides water regulation. Trees and plants, for example, have the ability to reduce pollution levels in the air while also providing recreational value in urban areas. The phrase "ecosystem services" is used to indicate these characteristics (Reid et a., 2012).

Nature based solutions	Stormwater management	Socioeconomic co-benefit	Environmental co-benefits
Stormwater Pond (Vijayaraghavan, 2016; Stahre, 2006; Mok, 2019)	Reduce peak flow, avoid flooding and overflow and provide sedimentation	Recreational, cultural, ecotourism and educational benefits	Sedimentation, evapotranspiration, infiltration, water purification, water storage and provision of habitat
Natural swale or rain garden (Guo, 2001) (Mok, 2019)	Reduce peak flow, infiltration and purification	Reduces SWM costs from reduced drainage pipes	Water purification, abstraction, water storage, habitat and improvement of the water cycle
Urban trees (Salmond, 2016) (Mok, 2019)	Reduce peak flow and provide climate change adaptation	Energy conservation, improved human health, reduce flooding potential, noise regulation and cultural values	Improved air quality, carbon sequestration, water storage, water purification and increased soil permeability
Wetlands (Mok, 2019)	Reduce peak flow, flooding regulation and water purification	Storms and erosion protection, food, fibre and energy provision, recreation, ecotourism, educational and inspirational value	Fish and wildlife protection, habitat provision, carbon sequestration, climate regulation, forest regulation and pollination
Green roofs and walls (Mok, 2019)	Making buildings more sustainable	Noise regulation, energy conservation, food provisions, extend lifetime of property and fire resistance	Air purification, runoff reduction, water purification, evapotranspiration and habitat provision
Permeable surface (Mok, 2019)	Provide infiltration to avoid flooding	Runoff reduction, groundwater recharge, urban temperature reduction and energy conservation	Water purification runoff reduction, evapotranspiration and groundwater recharge

Table 1: Nature based solutions and their benefits

In the current framework, the concept of ecosystem services is crucial. It's also known as the benefits that humans gain from healthy ecosystems. It is concerned with protecting societal and natural systems against risks such as floods while promoting those main values and it necessitates a synergic relationship between flood-related activities such as security on the one hand and ecosystem service delivery on the other. Ecosystem services is a structured approach to addressing and comprehending the synergies, interactions, linkages, interdependencies and trade-offs that exist across social, technical and natural systems. It separates the world into ecosystem services and well-being components (Vojinovic et al., 2016).

By understanding key characteristics, institutions can better manage, maintain, restore or evaluate ecosystem services. Several attempts have been made to classify ecological services (de Groot et al., 2002; Fisher, 2009). The dynamic complexity of ecosystem processes, as well as the inherent qualities of ecosystem services, should prompt us to consider a variety of classification methods (Costanza, 2008). Any attempt to develop a single, basic classification system should be addressed with caution due to the fact that ecological services are inextricably related to social processes and social decisions. The context in which ecosystem services research is conducted is critical for mobilising the ecosystem services concept.
The ecosystem services idea arose from a rising worry that the benefits humans obtain from nature are not sufficiently reflected in traditional economics, if at all (Goméz-Baggethun et al. 2010, Lelea et al. 2013). As a result, the idea can be viewed as an attempt to correct this balance by a systematic assessment of demand for and provision of all types of ecosystem services. To this purpose, the Millennium ecosystem assesmet's definition of ecosystem services is the most widely used today: the functions and products of ecosystems that benefit humans or provide societal wellbeing (M.E.A., 2005). Ecosystem services are divided into four fundamental categories by the M.E.A, each of which can be made up of a huge number of specific ecosystem services.

Type of service	Definition	Example
Provisioning	Products obtained from ecosystem	Food Fresh water Fuel wood Fibre Biochemicals
Regulating	Benefits obtained from regulation of ecosystem	Flood protection Water treatment Regulation of climate Air quality Noise erosion
Cultural	Non material benefits obtained	Recreation Education Social relations
Supporting	All other	Biodiversity Photosynthesis Soil formation

Table 2: Categorisation of ecosystem services

1. Provisioning services are goods that ecosystems provide and humans consume or use, such as food or freshwater. Food production on urban and peri-urban agriculture, rooftops, backyards and community gardens are examples of this in an urban setting (Goméz-Baggethun et al. 2010).
2. Regulatory services are services that healthy natural systems, such as wetlands, can provide, such as flood control and water purification. In an urban setting, this might

mean using vegetation to reduce temperature and pollution via shade, absorbing heat through evapotranspiration and reducing pollution through leaves.

3. Cultural services are intangible benefits that nature typically delivers, such as aesthetic enjoyment or contributing to place identity. Recreation and aesthetics are perhaps the most important services that the natural environment provides to humans in urban areas (Pontee et al., 2015).
4. Supportive services are basic processes and functions that are necessary for the supply of the first three types of ecosystem services, such as soil formation and nitrogen cycling (Cabral, 2017, Goméz-Baggethun et al. 2010).

2.6 Monetary evaluation of ecosystem services

The direct and indirect effects of an ecosystem on human well-being are referred to as ecosystem services (Czembrowski, 2016). Ecosystem services, which are often considered as economic advantages offered by natural ecosystems, are probably the most important movement in conservation research at the moment. They are the foundation of most market-based conservation systems. The basic assumption is that if scientists can identify ecosystem services, quantify their economic value and ultimately bring conservation closer to market ideologies, decision-makers will see the devastation of environmental degradation and act to protect nature (McCauley, 2006, Mukherjee et al., 2014).

Ecosystem services can be valued in a number of different ways. Fundamentally, ecosystem service valuation can be characterised from three perspectives: ecological, sociocultural and economic (Reid et al., 2005). Ecological value is based on the state of the ecosystem, which is described by certain features, whereas socio-cultural value is based on the influence it has on people's culture and community. However, economic value is frequently expressed in monetary terms, making it difficult to evaluate ecosystem services due to the lack of a market price for nature (de Groot et al., 2010). In order to improve decision-making and institutions for biodiversity conservation and sustainable ecosystem management, monetary evaluation should be used in conjunction with other instruments such as spatial planning and regulation.

The problem with present data regarding the cost-effectiveness of NBS is that most appraisals do not employ an adequate framework, which leads to an underestimation of the economic benefits of working with nature, especially over time (Czembrowski, 2016). Scholars have decided on multiple concerns that must be addressed. For starters, NBS are frequently received as multi-functional, with the ability to assist both local and global societies. Yet, whether locally or beyond the immediate region of implementation, benefits like water security, carbon sequestration and recreational space are rarely accounted for. This could be due to the fact that they are difficult to monetize or because non-market worth is highly unknown (Mukherjee et al., 2014). Secondly, evaluations seldom take into account trade-offs between different interventions and ecosystem services, or between stakeholder groups that may perceive the costs and benefits of NBS in different ways typically reflecting inequalities in the level of reliance on natural resources (Reddy, 2016). Another aspect is that engineered or grey solutions can usually be implemented with a high degree of certainty about the type and timing of benefits, whereas NBS tend to offer more flexible long-term solutions with benefits that may not be realised until after the costs have been borne within standard political or electoral cycles.

The balance of long-term public value against a lack of private short-term financial flows is a significant question that emerges from this theme. To obtain the benefits of infrastructural NBS investments, such as urban drainage systems and urban parks, a long duration and a huge scale are frequently required. Discounting future values, on the other hand, means that the long-term benefit is generally undervalued in present financing decisions, leading to economic, sustainability and ethical considerations (Guerry et al., 2015). Some view the current usage of environmental impact estimations by financial decision-makers as insufficient and disjointed, with the goal of supporting nature-based wealth accumulation (Bracking, 2012; Milne and Gray 2013).

2.7 Criticism on the NBS concept

The evaluation of ecosystem services through nature based solutions appears at first sight as a case for the increase of economic and business interest. A convincing case on the economic feasibility of nature services would mean increased funding efforts from private and public actors resulting in the mainstreaming of nature based solutions. However, from a nature conservation standpoint, organisations such as the International Union for Conservation of Nature (IUCN) have raised concern and criticised its short sightedness of an approach to monetize the value of nature (Cohen-Shacham et al..2016)

Ecosystem services, a crucial component of NBS, appear to environmentalists as a practical appeal for preserving and encouraging ecosystems, habitats and biodiversity at first glance. They provide a means of gaining broader support from organisations that might otherwise be hesitant to contribute funds to conservation projects. The concern, according to environmentalists, is that valuing and monetizing nature is reductive. Leaving aside philosophical problems about nature's existential value, Kronenberg (2015) points out that an overemphasis on economic valuation might lead to actions with unintended economic and even environmental implications. There will no longer be an incentive to conserve nature or prefer NBS over technical alternatives if nature does not provide services or solutions, if cheaper technological solutions are available or if market needs change (Kronenberg, 2015). This has been demonstrated by McCauley (2006) in his outline of technological innovation trends throughout human history, which have been largely driven by the need to find artificial replacements for and improvements on natural services.

2.8 Conceptual model

It is critical for decision makers to get essential insights into the current condition and future trend of nature based solutions in stormwater management, which necessitates the analytical technique of building a complete evaluation framework for NBS. This study builds towards a complete performance and benefit evaluation framework NBS in the context of three different European cities . It will support the assessment of national policy procedures in regard to nature based solutions in urban stormwater management.

This study provides a conceptual framework for analysing both the theory and the practice of NBS implementation.It adopts and expands an approach to policy needs that, in our view, identifies and examines the governing frameworks and conditions necessary to close the gap between a strategy or solution, a policy issue (the existing status) and a policy target (the desired situation)

Stormwater management	**Socioeconomic co-benefit**	**Environmental co-benefits**
Participatory planning and governance - Community involvement	Economic opportunities - Efficiency - Job creation - Urban regeneration	Ecosystem services - *Provisioning* - *Regulating* - *Cultural* - *Supporting*
Water Management - Pluvial flooding threat - NBS strategies	Health and well being - Accessibility - Health impact on residents	Ecosystem strengthening - Biodiversity
Governance capacity - Financing - Stakeholder - Integration		Climate adaptation - Carbon sequestration - Urban heat island

Figure 4: overview framework

3. Methodology

A review of the literature on the approach for highlighting the study design process is presented in this chapter. The author began the process of selecting the literature based on the intended research objective, which led to the use of the qualitative research method and the case study research method.

The goal of this thesis is to create a framework by which a benefit analysis for sustainable stormwater management can be conducted, in which stormwater management strategies around Europe are compared and being set in relation to current theory. Determining the benefits given by the development of NBS as ecosystem services is critical in the benefit assessment. It is important to identify the ecosystem services that can be provided within an urban context. The research is done in various parts: a literature research and three case studies around Europe.

The author proposes a qualitative approach of current policy reports and case studies were assessed using diverse criteria according to the different scopes of the topic, different levels of NBS implementation and availability of international peer-reviewed literature for certain subtopics. The author outlines the criteria for selecting relevant case studies significant for the current review in the first part, while the second describes the procedures of the literature survey to collect data from relevant international peer-reviewed publications.

3.1 Literature review

A literature review is undertaken to give a broader, theoretical context for the research as well as the conceptual framework for the study. This is accomplished by reading scientific articles and books, retrieved via Google Scholar and the RUG smartCat program, respectively. The literature study is carried out for a number of purposes.

As a starting point, a literature evaluation of existing assessment frameworks and methodologies is conducted with the goal of finding shared essential aspects of assessment procedures. Gaps and ambiguous points will also be found by mapping the discrepancies between the considered assessment frameworks in an attempt to be explained in the new framework. The literature review's second goal is to collect currently existing indicators in order to evaluate an NBS project. The unaligned terminology, shared part and already existent indicators between the evaluated frameworks are described in the following chapters. The framework will outline the supposed ecological benefits of NBs systems.

3.2 Comparative research

It is vital to draw on numerous contexts and establish conformances between these situations in order to find supportive and obstructing conditions that provide significant lessons for all of Europe and are not only true in a specific urban setting or scenario. This is best accomplished through comparative study with the primary purpose of searching for similarity and variance' (Mills, 2006). An experimental method, where the environment may be modified to see what difference it makes and therefore identify causal linkages, is superseded by such a search for similarity and variance. Comparing cases enables for causation to be deduced based on similarities and differences (Denters and Mossberger, 2006)

3.3 Case study

A case study research method would be most suitable to achieve the research objective, which is to understand the planning and implementation process of integrating NBS to urban stormwater management and its ecological co benefits in the three selected cases. Case study research is a qualitative method in which the researcher collects detailed, in-depth data from many sources of information in order to examine one or more contemporary, real-world bounded systems (cases) throughout time. The researcher then presents a case description and case themes. The case study's unit of analysis could be one or more cases, or it could be just one case (Creswell & Creswell, 2013).

The method is appropriate for research that wants to investigate a comprehensive and in-depth explanation of a process without the need for behavioural events to be controlled (Yin, 2009). According to Yin (2009), case study research has four main applications: explaining causal links in real-life interventions that are too complex for survey or experimental methods; describing actual interventions and their context; descriptively explaining some specific topics; and gaining a deep understanding of an event that has no clear, single set of outcomes in the evaluation process (Yin, 2009).

The framework applied in the three case studies on Rotterdam, Hamburg and London is based on the following steps:

1) Identifying and valuing ecosystem services relevant to the project site under different mitigation scenarios
2) Formulating recommendations

3.4 Case selection

The selection of appropriate case studies is a critical step in the research process. The research setting has a large impact on the usefulness of the results. As a result, it is critical to establish appropriate case selection criteria and devote time to locating suitable situations (Yin, 2014). Rather than creating a statistically representative sample, the goal of selecting case studies is to find the most instructive cases. The main criterion for selecting a case should be that it has specific or common characteristics that are relevant to the research (Gagnon, 2010)

3.4.1 Scale

Climate adaptation policy documents from each case study city will be analysed for London, Rotterdam and Hamburg. Attention hereby lies on the implementation of sustainable stormwater practices and its recognition of its ecosystem services.

By boosting stormwater retention capabilities and minimising the heat island effect, for example, these often smaller-scale actions can help to enhance resilience. These NBS can be highly useful for local rainwater collection, reducing heat levels in cities by giving shade and mitigating the effects of air, water and soil pollutants. Neighbourhoods can be constructed as resilient functional groupings. Local infrastructure, such as stormwater drains, can be relieved by implementing NBS at the neighbourhood level. Collaboration between the public and private sectors is critical at the neighbourhood level and NBS implementation can aid in the formation of alliances among the various players.

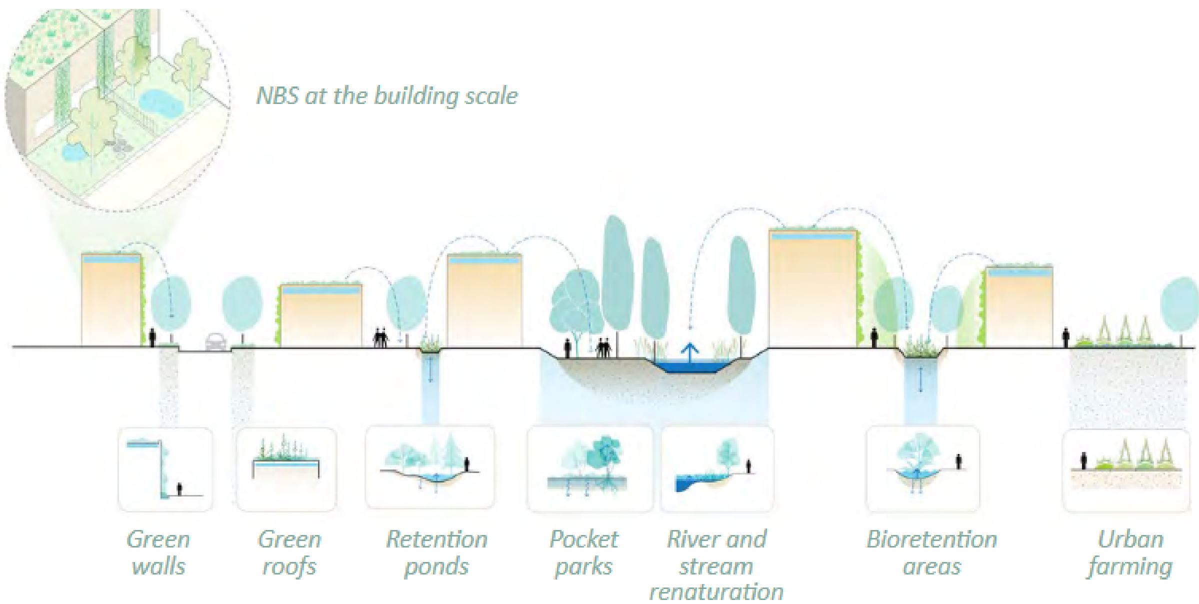

Figure 5: Schematic section of NBS at the neighbourhood scale (World bank, 2021)

3.4.2 Units of analysis

The entity that frames what is being studied in a study, or the entity being studied as a whole, is the unit of analysis (Gammelgaard, 2014). The case selection has been conducted under the following criteria:

Selection criteria	***Description***
Urban area	Metropolitan area
Existing nature-based stormwater management	The case fulfils the fundamental aspects of the NBS definition: it is inspired or supported by nature, provides environmental, social and economic benefits
Available information on policy	The city council or respective state has existing legislation on climate adaptation strategies
Contemporary policy report	The policy report cannot be older than 5-7 years, most recent report
Variety	The cases differ in their physical characteristics, stakeholder constellation and focus or objectives.

Table 4: criteria for case selection

The criteria have led to the selection of the following cases in Europe. Blue Green infrastructure development projects in the cities of London; Rotterdam; Hamburg. The result is the comparative case study analysis of the differences in the ´practice and theory of NBS implementation in urban stormwater managers in the three cases

3.5 Designing the research approach

In accordance with the three research questions, this part explains the research procedure of this thesis and the relationship from literature evaluation to data analysis.

In order to answer the research questions, the literature analysis and data analysis consisting of policy reports and project plans were conducted. The table below shows the process and flow of this research.The structure of this research design adapts from case study research methods (Yin, 2009). Starting with a review of the literature, developing an analytical framework based on the findings and then making suggestions. To develop the structure of the research design for this thesis, these processes were synthesised with the case study research methodology.

	Which ecosystem services does nature-based stormwater management offer?	*To what extent does the deployment of sustainable stormwater systems benefit ecosystem services in the case study cities?*	*To what extent do nature-based stormwater management differ in theory and practice?*
Literature review	Literature on NBS		
Literature analysis	Case literature	Case literature	Case literature for supporting and comparing with the policy results .
Analytical framework		The empirical findings in this column will be summarized and analysed within the framework in order to answer the question	The findings in this column will be combined with the analysed data from RQ1 and RQ2
Policy Analysis		Policy Content analysis Comparison between cases	Comparison theory and practice

Table 5: research design process

To obtain additional information related to the study questions, reports from planning practices, documents from nature conservation organisations, private and public records, websites and governmental reports are analysed. After being discovered on the internet via Google's search engine, the documents are sought from relevant actors. All documents are reviewed for appropriateness, timeliness and accuracy. Papers about the city's policy and institutions are also used to provide background information about the city in order to gain a better understanding of the case.

For the policy analysis on the case study cities, an urban plan and a climate plan have been selected for each city.

POLICY DOCUMENT	LONDON	HAMBURG	ROTTERDAM
URBAN PLAN	The London Plan 2021	Hamburg 2030	Ontwerp-Omgevingsvisie
CLIMATE PLAN	London environment strategy	Hamburger Klimaplan	Rotterdamse adaptatie strategie

Table 6: Overview policy documents

When looking at the policy documents, the assessment for the replication of NBS are conducted by following the following steps:

The assessments begin with identifying urban development priorities and long-term policies for implementing nature-based solutions. Secondly, the difference between the current policy mix and the long-term policy mix for NBS implementation must be determined. Identifying potential barriers and incentives Third, consider whether or not incentives are present in assistance programs. Finally, evaluate the policy's success as well as how it functions as it moves from theory to practice.

Policy stage	Definition
1. *Identification*	Identification of urban development priorities and sustainability policies.
2. *Design and adaptation*	Analyse the gap between existing and the desired sustainability policy mix for the implementation of urban priorities and policies
3. *Implementation*	Establish policies and incentives or compliance assistance programs to increase funding, awareness and embeddedness of NBS. This funding sources are in the form of policies on stormwater utility fees, flood control district funds, grants
4. *Evaluation*	Assess the success of the policy, incentive or compliance assistance program

Table 6: Definition of all stages of the policy analysis

3.6 Analytical framework

In this part, the analytical framework is presented which objective lies in determining and assessessing co benefits, ecological services of NBS in stormwater management. When applying NBS in urban environments, the framework contains four dimensions that may occur simultaneously (Kabisch et al., 2016):

1) co-benefits for human health and well-being
2) integrated environmental performance (e.g., the provision of ecosystem services)
3) trade-offs and synergies in biodiversity, health, or the economy
4) citizen participation in governance and monitoring

The framework advances current knowledge by highlighting not only the benefits and costs of NBS derived from existing ecosystem services, but also the benefits and costs of interactions across socio-cultural, economic, biodiversity, ecosystems and climate elements (Plieninger et al., 2015).

Indicator	Awareness/Objective	Measures/ Implementation
Climate mitigation and adaptation	Carbon sequestration Reducing urban heat island effect Pollutants captured by vegetation	NBS action in relation to carbon sequestration and heat island Green space Regulations/ Urban greening factor Green network (air circulation, decibel reduction) Promotion natural water cycle and conservation
Ecosystem strengthening	Species richness and biodiversity Ecosystem services Recognising Value of nature	Interlinked Urban green/Green corridors (urban forest, woodlands) Financial support schemes Defining nature
Economic opportunities	Green jobs by NBS projects Work efficiency Urban regeneration (economic performance) Number of jobs created	Proof of efficiency (at workplace) Increased property value Gained economic value (GDP)
Participatory planning and governance	Stakeholders' participation and community involvement Quality of participatory process	Meetings Information availability Involvement campaign
Social justice and cohesion	Accessibility to public green space Recognition of socio-economic inequality regarding access	Strategy for equal distribution of access to urban green Land use and building regulations (minimal distance to green)
Public health and well being	Attendance in green space of inhabitants Outdoor activity Aesthetics Psychological effect on residents	Interlinked Urban Green (parks, walk trails) Sports and community facilities
Water Management	Flood risk due to increased rainfall Recognition of shortcomings of traditional grey sewage systems Need for integrated stormwater management to protect built environment	NBS strategies in relation to flooding Control runoff and flood resilience through BGI Reduction of stormwater treatment costs Incentive mechanism policies (Subsidy, consultation, stormwater fee reduction, reimbursement, private retrofit)
Governance capacity	Integrated Stormwater Management Responsibilities Actors involved Address Financing	Integration of the drainage system into a multifunctional green infrastructure role of green measures in new developments Public or private development/ financing Pilot projects/strategies Financing concepts Instruments

Table 7: Analytical Framework for the assessment of benefits of NBS in urban stormwater management

For identification of ecosystem services through nature based solutions, a framework has been completed with useful measures and strategies where the first step is to conclude a gross list of services possibly generated. The proposed methodology will be conducted for identification of present ecosystem services within the various case study cities. Each indicator will be analysed on its degree of awareness and implementation. In this context awareness means the identification of a problem and need for a solution. The implementation addresses the concrete action against it which are indicated based on keywords such as interaction, investment, monitoring and agreement making.

Environmental

As previously stated, NBS play an important role in shaping cities' natural capital by providing a variety of benefits. The most significant benefits are associated with ecosystem services related to climate adaptation and biodiversity.

Socio economic

Many factors influence NBS operations and perception in the broader societal environment. Its contribution to improving climatic conditions directly translates into bettering living conditions in the city, improving residents' health and ensuring individual well-being. The criteria assess the adequacy of NBS planning by evaluating the governance component at the municipal level. Stakeholder engagement, community participation in NBS processes (e.g., planning, decision-making). The presence of public awareness campaigns are also considered in the proposed criteria. NBS can increase financial capacity and provide potential economic opportunities. The criteria include whether there is a dedicated budget for NBS, the annual costs of monitoring and maintenance and the development of efforts to promote NBS in households. As economic opportunities, the criteria for implementation mention the NBS program for new green jobs, businesses and activities, as well as tourist promotion.

Water management

Measuring and improving water-related ecosystem services, such as a positive impact on the regulation of the disturbed urban hydrological cycle by capturing, retaining, infiltrating and reusing stormwater within catchment areas, closer to the source of runoff, while reducing the risk and effects of torrential rains and floods. The governance capacity focuses on the stakeholders involved in ensuring NBS planning at the city level, as well as stakeholder knowledge and participation. This goal is linked to criteria such as NBS planning at the city level, as well as stakeholder knowledge and integration.

3.7 Grading scheme

In order to evaluate the policy docutes based on the previously set indicators, a grading table has been established. This table will take into account the factors of the awareness and implementation range of each indicator. They are graded in an ordinal fashion, ranging from Prominent (++) to Absnet (- -).

Grading	Prominent	Largely Prominent	Neutral	Largely Absent	Absent
Symbol	++	+	+/-	-	--

Table 8: Grading scheme for policy evaluation

Awareness: This implies that the benefits of ecosystem services, as well as the general benefits of NBS in urban stormwater management, have been acknowledged. However, this does not include any action plans to facilitate the implementation of it, but rather is limited to the recognition of the problem and solution. Policies which are restricted to awareness will score in the fields **'Largely Absent'** and **'Absent'**.

Example: *Various benefits provided by NBS on their potential for rainwater infiltration as a proxy for a wide range of benefits such as improved health and biodiversity conservation (p.325, LP).*

Implementation: this implies that there has been detailed actions being taken to achieve the implementation of nature based solutions or their ecosystem services. One has to look out for the following qualities: concrete actions such as interaction, investment, agreement making or program. Policies which do include implementation measures score in the fields of **Largely Prominent'** and '**Prominent'**.

Example: *The government's Natural Capital Committee is creating an accounting framework to address the issue of underinvestment in managing and improving the natural environment and green infrastructure (p.192, LP).*

4. Results

The findings from the policy analysis of diverse policy documents from London, Hamburg and Rotterdam are presented in this chapter. The introduction to the city and its policy documents is followed by sections on the analytical indicators in each case's structure. The institutional aspects of integrating NBS into the case's stormwater management are covered in the first section. The second segment responds to the highlighted business prospects and value of nature. The third section introduces the implementation processes and instruments, followed by information on its drivers and barriers. The interpretation, which includes the grading system and a reflection on each individual instance, is covered in the final section.

4.1 London

Picture: london.gov.uk

4.1.1 Context

On 7th August in 2002, an inch of rain fell in central London in 30 minutes during the evening "rush hour", resulting in the closure of 5 mainline railway stations and considerable disruption as London's drainage infrastructure was too old and overloaded to cope with such events (Penning‐Rowsell, 2019). As large parts of London's sewer system which combines storm water drainage with waste water sewerage date back to the 19th century, increased population and reduced urban surface permeability mean that the city's drainage systems are under acute pressure (Jenkins, 2017). Pluvial flooding is regarded as the most likely cause of flood events, as well as one of the major short-term climate hazards facing Greater London. Up to 680,000 houses in London are predicted to be at danger of surface water flooding with a likelihood of at least 0.5 percent per year, with 400,000 of these being in addition to those vulnerable to rivers and the sea. Between 2001 and 2011, the number of residential properties prone to surface water flooding increased, as did the proportion of urban land covered by manufactured surface water (Penning‐Rowsell, 2019).

4.1.2 Stormwater Management in the UK and London

The United Kingdom has taken a very supportive stance on water sensitive development, typically referred to in the UK as Sustainable Urban Drainage Systems (SUDS). Although not required, SUDS are repeatedly listed as preferred solutions for stormwater management. In the context of regional planning for example, the "Planning Policy Statement 25 for Development and Flood Risk" requires that SUDS specifically be considered at every level of flood risk planning (Department for Communities and Local Government, 2019). Similarly, the Town and Country Planning Assessment of Environmental Effects Regulations (Cullingworth, 2006) determine that SUDS may be used to mitigate negative impacts on the environment. The building sector establishes a hierarchy of building water management that favours infiltration over piped systems.

Sustainable drainage cannot be widely implemented by the Greater London Authority alone; it will require an integrated strategy from many different partners. The GLA received assistance from the Environment Agency, Thames Water and London council in creating this action plan and they have all agreed to support a number of the measures. Additional counsel has been obtained from numerous non-governmental organisations and London boroughs and the success of the initiatives will depend on their cooperation (Greater London Authority, 2016).

The public sewage systems in London are owned and operated by Thames Water. For projects that can remove surface water from the combined or foul sewerage system throughout its operational region, Thames Water has given cash for the years 2015 to 2020. The "Twenty Twenty" program seeks to prevent the discharge of rainwater into sewers from at least 20 hectares of drained land (Greater London Authority, 2016). Defra is the sponsor of the executive non-departmental public body known as the Environment Agency. In England, its main duties are to advance sustainable development and safeguard and improve the environment. It requires a comprehensive assessment of all flooding causes, including flooding from surface water. Over the next six years, 35 projects totaling more than £12 million will assist London boroughs in managing their risk from surface water flooding.

More plans are being designed that utilise sustainable drainage strategies as knowledge of such projects increases. Localised projects are now being undertaken by many boroughs. The majority of these use a strategy similar to this action plan, integrating the project into broader goals of enhancing amenities or the appearance and function of buildings and public places. The GLA has started a register to document these instances throughout London. It is envisaged that this will contribute to a body of knowledge on possibilities and excellent practices.

Numerous NGOs have also made significant contributions to the implementation of sustainable drainage projects as well as the dissemination of information about the advantages and necessity for sustainable drainage. Important responsibilities must be played by organisations like Groundwork London, Thames21, London Wildlife Trust, Wildlife & Wetlands Trust and several locally oriented organisations. In fact, several of these have already provided long-lasting drainage systems at a variety of places. They could play a bigger part in this field because they have strong community engagement skills. They can support local project implementation in particular, which necessitates the fostering of interpersonal ties (Greater London Authority, 2016).

Finally, the UK cases demonstrate that strict contractual rules and requirements formalise the organisational roles of local governments and project developers in terms of tasks, responsibilities, risks, and revenues. Nonetheless, urban development projects generate significant public-private collaboration and interaction. In the United Kingdom, general planning guidance documents and decisions are made based on planning permits, which usually coincide with negotiations with private developers. Planning documents are general, and decisions are in negotiation for permits (Heurkens & Hobma, 2014). The plan is not a formal document, but rather guidance. Formal decisions are made on a local authority's planning permit, and negotiations take place regarding SUDS measures. These services are provided by developers. Defra and the environmental agency, on the other hand, invest in Sustainable drainage systems on public land.

4.1.3 Policy

Urban plan: London 2021

The Greater London Spatial Development Strategy is known as the London Plan 2021. It outlines the Mayor's plan for good growth as well as a framework for how London will expand over the following 20 to 25 years. The Plan is a component of London's statutory development plan, therefore its rules should influence decisions regarding planning requests around the capital. Borough's Local Plans must be in "general conformance" with the London Plan in order to ensure that the planning system for London functions cohesively and reflects the overall strategy for how London can develop sustainably, which is set forth in the London Plan.

Climate plan: London Environment strategy

One of the seven strategic papers the Mayor will use to convey his vision for London is the London Environment Strategy (LES). London boroughs play a significant role in the execution of each of these plans. The local authorities of London are mandated by law to take care of issues like air quality, parks, noise pollution, and climate change as well as to collect domestic rubbish inside the LES. It recognizes that in order to realise this 2050 goal, the necessary plans must be put in place as well as fast action. The strategy recognizes that the Mayor cannot realise this vision alone, but that he and his organisations can set good examples and will use the resources at their disposal to carry out the strategy's objectives. The strategy calls for collaborative action from a variety of different stakeholders, including the government, London local authorities, third sector organisations, and businesses.

4.1.4 Institutional

In terms of the danger of pluvial flooding, the policies stress the need to move further than just rely on traditional grey drainage systems . Planning and designing new developments with care should prevent the fragmentation of existing green space, use sustainable drainage methods to lower stormwater runoff rates and incorporate additional tree planting. London's policies capture the various co-benefits of NBS next to the stormwater management aspects. It recognises the ecosystem services of NBS in the area of air pollution, heat and the various advantages offered by NBS on their ability for rainwater infiltration as a proxy for a variety of advantages like increased health and the preservation of biodiversity

> *'London's green infrastructure - its parks, green spaces, trees, rivers, wetlands and green roofs – can reduce the impacts of climate change and help to store carbon' (1:15, p 117, LP).*

The implementation of green infrastructure techniques can assist boroughs in locating potential strategic opportunities. Boroughs need to develop green infrastructure plans that highlight prospects for interborough cooperation. To determine the appropriate level of urban greening necessary in new developments, boroughs should develop an Urban Greening Factor (UGF). London municipalities have used a variety of strategies to encourage community involvement in neighbourhood green areas.

4.1.5 Economic

Climate change has the potential to reduce the value of the world's financial assets by £2.5 trillion and possibly up to ten times that amount in the worst-case scenario (Greater London Authority, 2018). However, in the case of Lonodn, NBS contribute significantly to society, with ecosystem services totaling billions of euros. London uses a natural capital framework and analysis which is to be used in decision making for infrastructure such as business cases and investment appraisal. The framework allows to measure the value of ecosystem services in their direct and indirect impact. Natural capital can be defined as the stock of the physical natural assets (such as soil, forests, water and biodiversity) which provide flows of services that benefit people (such as pollinating crops, natural hazard protection, climate regulation or the mental health benefits of a walk in the park). Infrastructure both contributes to and is impacted by this decline but can also help reverse it.

> *'Londoners avoid £950 million per year in health costs due to public green space, the value of recreational activities is estimated to be £926 million per year' (2:96, p133, LES).*

> *'For the average household in London, the monetary value of being in close proximity to a green space is over £900 per year. the value of recreational activities is estimated to be £926 million per year' (2:99, p133, LES).*

This framework allows for direct recognition of benefits of NBS next to the drainage of various ecosystem services. The All London Green Grid is a green infrastructure policy framework outlined in the London Plan's Supplementary Planning Guidance. The many functions and benefits of green infrastructure were recognized. It did not, however, prioritise projects and interventions based on their intended role or specific benefit in each region. Higher resolution spatial data has become available after the publication of the report in 2012. This enables for a more in-depth analysis of where green infrastructure improvements could deliver significant benefits at the neighbourhood level.

A key policy in the Plan is the healthy streets approach which is designed to improve air quality, reduce congestion and help make London's diverse communities greener, healthier and more attractive places to live, work, play and do business.

> *'In 2010, London air pollution was linked to over 3,000 hospital admissions. The economic cost of these health impacts in London is estimated as being up to £3.7bn a year' (2:36, p52, LES)*

In view of this estimation, London has set its aim to have the best air quality of any major world city by 2050, going beyond the legal requirements to protect human health and minimise inequalities. Londoners contribute significantly to preserving and improving the city's ecosystem. Traditional local council funding structures are unlikely to have the funds today to maintain and improve every public space and green area. According to the plans, local residents, companies and community organisations that interact with the public can actively manage local places and secure financing in addition to volunteer time. Boroughs have to come up with their own maintenance funds.

> *'Havering actively supports a Friends of Parks network that ensures local communities are actively engaged in decisions about managing the borough's parks. This supplements the work of the borough's grounds maintenance team' (2:121, p.164, LES).*

4.1.6 Process, Management and Instruments

The policy report advocates for a green infrastructure approach for London, recognizing its economic and social significance and proposes an Urban Greening Factor (UGF) model for the city to help fund it. The Urban Greening Factor is a planning policy instrument evolved from a series of Green Space Factor (GSF) frameworks that have been adopted in a number of European and North American cities in order to stimulate more and better urban greening.

> *'A number of cities have successfully adopted a 'green space factor' to encourage more and better urban greening. The Mayor has developed a generic Urban Greening Factor model to assist boroughs and developers in determining the appropriate provision of urban greening for new developments' (1:38, p119, LP).*

It is a technique for assessing the degree and scope of urban greening. It enables large-scale developments to demonstrate how they have used urban greening as a crucial component of site and building design in order to comply with the London Plan on Green City policy (Greater London Authority, 2021).

Figure 6: Green cover map of London (Greater London Authority, 2019)

London introduces the environmental net gain approach which entails taking steps to reduce the substantial potential impact on natural capital of many big infrastructure projects. Infrastructure investors, developers, providers and operators must follow the mitigation hierarchy when delivering environmental net gain compared to the pre-development baseline natural capital frameworks and analysis to be used in decision making for infrastructure such as business cases and investment appraisal infrastructure investors, developers, providers and operators must follow the mitigation hierarchy when delivering environmental net gain compared to the pre-development baseline natural capital frameworks and analysis to be used in decision making for infrastructure such as business cases and investment appraisal (UK Government, 2019).

London emphasises on collaborative working with a wide variety of stakeholders. Extensive collaboration of various stakeholders and institutions such as: mayor, government, green spaces commission, London boroughs, Risk management authorities.

> *'Boroughs should prepare green infrastructure strategies that identify opportunities for cross-borough collaboration, ensure green infrastructure is optimised and consider green infrastructure in an integrated way as part of a network consistent' (1:3, p116, LP)*

London's regulations offer guidance on how to meaningfully incorporate green infrastructure through the integration of water management. Development plans should include relevant green infrastructure components that are connected to London's larger network of green infrastructure. They clearly state the advantages of integrated management but do not offer clear instructions on how to implement it.

> *'Green infrastructure should be planned, designed and managed in an integrated way to achieve multiple benefits' (1:1, p116, LP)*

> *'All development takes place within a wider environment and green infrastructure should be an integral element and not an 'add-on' (1:14, p117, LP)*

Explicit financing schemes which will move the actual implementation of the NBS strategies and retrofit to sustainable drainage systems ahead. Recognizes the problem of correctly valuing the value of nature in the current discourse of climate adaptive planning, NBS seen as a liability in projects. London locates special attention to NBS as an investment strategy. The Mayor's Greener City Fund will invest in strategically important green infrastructure projects.

> *'The Mayor's programme will comprise the following elements: community grants for creating greener space – investment in small and medium scale greening projects in green spaces across London' (2:113, p153, LES)*

> *'Natural capital accounting addresses this by bringing together the full benefits of green infrastructure and presenting them in a similar way to other capital assets, like buildings' (2:28, p38, LES)*

In its most recent sustainable drainage system consultation, London made a policy recommendation that aims to incorporate a Natural Capital Approach into planning and decision-making. In order to prioritise and identify strategic possibilities for green infrastructure and habitat provision or improvement and as a consistent measure for attaining environmental net gain from new development, this builds on a spatial evidence base, the natural capital network. The proposed Local Industrial Strategy, which is informed by the baseline data and cites safeguarding and strengthening Natural Capital as a key strategic objective across a number of policies including place-making, climate change and air quality, supports the NBS policy. When these financial gains are absent, green infrastructure is sometimes seen as a liability—a cost that must be borne rather than an asset to be invested in. This disregards the vast array of advantages that green infrastructure may offer, from improved physical and mental health and higher property values to less flood and heat danger.

4.1.7 Interpretation

London's approach to nature based solutions has been performing quite well in the selected indicators. In general the differences between awareness and implementation are not substantial. The performances of the two policy plans are quite balanced, ranging from strong execution in some fields to ones that show substantial deficits. In London, there has been significant advancement in the monetisation of environmental impacts in policy evaluation. To account for the shadow price of carbon, the effects of air pollution on human health and the nuisance values of noise, for instance, precise monetary values are now employed. To make sure that environmental implications are considered in policy and project appraisal, other government departments and agencies have also created comprehensive recommendations.

Theme	Indicator	Awareness	Implementation
Climate mitigation and adaptation	Carbon sequestration	+	-
	Urban heat island effect	+	+
Ecosystem strengthening	Biodiversity	+	+
	Ecosystem services	++	++
Economic opportunities	Green jobs by NBS	+	--
	Work efficiency	--	--
	Urban regeneration	-	-
Participation	Community involvement	-	+
	Quality of participation process	-	+/-
Equality	Accessibility to public green space	+	-
Health and wellbeing	Attention to residents' Health	++	-
Water management	Pluvial flooding recognition (flood protection)	++	+
	Insufficiency of grey and opportunity for NBS	++	++
Governance capacity	Integration	++	+
	Institutions /stakeholder	++	++
	Financing/incentive scheme	+	++

Table 9: Grading table London

4.1.8 Reflection

The policies address a specific need to promote the awareness and the retrofitting of sustainable drainage systems right across London. It contains a series of actions to make the drainage system work in a more natural way which will bring a wide range of benefits including: steadily reducing flood risks by easing the burden on our drains and sewers reducing pollution of its tributary rivers and streams creating more pleasant landscapes, streets and settings for London's buildings providing opportunities to save water providing opportunities for school activities and studies related to the water cycle. The main focus of the action plan is on the retrofitting of sustainable drainage to existing buildings, land and infrastructure. It is recognised that funding pressures mean there will not be funds specifically for a large-scale drainage improvement programme. Instead the key is to identify when and where other planned maintenance, repair or improvement works are scheduled and then to identify opportunities to retrofit sustainable drainage as part of those works. This way sustainable drainage can be introduced at a much lower cost.

4.2 Hamburg

Picture: Hochbahn Hamburg

4.2.1 Context

Urban development in the growing metropolitan city of Hamburg challenges the city's wastewater management practices. By building up to 10,000 new homes per year and further redensification of residential and industrial areas comes an increase in surface sealing of 0.36% per year. These areas produce runoff that is an increased burden on the city's drainage systems of sewer networks, water bodies and trenches (Bertram, 2017). The number of heavy downpours in Hamburg is increasing as a result of climate change. According to the authority, 180 "heavy rain" events have been recorded in the last ten years (Feddermann, 2021).

4.2.2 Stormwater Management in Germany and Hamburg

Germany has taken an especially strong federal role in the support and regulation of sustainable water management solutions. The Water Resources Act establishes clear directives for water resource management, including groundwater pollution and degradation, urban wastewater treatment, environmental protection and flood risks (WHG, 2000). It establishes frameworks for community action networks, largely believed in Germany and other countries to be the first course of action in implementing systems. For years, water sensitive or "decentralised" solutions as typically referenced in Germany have been a water management goal. Recently, decentralised methods were officially adopted as the preferred method for stormwater management. Decentralised methods are therefore to be considered first and implemented when possible (Bundesministerium für Umwelt, 2020).

The management of water resources is the ministerial duty of the so-called State Ministry for Environment and Energy (BUE), Hamburg's highest technical authority. This obligation has historically grown and is now quite complex. BUE has a number of affiliated authorities handling advanced operating functions. The districts, which are the lower water authorities at the local level, are in charge of carrying out operational duties as well as making planning and approval decisions (Becker, 2006, Bertram, 2017).
The State Ministry of Economy, Transport and Innovation, which, for example, is in charge of the main roadways, is another significant participant. The State Office for Roads, Bridges and Water Bodies implements measures. The state-owned utility Hamburg Wasser is responsible for all operational responsibilities, including infrastructure building and maintenance, in the areas of drinking water supply for nearly 2 million people, wastewater drainage and treatment. In agreement with its board of governors and any other relevant municipal boards, Hamburg Wasser establishes a cost-covering wastewater charge for their services relating wastewater management (Waldhof et al., 2012).
Stormwater management in Hamburg has long been unevenly distributed among these various parties and sporadically governed by each group's legislative framework. Laws governing construction, planning and traffic make significant references to stormwater management. Technical rules for building drainage, property drainage, public drainage systems, road drainage and waterway construction are added to the legislative frameworks. Due to the current circumstances, neither Hamburg Wasser nor the other stakeholders were able to develop a thorough and integrated strategy for stormwater management in the city (Bertram, 2017).

In Germany, responsibility for both urban stormwater and wastewater management is delegated to the municipalities. The preparatory plan shows the intended urban development for a municipality. Within this framework, the binding land-use plan then defines the use of the individual parcels (Nickel et al., 2014).

4.2.3 Policy

Urban Plan: Hamburg 2030

The current concept, which was developed in close collaboration with all specialist authorities, provides detailed data on demographic development findings, examines individual age groups and typical life situations, shows developments and focal points of action in different specialist policies in cross-age group topics and describes the next steps: more social dialogue, ongoing monitoring and networking both within the Hamburg metropolitan region and beyond.

Climate Plan: Hamburger Klimaplan

The climate adaptation transformation path aims to make Hamburg a climate-resilient city. In collaboration with authorities and public companies, strategies and measures are developed and implemented for this purpose. These include direct climate impact protection, such as in civil defence, including storm surge warnings and risk communication and the health sector, including heat warnings, climate-adapted urban infrastructure development, such as heat-resistant road surfaces and drinking water supply measures and the preservation of a high quality of life.

4.2.4 Institutional

Resilience is the new buzz word. It means making cities more robust and able to withstand extreme climatic events, in order to protect people, animals and plants. The increasing risk of heatwaves and droughts on the one hand and heavy rainfall on the other requires a targeted use of the options and development opportunities offered by careful use of water in the city and expansion of the green infrastructure. The established civil protection paradigm includes both catastrophe management and disaster reduction. If the worst occurs, strategies must be created and precautions must be taken to guarantee that the consequences on the city and its residents are as minimal as possible. These include safeguards against the direct consequences of the climate, such as risk communication, interactive maps and storm surge warnings.

This has been expanded to cover additional climate change risks like health protection, continued development of urban infrastructure to adapt to climate change, for example by using heat-resistant road surfaces; and measures related to drinking water supply and the maintenance of a high quality of life. The effects of climate change may also require new functions for state public services. These include, for example, new warning systems, disaster funds or principles for insurances for climate-related damage. Account must also be taken of developments in digitalisation and other social developments that could lead to the creation of new functions for state public services.

Hamburg has a special focus on green roofs, biodiversity and urban heat island reduction. Greening the city and its rooftops is one of Hamburg's goals in reaction to climate change. The metropolitan region will have 100 hectares of green roof surface installed in all. Up until the end of 2024, the Hamburg Ministry for Environment and Energy will contribute € 3 million toward financial support for the installation of green roofs. Up to 60% of installation expenses may be covered through subsidies for building owners. Additional advantages include decreased energy expenses due to enhanced building insulation, longer green roof lifespans that result in cheaper maintenance costs and a 50% decrease in rainwater fees due to the green roofs' ability to retain rainwater (Behörde für Stadtentwicklung und Umwelt, 2014).

> *'The city's green roof strategy, a programme for developing green roof landscapes in the city, gives Hamburg an opportunity to target areas for improvement' (p.19, UD).*

> *'For example, can be retained in water basins that fill only when needed or channelled along open pipes into existing water bodies; it can seep away on green roof tops or run off more readily if sections of paving are taken up in some districts. A lot can be done in this sector' (p.45, UD).*

Green networking represents the city's green infrastructure of parks, allotment gardens, forests, field marks and cultural landscapes. The aim is to preserve Hamburg's current green structures - the green network, to develop them further, to link them together and to use them in urban development at an early stage to consider. The two key topics of heat reduction and promoting natural water cycles have been incorporated into landscape design tools over the past few years and are summarised in the "Grün Vernetzen" (green network) map. This map shows locations with strong infiltration potential, priority surfaces for creating cool air, key zones for producing cool air and housing complexes with a large heat island effect. The Grün Vernetzen map displays major green places, such as Hamburg's green network, as well as locations crucial to the city's climate and air quality.

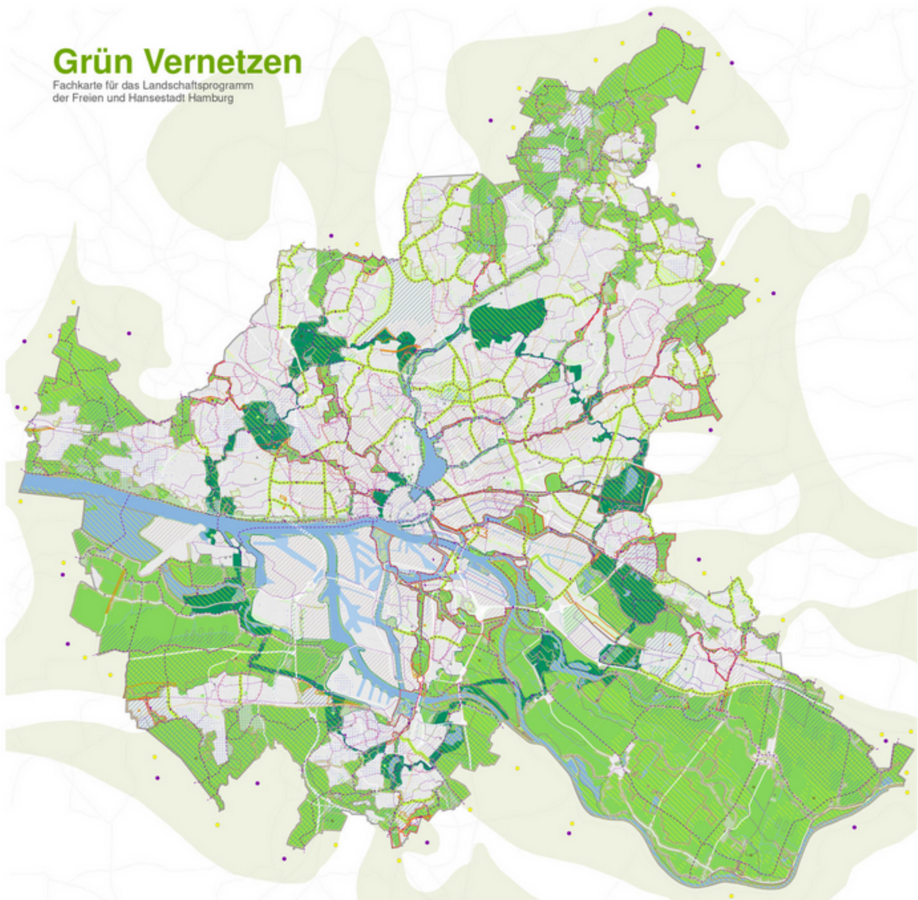

Figure 7: Green Network Hamburg (Stadt Hamburg, 2018)

The map depicts Hamburg's green network as a central spatial objective, as well as strategic target statements for natural balance, specifically the urban climate and the living space network, as well as recreation and the landscape. Priorities for spatial implementation are established by presenting these fields of action. In terms of accessibility, Future "neighbourhood gardens" on private property or "community gardens" on suitable public land may be added to the traditional individual green spaces, such as private renters' gardens and allotments, particularly in highly populated areas. Numerous initiatives in Hamburg have either been launched or are now being developed with the goal of maintaining and enhancing the quality of open space in the small metropolis.

4.2.5 Economic

In contrast to the other case study city, Hamburg's policy does not include economic opportunities. However they recognize the importance of a balanced environmental, social and economic responsibility which aims to drive sustainable urban development forward.

> *'In many parts of the city more opportunities are arising to improve the quality of this very diverse green network, to further refine it and thus enrich the urban space – even in locations occupied by trade and industry or the port' (p.43, UD).*

Hamburg intends to initiate the necessary measures in the coming years so that citizens can continue to live in a city that is worth living in, that is economically successful and affordable, that is a large metropolis that contributes to climate change management. The primary economic force indicated in the strategies is urban renewal. Even in areas where trade and industry or the port are present, there is increasing potential to enhance the quality of this extremely diverse green network, further develop it and therefore enrich the urban environment.

4.2.6 Process, Management and Instruments

In terms of participation, an increasing percentage of locals desire to do more than just use their open spaces. Hamburg wants to support this commitment in every way possible. New pilot programs and testing grounds have been created as a result of the "Urban Gardening" trend. The "My Tree - My City" campaign's success demonstrates how eager the people of Hamburg are to support nature in their community and contribute significantly to replanting the city's historic tree stock. Stakeholder participation is now a well-established procedure where the Centre for Climate Issues regularly invites people to meetings and incorporates their suggestions and opinions when formulating the measures in the revised plan for Hamburg.

The campaign for high-quality open space requires the active cooperation of many different parties in order to finance the projects. To guarantee that "green value" is added to projects, the public purse and private investors must work together.

The Hamburg Water Plan already described in the Strukturplan Regenwasser (Rainwater Structural Plan) 2030 will be established and introduced as a water management framework plan for matters relating to water and waste water management. The long-term aim is that the water plan, as a city-wide scheme integrated in other spatial plans and as a planning instrument, has sufficiently detailed local measures which can be implemented in practical projects. The water plan is based on thematic maps (e.g. infiltration potential map, water regime, topography). Besides the water management framework conditions (e.g. water bodies, sewers, infiltration into groundwater), the water management support plan needs to take account of any upstream or downstream connections plus any requirements for areas for water management measures.

4.2.7 Interpretation

The main challenges in Hamburg are Climate adaptation, resilience and mitigation. The policies excel at climate change adaptation in water management by improving flood protection through stormwater and rainfall management and storage. Consistent improvements in water quality are on the agenda. Regulation of the built environment has influenced regeneration, land use and urban development.

The climate and urban plan form Hamburg at first sight do not perform very well in terms of the set indicators. The immediate reaction would be that Hamburg does not have a complex plan for stormwater management and does not acknowledge the benefits of nature based solutions. However the more likely reason for the poor performance is that Hamburg organises their detailed implantation plans not in the conformal urban plans but relies on more specialised reports and documents. A more detailed report has been done by the private company of Hamburg wasser, the municipal Water Supply and Wastewater Disposal Company.

While Hamburg recognizes the importance of green infrastructure as a critical component of a healthy and climate-resilient society, the term "ecosystem services" has not been adopted.
Consequently, no calculations on the gained value of nature and its benefits have been made. The identification of the advantages of ecosystem services is hampered at the governance levels by a number of complications. Emphasising ecosystem services that are not directly connected to the usage of parks or woods as recreational spaces is currently not a widespread practice.
For instance, controlling environmental services such as noise and air quality may not always be perceived directly by citizens and urban planners.

Theme	Indicator	Awareness	Implementation
Climate mitigation and adaptation	Carbon sequestration	+	-
	Urban heat island effect	+	++
Ecosystem strengthening	Biodiversity	+	++
	Ecosystem services	--	--
Economic opportunities	Green jobs by NBS	-	--
	Work efficiency	+	--
	Urban regeneration	-	-
Participation	Community involvement	-	-
	Quality of participation process	--	-
Equality	Accessibility to public green space	+/-	+
Health and wellbeing	Attention to residents' health	++	+
Water management	Pluvial flooding recognition (flood protection)	+	++
	Insufficiency of grey and opportunity for NBS	-	+
Governance capacity	Integration	-	--
	Institutions /stakeholder	+	++
	Financing/incentive scheme	+/-	-

Table 10: Grading table Hamburg

4.2.8 Reflection

Hamburg, devised creative strategies to encourage the adoption of SUDS and relevant green infrastructure components by its residents. A partnership between the city council and a private water firm, intends to find long-term solutions to prevent water contamination from combined sewer overflow and urban runoff as well as flooding of basements, streets and houses. Additionally, it aims to incorporate water management practices into regional and urban planning and provide a strategy and instructions for future rainwater management. A green roof strategy was also introduced by the city of Hamburg in 2016, offering financial assistance to those who wish to build green roofs. As a result, prices for sewage water and rainwater can be decreased in addition to the city's capacity to retain more water.

Future-proof rainwater management operates in an area of conflict with investors, expenses, space needs and other urban development considerations. Collaboration between water utilities and urban planning stakeholders is essential for a successful transition to nature based solutions. A combination of business-as-usual initiatives and the implementation of water-sensitive urban design is a potential strategy. The core components are a consistent adaptation approach, technical fundamentals and knowledge.

The Hamburg policy documents were in general much shorter than the other two cases and lacked in-depth information at times. This could not be avoided, however, because instead of diverting to technical reports, one climate plan and one urban plan had to be chosen to allow for adequate comparisons throughout the cases.

4.3 Rotterdam

Picture: Marthe Derkzen

4.3.1 Context

The Dutch city of Rotterdam, which is situated in a low-lying region of the Rhine and Meuse river delta, is the subject of the study. Over 257.6 km2 of densely populated land, more than half of which is paved or semi-paved, the city is home to more than 640,000 people. A combined sewage system covers the majority of the city (1800 km), while a separate sewage system covers the remaining 500 km (Solomon, 2013). Historically, Rotterdam's stormwater systems have been built with an estimated in-sewer storage capacity of 10 to 12 millimetres to handle rainfall intensities of around 20 millimetres per hour across brief time frames of 10-15 minutes (RIONED Foundation, 2017). However, the original infrastructure has deteriorated significantly over time and several components have to be replaced, therefore the precise capacities are mostly unknown. The history of Rotterdam, which involves "protecting itself against and living with water," has had an impact on the growth of the city. The city's adaptation program, Rotterdam Climate Proof, is a part of the Rotterdam Climate Initiative. It implements the municipality's ambition to make Rotterdam totally climate-proof by 2025 (Dai et al., 2018).

4.3.2 Stormwater Management in the Netherlands and Rotterdam

Water management in the Netherlands is characterised by a multi-level governance system from the European Union to the local level. 'Decentralised whenever possible, centralised whenever necessary' as the motto of water management indicates that it is based on a relatively high degree of a decentralised model. (Mees, 2016) Pluvial flooding is a shared responsibility of the local government and residents. Furthermore, municipalities have a large margin of appreciation regarding the choice of policy instruments such as local regulations and permit systems or more informal ones such as subsidies and facilitating participatory projects. One of the key underlying concepts of Dutch water management is the Three-Step Approach, which entails the capturing, storing and draining of water – similar to the function of a sponge (Dai et al., 2017).

In Rotterdam, the Water Authority and the municipality share responsibility for managing urban water resources as part of the city's climate adaptation plan. When the local authority starts a project for spatial planning, it must consult the Water Authority beforehand and take into account how the project may affect water management. The Water Authority's suggestions must be taken into account by the municipal authorities as a sign of shared responsibility (Dai, et al., 2018, Climate Adaptation Strategy, 2013).

Based on the Water Act, Environmental Management Act and Spatial Planning Act, municipalities are legally obligated to manage urban water. Rainwater collection on individual properties belongs to the residents. Municipal policy plans define the extent of the public responsibilities in more detail. However, the municipality has consistently decided to go above and beyond their official duty of care and to assume private obligations. As a result, citizens frequently rely on the municipalities and are not aware that they have a formal obligation to manage rainwater on their property. Awareness campaigns with concrete examples of how to make homes and parcels of land more rainproof have been organised in response to encourage citizens to fulfil their duties and involve private actors in making their city rainproof. However, this is essentially a political decision in terms of the staff and the funding for rainproofing measures. Rotterdam's Climate Initiative receives financial support from the national government. The municipality will spend €5.8 million a year between 2016 and 2020 on rainwater collecting and processing (Municipality of Rotterdam, 2016).

In conclusion, municipalities are in charge of the sewage collection system, urban drainage and rainwater collecting and disposal. In accordance with regulations, handling rainwater must at the very least involve the following actions: "storage, transport, effective use or recharge, whether or not after treatment, on or into the ground or into the surface water, as well as its transfer to a treatment plant" (Ministry of Transport, Public Works and Water Management, 2010). The convergence of urban stormwater management and spatial planning is highlighted in its ambitions. Water management must be integrated with other fields, particularly with planning. Urban planning and water management laws, rules, policies, and strategies are crucial in determining how well these two fields are integrated and cooperative.

4.3.3 Policy

Urban Plan: Ontwerp- Omgevingsvisie

The first Rotterdam environmental vision describes the medium and long-term course of spatial development for the city's entire territory. The vision paints an inspiring picture of the city's future and serves as a guide for future development. This is critical not only when things are going well, but also when the city is vulnerable. To some extent, the vision is adaptable and will evolve in response to its challenges. Nonetheless, there are a few decisions that must be made. Only in this way can one work on the city in a well-founded, thoughtful manner. Residents, entrepreneurs and municipality collaboration partners all contributed significantly to the development of the environmental vision. This was accomplished through discussions with the city and the use of the Municipal Poller app in 2020 and early 2021.

Climate Plan: Rotterdamse adaptatie strategie

Rotterdam’s tradition of ‘protecting itself against and living with water’ has shaped the development of the city. The city’s adaptation programme, Rotterdam Climate Proof, forms part of the Rotterdam Climate Initiative. It operationalizes the municipality’s aim to make Rotterdam 100% climate-proof by 2025.

The Rotterdam adaptation strategy is a guiding municipal framework in which the ambition and strategy for a climate-proof city are expressed. The proposals and measures from the Rotterdam climate adaptation strategy indicate the course desired by the Municipality of Rotterdam. How, where and when this will be implemented in concrete terms will take place in consultation with all responsible urban partners and will result in joint agreements on specific implementation of measures and activities.

4.3.4 Institutional

Rotterdam is conscious about the challenges it is faced with. According to the KNMI, the precipitation intensity increases by 14% per degree increase in temperature. A shower that occurs on average once every five years in the current climate will occur on average once a year by the middle of this century. Therefore the municipality of Rotterdam aims to become a 'water-resistant city' which is robust and resilient (grey and green-blue), hard and soft. They are focusing on adaptive measures that retain and delay rainwater

Rotterdam is committed to more green in size. For both the implementation and development of the Rotterdam adaptation strategy, long-term solutions for incorporating local storm water management practices into urban planning and development are currently being created.

> *‘We will do this in the coming years with seven large public space projects: 'The 7 City Projects'. They also encourage greening on a smaller scale throughout the city; for example through the construction of green roofs, greening of industrial estates and the 'softening' of streets by replacing superfluous pavement with plants’*

Rotterdam is attempting to promote small-scale stormwater management practices (such as green roofs, on-site water retention, or public rain gardens). Several mixed or multipurpose storm water retention structures have also been built and are integrated into the design of parking garages or public plazas. However the starting step of implementing Rotterdam's plan is to comprehend through visual model instruments, to identify susceptible areas in public space better and design and implement the necessary countermeasures. By using these tools, the order of things in time can also be determined.

Water storage is an important aspect in Rotterdams resilience strategy. Some of the options mentioned here have already been implemented in Rotterdam.Water squares, water plazas and infiltration zones could help compensate for the increasing urban infrastructure and allow surface water to seep back into the ground. Underground water storage like the Museumpark car park, which has a capacity of 10 million litres, is another option. Rotterdam considers green roofs, facades and green spaces all as good ways to help alleviate runoff during flooding. Additionally, green spaces can also be an excellent way to bring the community together and increase awareness of the water system.

> *‘In public space, softening and greening streets and squares is a good measure. Water plazas are an attractive solution for high usage pressure and limited space. In the linear space of streets and roads, infiltrating green areas (bioswales) can be an appropriate measure, as can the application of water-passing pavement’ (6:104, p.44, RA).*

Adaptation measures allow the city's biodiversity to grow and create ecological added value for Rotterdam. Biodiversity is critical to the city and region, but it is under threat in Rotterdam and the surrounding agricultural areas. The number of plant and animal species is decreasing. Some species groups are experiencing a disastrous decline. Rotterdam understands the direct consequences for nature and what it means for the city, because health and prosperity are inextricably linked to biodiversity.

> *'Biodiversity is essential for the city and region and is under pressure in Rotterdam and in the agricultural areas around us. The number of species of plants and animals is decreasing. In some species groups we see a disastrous decrease. This has a direct effect on the state of nature in the Netherlands and Europe. It has consequences for nature itself and for us; our health and prosperity are closely linked to biodiversity' (5:13, p.44, OO).*

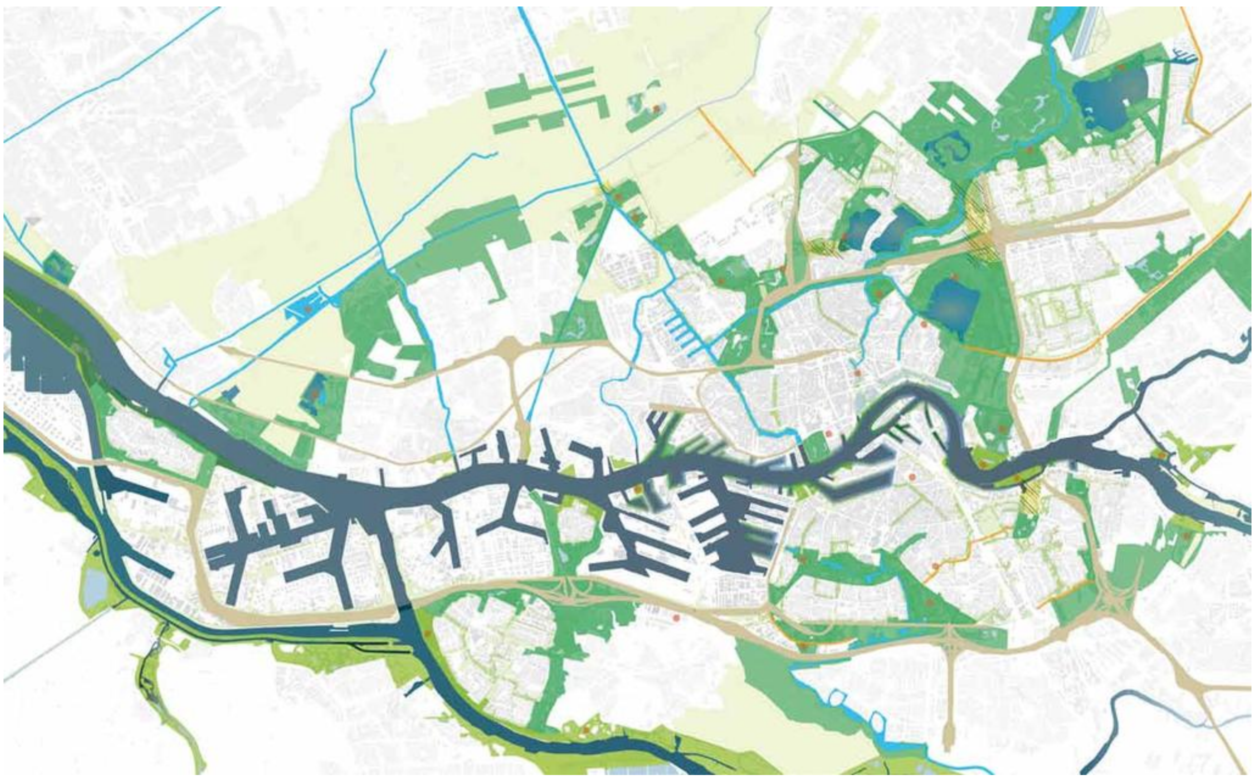

Figure 8: Natuurkaart Rotterdam (Gemeente Rotterdam, 2014)

Combat this by creating missing links between canals and parks in the city and making more connections to the greenery and water outside the city. The Rotterdam Environmental Impact Report (ROER) makes clear that the situation is improving in many areas and indicators. At the same time, this ROER makes it clear that environmental quality, such as the water, soil system and biodiversity and the environmental aspects of the living environment require constant attention

Although Rotterdam has a relatively large amount of green outdoor space per inhabitant, the greenery is not always usable, accessible or connected and it is not always located in a logical place. An attractive public space that is accessible to everyone, that lends itself to intensive and varied use and to meeting.

With the addition of walking and cycling paths, Rotterdam hopes to further connect this area of greenery and water. Making connections between and accessible to the natural areas on the fringes of the city is a crucial first step. As a prerequisite for building more dwellings, an urban park and access to it must be nearby.

4.3.5 Economic

The economic aspect in the policy reports have been addressed. This can be seen in the motto of the Water Plan which is paramount: 'working on water for an attractive, economically strong and climate-proof city'. This is part of the water-resistant city strategy. This includes maintaining the urban water system well and improving it in such a way that the city will be less vulnerable to flooding in the future, for example by increasing storage and drainage. At the same time this system offers economic benefits to Rotterdam.

At present, 3600 jobs in the region are directly linked to this. With the many companies in the maritime sector, hydraulic engineering and delta technology, there are also good opportunities for growth for the Rotterdam region. In doing so, Rotterdam contributes with climate adaptation to the ambitions that the city has in the physical, economic and social field. Rotterdam experiences climate adaptation as an economic opportunity for supporting green growth. The challenge to appropriately value the ecosystem services of blue green infrastructure, it is important to clarify quantitative benefits whenever possible. Economic opportunities are a strong argument for NBS in urban stormwater management. Rotterdam identified potential in the growing green blue economy and their opportunity for the Delta city.

> *'This 'green adaptation' makes the living environment more attractive, can act as an engine for green growth and mobilise Rotterdammers to actively participate. Companies can benefit from the increasing focus on climate adaptation' (6:15, p.4, RA).*

> *'There is also an indirect benefit for society in the creation of new employment opportunities for Rotterdammers in the 'green-blue' economy and delta technology. This is increasingly becoming an engine for economic growth and offers prospects for both highly and less-educated Rotterdam residents' (6:64, p.15, RA).*

Rotterdam extensively advertises its climate adaptation strategy and engages in city branding. Such branding is all about the associations that a place evokes based on its visual, verbal and behavioural expression. Rotterdam also considers climate change as an opportunity and advertises itself as a safe, climate-proof innovation and climate-knowledge hub . It showcases infrastructural projects like the Benthemplein water plaza and considers them as assets.

4.3.6 Process, Management and Instruments

Picking up a dutch planning tradition, participation strategies are well developed Urban planners, infrastructure managers and public stakeholders such as property owners and community organisations collaborate with the goal of transitioning to small-scale integrated water retention systems.

There are more concerns about cost and benefit allocation, maintenance and the long-term viability of small-scale organisations than about roles and responsibilities. Citizens and businesses are encouraged to play an active and positive role as "producers." Making a city together is an important part of Rotterdam's working method, because in order to realise its ambitions, everyone must be involved. Participation is both a principle and a method of operation that applies to municipal officials, developers and residents. Adaptation occurs in urban space; residents, businesses, knowledge institutions and interest groups, in addition to the municipality, can participate and contribute to Rotterdam's climate resilience. The municipality is actively informing and offering action perspectives to citizens. By informing and involving other parties, especially the residents of Rotterdam, they become aware of their own responsibilities and can take measures themselves.

> *'Small-scale adaptive measures in the capillaries of the city offer the opportunity for active participation and a broader interpretation of the cooperation between government and other parties. In this way residents, collectives and corporations, organisations and companies can all contribute to a climate-proof city. Take green roofs, for example. Climate adaptation is top down and bottom up' (6:51, p.14, RA)*

Private action is a crucial stakeholder in Rotterdam's successful NBS climate adaptation program. One might think of developing facade gardens and "rain gardens" in the private sphere. It is also possible to have blue roofs and utilise rainwater inside the structure. A few programs have been developed that are aimed at inhabitants. It has been urged to soften gardens using the slogan "Tile out, Green in" and to build facade gardens using the "Green Team"initiative

> *'For sustainability and climate adaptation, the municipality and building owners must also make choices together because of the relationship between measures in buildings and the public space. That's why we offer support and we do it together' (5:60, p.105, OO).*

Integration from a spatial standpoint, combines as many challenges as possible in a single spatial solution and/or a shared/limited space. This allows Rotterdam to make the best use of available space while avoiding unnecessary competition for it. It also highlights areas of the city where there is a real spatial constraint. Integrating urban development is an active approach to dealing with interconnected issues. One has to connect them as much as possible in order to solve them as effectively as possible. Working integratively does not aim to be complete (integral) in its approach. However, the optimal task bundling and solution coordination

Integrated stormwater management is the outcome of the realignment of ministries and stakeholders and a comprehensive water-related legal framework. Different authorities in Rotterdam are attempting to work together to create a climate-proof city.

> *'Realising the water-resistant city is custom work that necessitates close collaboration between municipal water managers, spatial designers, and administrators, as well as*

> *water boards. Working in the space of the city entails collaboration with other parties such as housing associations, project developers, and, most importantly, residents.*
> *Active and targeted communication is used to increase awareness and participation' (6:96, p.42 RA).*

Rotterdam recognizes the difficulty in properly integrating climate adaptation measures with other urban projects and initiatives, such as with the routine management and upkeep of roads and vegetation. Both in large-scale urban development and in initiatives linked to resident action. The city can only become completely climate-proof in this manner. Furthermore, there is less money available than before in the current economic climate to carry out ambitions.

Linking the environmental vision goals to municipal investments in the city is necessary for their realisation. As a result, one has to consider the decisions based on the environmental vision to be the foundation for the municipal investment plan and the municipal lobbying of other authorities. The transition from the urban goals to concrete elaboration also requires the (main) area projects and area-oriented strategies. The multifunctionality of nature based solutions is crucial to seek financing from various sectors.

> *'Linking can be accomplished by collaborating with other parties who invest in the future of Rotterdam, such as area development, network maintenance, or real estate transformation. However, participation in small-scale initiatives by citizens and businesses is also part of this' (6:53, p.14, RA).*

Coupling can be achieved by working with other parties who have an interest in Rotterdam's future, local development, network upkeep, or real estate change. At the same time, Rottterdam puts more emphasis on collaborating with current maintenance plans for roads, vegetation and sewage.

> *'The challenge is to integrate climate adaptation measures into other urban programs and projects, such as regular road and greenery management and maintenance.*
> *Not only in large-scale urban development, but also in existing city projects.*
> *Only in this way can the city become completely climate-proof. Furthermore, in the current economic climate, there is less money available for major plans than previously' (6:52, p.14, RA).*

4.3.7 Interpretation

Rotterdams programme addresses the multiple climate themes: precipitation, heat, drought, groundwater and flooding. The programme is finite and aims at a climate-proof city by 2030. Measures to achieve this are being taken in public outdoor spaces, but also on private properties. The programme is designed to impress upon a large segment of the population the urgency of climate change and to motivate people, organisations and businesses in society to work together on. In dealing with climate adaptation, Water Sensitive Rotterdam is, in its communication and approach, focused on involving municipal services, city residents, businesses, interest groups, associations, etc. on an equal footing. It needs to become a movement led by local authorities, together with citizens and business people. To increase its impact, Rotterdam has developed an integration plan to make the most of its interventions. Integration capability includes cooperation between policies (inter-departmental integration), coordination inside policies, within the context of water policy, and coordination externally between water policy and NGOs.

Rotterdam demonstrates how projects that foster mutually reinforcing relationships between the economy and nature lead to innovations for the city (Green growth). Better management of natural resources yields social advantages. But more work needs to be done to adequately use it as a tool in decision making. While a lot of pioneering is done by front-runners among businesses, organisations and governments; it is not yet standard practice. There is frequently a lack of knowledge and current laws can be a barrier. As a result, a long-term link between financial and natural capital does not yet exist, but the groundwork has been laid. It is critical to address the identified challenges in the future. Only then can businesses, environmental organisations and citizens expand the opportunities for protection and utilisation.

Theme	Indicator	Awareness	Implementation
Climate mitigation and adaptation	Carbon sequestration	--	--
	Urban heat island effect	-	+
Ecosystem strengthening	Biodiversity	+	+
	Ecosystem services	+/-	-
Economic opportunities	Green jobs by NBS	++	+
	Work efficiency	+	-
	Urban regeneration	-	-
Participation	Community involvement	++	++
	Quality of participation process	+	++
Equality	Accessibility to public green space	+	+/-
Health and wellbeing	Attention to residents' health	+	+
Water management	Pluvial flooding recognition (flood protection)	++	+
	Insufficiency of grey and opportunity for NBS	++	++
Governance capacity	Integration	++	+
	Institutions /stakeholder	++	+
	Financing/incentive scheme	+	-

Table 11: Grading table Rotterdam

4.3.8 Reflection

Increasing the use of ecological solutions, or ecosystem services, creates a win-win situation. At the same time, the city is becoming greener and more climate-resistant. Climate adaptation and improving Rotterdam's ecological qualities can go hand in hand. Through NBS, the city's water management department demonstrates clear commitment and expertise in the areas of sustainable stormwater management and ecosystem services. However, there is still work to be done in terms of valuing natural capital and resources.

Engagement with industry and academic institutions is underway, as is the development of a solid long-term climate adaptation strategy. Actions at the local and national levels were suggested to improve governance. Concentrate on increasing the transparency of decision-related information, using data to guide decisions and tracking adaptation progress in the future. Future funds could be used to support regulations, better departmental collaboration and initiatives to build a more circular water system. To strengthen resilience, efforts must be made to construct a more circular water system, increase departmental collaboration and develop better methods for monitoring adaptation progress.

5. Discussion

In this chapter, a comparison and suggestions are presented in order to help readers make wise decisions about where to supply the right NBS. Examples from the case study cities are used to demonstrate how various aspects of this strategy are being put into practice. In certain places, strategic planning techniques are also starting to be incorporated into more comprehensive policy and decision-making. Here, a number of suggestions are offered to policymakers to guarantee that such procedures become commonplace.

The distinctions between the three case study cities are thoroughly explored in this chapter. It will also include recommendations based on real-world practice examples and relevant tools from and for the case study towns. It concludes on how the results diverge from the body of previous research.

5.1 Relating the cases

	London	Hamburg	Rotterdam
Climate adaptation	'Best air quality of any major world city by 2050'	'Climate-resilient city'	'100% climate proof by 2050'
Ecosystem services (monetary)	Detailed evaluation of ecosystem benefits (yes)	Limited recognition of the range of ecosystem services (no)	Recognition of co-benefits (no)
Economic	Opportunities in the areas of maintenance and attractiveness	Urban regeneration as a driver towards economic development	opportunities in the 'green-blue' economy and delta technology
Stakeholder involvement	encouraging greater participation	Stakeholder participation is now an established process	Enhancing awareness Proactively engaging stakeholders at an early stage
Accessibility	Awareness of inequity but no action	Focus on densely populated districts to gain access	Aims for accessible green spaces where the various resident groups meet
Responsibility of authorities	Boroughs as the main actor and driver for NBS	Public - private	Clear allocation of municipalities duties
Financial agreements	Investor and fundraising plan Greener city fund	Public national budget Public local authority budget	Financed by City of Rotterdam from sewerage budget Budget for NBS projects, mainly co-financing
Maintenance	Mostly by community participation	No information	Unclear
NBS	Sustainable drainage systems	Focus on Green Roofs (on site control)	Water storage (Downstream control)
Integration	Touches on the effort to integrate to reduce misconnections	Aims integrate NBS in other spatial plans and as a planning instrument	Integration as an important part of the strategy

Table 12: comparison of case study cities

The three case study cities of London, Hamburg and Rotterdam are facing similar challenges. They have to handle continuous urban growth on the one hand and increasing flood risks on the other. Traditionally, all three cities have a strong water management sector at hand, however the approaches and strategies to the challenges can differ.

London has set a precedent in the introduction of monetary evaluation of the value of nature and its ecosystem services. By the use of existing guidelines and literature, it was possible to include monetary estimates of ecosystem services. However, there was no cost benefit analysis conducted which could prove the investment in nature based solutions to be considered profitable for the case of London. The results are considered an underestimation of the full value of implementing nature-based solutions due to the difficulty in capturing the full extent of generated ecosystem services. The failure to estimate all provided ecosystem services monetarily

highlights the need for complementary valuation methods for decision-making. London introduces frameworks for assessing the value of ecosystems, such as the environmental net gain approach and the natural capital framework, that perform better in capturing the full range of values.
The London case demonstrates that private actors do indeed "lead" urban development projects in the private sector. Additionally, they are able to influence development at all stages of development because they are devoted to incorporating public and civil demands into their plans and demonstrating a long-term financial and operational commitment to the project. Local planning authorities do not lose control of development, even if they play a facilitative role in it. One could argue that local governments effectively use alternative management practices, such as bargaining and capacity building, to make up for the lack of land and capital. Because the NBS project facilitates negotiations of a business case between a local authority and a private developer, the organisation of the UK local planning system necessitates the monetary evaluation of ecosystem benefits. The developer can be persuaded that incorporating NBS into their development plans will result in increased investment revenue.

Rotterdam is a case study city that leads the way in terms of climate adaptation and the involvement of policy actors such as the business community and residents, making it an interesting location for this research. The Rotterdam planning context contributed to a leading role of local planning authorities which enacted the goal to further integrate urban stormwater planning into the spatial planning process. The focus of a project in Rotterdam lies on citizens, particularly local residents, who have the possibility to actively participate in the development.
The mentioned stakeholders are still limited to municipalities and initiatives in which private households are invited to participate. This excludes most industries and private enterprises from the strategy for scaling up nature-based solutions. It is restricted to Rotterdam businesses, which are encouraged to play an active and positive role as producers in the transition to NBS. This demonstrates that there is still significant opportunity to engage more industry stakeholders in supporting the development of nature-based solutions. Due to scepticism about the benefits and technical feasibility of nature-based solutions, industry stakeholders, primarily private firms, do not tend to implement them proactively. This was demonstrated in London and Hamburg, where NBS's economic profile was rather weak. This could be due to a lack of knowledge and experience with urban nature-based solutions, combined with a tendency to seek technical solutions to sustainability issues.

Hamburg did not excel in terms of urban stormwater management policies in their urban and climate plans. This is due, in part, to the nature of Hamburg's planning context, which relies heavily on the public sector and its binding but generic plans, strong but general. The investments are derived from the use of tax money to implement NBS measures, in contrast to Lonon, where planning decisions are negotiated for permits and sources of private development funding. In this view the monetary estimation of ecosystem services has not played such an important role for Hamburg and Rotterdam with their strong local led authorities as it has for London for which adding NBS as part of development projects is part of the negotiations with private parties.

Evidence of various finance approaches and difficulties for several ecological domains where urban NBS have been discovered The extent to which private value can be captured from the NBS strategy, as well as the scale investment amount and investment lifespan, appear to vary or have not been determined at all in conjunction with the various financing strategies. Urban nature-based solutions face socio-economic and political obstacles more often than biophysical ones that prevent their commercialization. Good nature-based urban innovation confronts significant obstacles in obtaining long-term (private) financing since they are unable to realise value from the ecosystem services they provide, because they lack a successful business model. Urban gardening and urban tourism are examples of applications with a clear value proposition, value delivery architecture, and value capture component (financial payoffs), whereas ecosystem services (air quality, for example) and green spaces generate value that is challenging to appropriate for a private company. Due to the public nature of the payoffs produced, which are traditionally the responsibility of the government, there is a lack of a clear accounting framework for ecosystem services. This disconnect between the central stakeholders and the need to deal with these complex innovations makes it difficult to design public-private cooperation with incentives that are well-aligned among all stakeholders (academic, business, government).

The key to increasing industry investment is to emphasise the relevant values that nature-based solutions generate, both for the industry and for potential real estate buyers. Demand can be increased by developing new neighbourhoods that include nature-based solutions that provide recreational, aesthetic and quality-of-life benefits desired by potential homeowners and other relevant stakeholders. There is a need for demonstration and knowledge sharing around the potential of urban nature-based solutions for urban regeneration and, as a result, increasing the value of land and real estate in order to help facilitate change in the urban development industry. NGOs, stakeholder and sectoral networks are examples of stakeholders who could fill this role. Certification schemes can also contribute to increased demand for nature-based solutions in urban development.

The effectiveness of knowledge-sharing efforts aimed at various stakeholders in the urban development industry is dependent on a thorough understanding of what motivates them. Housing associations, for example, are semi-public entities with the mission of serving the public's social and economic interests. In that capacity, they benefit from tax breaks and can develop real estate at a lower cost than commercial real estate developers. Nature-based solutions are likely to improve the quality of life of their tenants. As a result, when presented with nature-based solutions as an intervention for improved liveability, health and well-being and the creation of local jobs, they are more likely to be interested. A commercial developer, on the other hand, is likely to be more sensitive to arguments focusing on customer demand for specific qualities associated with in-demand nature-based solutions, which may increase property value.

5.2 Recommendations

I. Encourage stakeholder collaborations

Stakeholder participation, collaborative action and the community voice are vital in planning NBS to equitably meet multiple needs. Building trust amongst stakeholder groups and being flexible to accept changes in planning and procedures are necessary for citizen engagement in urban planning and ecosystem management, which can be time-consuming and expensive (Li and Emerton 2012). However, when done well, citizen involvement and engagement can support urban planning by assisting in the discovery of local residents' needs and desires, thereby supplying the foundation for enhancing the livability of urban spaces, which has the potential to be advantageous to both people and nature. The identification of prospective NBS that could solve the major societal issues that urban inhabitants have outlined in a comprehensive manner that is considerate of community needs and aspirations can also be facilitated by citizen engagement.

Hamburg, the European Green Capital of 2011, began a tree-planting effort in June 2011 to fill in the gaps in the tree population along the city's roadsides with the help of its residents. The city of Hamburg has planted 2011 trees during the year it is the European Green Capital. The city of Hamburg's efforts to make the city greener were supported by the residents of Hamburg. They helped fill in all the gaps in the tree population along the roadsides that had developed recently with their donations. On an online map, residents of Hamburg may find the area of their choice and donate to the tree of their choice. For every tree that received donations of 500 euros, the City of Hamburg provided an additional 500 euros to cover the typical planting costs of 1.000 euros per tree. The city, which was also setting an excellent example, paid for additional new trees in 2011, the year designated as the Green Capital (Free and Hanseatic city of Hamburg, 2015).

II. Build and maintain the scientific basis to guide a strategic approach to spatial planning for NBS

Evidence of the NBS advantages is required to justify the shift toward adopting NBS for climate change adaptation and mitigation. This can include comprehensive strategies that integrate the advantages of green, blue and grey-engineered infrastructure. NbS plans must be supported by solid research. This covers the location, condition and capacity for providing ecosystem services of existing natural capital assets. Identification of opportunities for NbS to meet beneficiaries' needs depends on the distribution of prospective beneficiaries for each ecosystem service, the demand for these services and any supply-demand imbalances. It's important to comprehend how cities and its inhabitants can profit from nature.

The Urban Greening Factor (UGF) is a tool that assesses and quantifies the volume and quality of urban greening that a program offers in order to help developers decide on the right quantity of greening for new construction. The aims of the UGF include: to accelerate greening of the built environment – making sure London is greener as it grows and to ensure better planned, better quality greening interventions that contribute to a functioning GI network. The UGF supports landscape-driven planning, which involves designing and developing green infrastructure earlier in the planning process (Greater London Authority, 2021). For instance, it implies that the use of financial incentives, particularly in the retail and commercial sectors, can be quite successful. for instance, by establishing a new drainage fee depending on the structure or land's surface area. This implies that any property with a sizable surface area that drains to the neighbourhood drainage system would incur a significant additional cost. This strategy has improved the economics of using sustainable drainage methods in such circumstances. The disconnect programs really imply that substantial investments in sustainable drainage can be justified provided the bill payer is hit with much higher fees to discharge rainwater.

III. Invest in methods and tools for prioritising NBS and analysing trade-offs at the urban scale.

Supporting, developing and testing strategies for designing NbS at the landscape scale while considering trade-offs between various benefits is necessary. While new ways are being developed, it's important to make sure they can evaluate the advantages and disadvantages of various intervention kinds. This can be achieved by analysing the demand for the advantages and services that NBS can provide or, alternatively, the issues that NBS must solve and contrasting this with the maps of ecosystem service supply to detect any gaps that indicate an unmet need. To maximise the health and socioeconomic advantages and generate green jobs, NBS like new urban parks or community orchards might be built next to underserved neighbourhoods.

The Grün Vernetzen map Hamburg represents the city's green infrastructure - parks, allotment gardens, forests, field marks and cultural landscapes - to allow for development. The proven spatial model of the green network serves as the foundation for this, combining and developing the typical landscapes of Hamburg, natural qualities and urban open spaces into a city-wide network. Future urban development challenges, particularly those pertaining to Hamburg's urban green, are to be met with the assistance of this long-term viable model. Furthermore, strategic goals for natural balance are formulated in the green networking map, particularly for the urban climate and habitat networking, as well as recreation and the landscape. While the original goal is to promote an urban and open space structure that meets the diverse demands on open spaces and protected natural balance assets, it can also be applied to the levelling of socioeconomic factors by connecting green networks to disadvantaged areas (Free and Hanseatic city of Hamburg, 2015).

The London city council has created a Natural Capital Account for London's Public Green Spaces in collaboration with the National Trust and Heritage Lottery Fund. The account offers an evaluation that demonstrates the financial worth of public green spaces. By highlighting the benefits of assets that are typically not reported in economic terms, a natural capital account expands on traditional financial accounting. The natural capital framework outlines how the account may guide decisions to assist obtain the long-term funding and investment needed for London's public green spaces (Greater London Authority, 2018).

> *'for each £1 spent by local authorities and their partners on public green space, Londoners enjoy at least £27 in value' (2:99, p133, LES)*

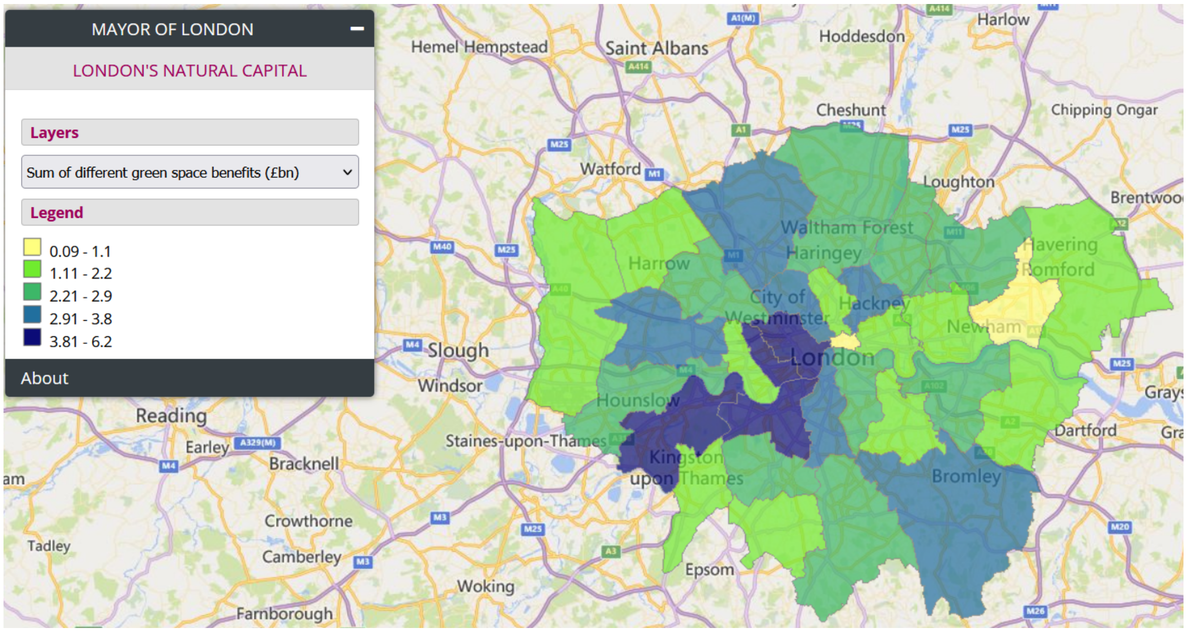

Figure 9: Natural capital accounts by borough (london.gov.uk, 2022)

IV. Integrate NBS into planning and overall policies.

Governments are increasingly looking for economical and comprehensive solutions to environmental problems that will not only reliably produce their intended immediate effects, such as more open space for recreation and less air pollution, but will also benefit society as a whole by enhancing health and well-being. To increase resilience and incorporate ecological considerations into urban planning and decision-making, policymakers in cities and at the subnational level can set an example. Nature can be part of the answer rather than an infrastructure plan where it is a problem, a cost and a political risk (Van Hamm, 2004).

Planning for NBS collaboratively can integrate a variety of distinct policy sectors, including stormwater management, environmental protection, recreation, public health and regeneration. This is an effective strategy that can be applied in situations where conceptual understandings must be developed and agreed upon in addition to actual procedures. Additionally, it can be argued that educating professionals on the benefits of green infrastructure could contribute to the creation of new tools that planners, managers and policymakers can use. The next challenge for sustainable stormwater management is creating more tangible mechanisms to make sure that natural solutions are at the centre of the planning process. Moreover, it became evident that individuals working at the local and regional levels require very practical assistance on how to translate such conceptual thinking into useful planning tools.

Rotterdam's adaptation strategy examines whether new policies create opportunities or conflicts in the city's vision, as well as how to resolve them. When developing new sectoral policies, the power of the sectors is used to improve the whole. It elevates the Rotterdam environmental vision above the level of a collection of disparate policy documents. Rotterdam makes the best use of the possibilities for realising water storage in conjunction with area development. At the same time, it is increasingly focusing on integrating with existing road, greenery and sewerage maintenance programs. Other programs, such as "child-friendly neighbourhoods" and "green schoolyards," provide opportunities as well. Rotterdam gradually greens and becomes more water-resistant in the system's capillaries as a result. (Gemeente Rotterdam, 2021)

6. Conclusion

In this chapter, the primary and secondary research questions will be answered and a concussion will round off the thesis.

Which ecosystem services does nature based urban stormwater management offer?

In addition to having the potential to adapt to climate change, nature based solutions also provide a number of advantages, particularly those connected to the distribution of urban green space for social and health reasons. The ecosystem services come in the forms of providing, regiulating, cultural and supporting (Table 2). NBS ecosystem services protect and provide natural habitats, conserve water resources and improve water quality. In addition it manages and mitigates flooding risk by improving cities' ecosystem resilience to and mitigation of climate change and increases the ability to store carbon through new planting or other means. It reduces pollution levels and improves opportunities for people's health and wellbeing and provides access to natural and cultural resources that contribute to the unique qualities. The focus in the policies of the three case study cities, however lies firmly on regulating, cultural and supporting than provisioning.

How prominent is the deployment of sustainable stormwater systems to benefit ecosystem services in the case study cities?

The three case study cities all have nature based solutions applied in their urban stormwater management. Nature-based solutions have clear potential to contribute to the urban environment, both in restoring economic vitality, enhancing biodiversity and providing attractive and healthy places to live and work. The various approaches have been identified towards activating and stimulating the mainstreaming of nature-based solutions for urban stormwater management and its ecosystem services. However, there is only one case for which there is actual proof of the benefits of nature-based stormwater management. Because London presented an explicit monetary valuation of the city's ecosystem service benefits in terms of health benefits from reduced treatment costs due to air pollution and heat islands, recreational and urban regeneration. Although Hamburg and Rotterdam have identified these benefits, there is no quantitative data on their impact on the city system. However, this does not imply that there are no benefits in these two cities; rather, the tools for valuing ecosystem services are not yet available. Cost-benefit assessments are required to analyse the full spectrum of potential multiple NBS benefits in terms of single project evaluations as well as a comparison between simply "grey," "green and blue," and "hybrid" solutions in order to determine the cost-effectiveness of NBS. Economic studies of the costs of inaction and the potential for catastrophic failure of merely technical remedies are included in this. Studying the monetary and non-monetary values of NBS initiatives should fully account for the whole range of social and economic effects.

To what extent do nature based stormwater management differ in theory and practice?

Beginning with the terminology of nature based solutions. The term NBS has been used throughout the policy documents interchangeably with blue green infrastructure. NBS is rarely used in the policy documents, despite Pauleit et al's proposal that it be viewed as an umbrella term that encompasses UGI as well as ecosystem-based adaptation and ecosystem services. While Hamburg and Rotterdam continue to use the term "green blue infrastructure," London chooses to refer to sustainable drainage systems. This demonstrates the need to thoroughly integrate the idea of nature-based solutions into the planning system and its terminology. Since UGI is a planning-related concept, the emphasis is on the strategic importance of incorporating green spaces and the ecological services they provide into urban development at various scales. NBS puts its emphasis on participatory processes in creation and management.

There has been a shift in the perception of the range of ecosystem services as desirable by the implementation of NBS. The literature identified a diverse range of ecosystem service types and its implementation (table 2 & 3). However, according to the policy analysis, they are limited in practice to regulating, cultural and supporting services, leaving provision of services out of the policies. This might be viewed as an underutilised component of urban policy making and planning. Urban agriculture can grow quickly in cities if nature's ability to provide services is harnessed. By linking local food and energy production to community objectives like preservation of the urban environment, provision of space for urban recreation, care facilities, or educational opportunities, urban agriculture may support urban requirements (Pearson, 2010). Since it is situated as a garden on a rooftop or balcony, an allotment for amateur gardeners that expands the infiltration area in the city and a component of nature-based urban stormwater management, it also has an impact on urban stormwater management. A liveable and sustainable city can benefit from urban agriculture in numerous ways.

A variety of techniques can be used to implement nature-based solutions for urban stormwater management. Source control, Onsite control, Slow transport and Downstream control were all introduced in the literature. The first two categories of source and onsite control are frequently prioritised in practice. There has been a strong emphasis on urban trees, green roofs and permeable surfaces as a means of achieving nature-based stormwater management. However, these are smaller-scale installations. Since this control of areas frequently lies in private domein, cities have focused on active participation programs to persuade residents to accept these sustainable drainage measures. Practice and theory align however the implementation strategies are presenting a greater variety of the so called control techniques. Some cases show a clear focus on one or two control strategies and are disregarding others (table 2 & 3).

Large-scale SuDS infiltration in the open soil is provided by London's parks, gardens, and green spaces, along with the interception that parkland trees offer. Smaller-scale infiltration solutions also exist, including as kerb inlets, grass verges, and permeable paving. By gathering local surface water, bioretention systems are utilised to treat and manage storm occurrences. Before passing through growing media and vegetation, water gathers on the surface. Here, it either

seeps in or is collected by pipes that lead to an appropriate outfall.
Hamburg implemented a comprehensive green roof policy with a focus on onsite control through green rooftops and urban trees. It aims to green at least 70% of both newly constructed structures and suitable flat or slightly pitched roofs that are being renovated. Slow transport and storage has so far been mostly neglected.
Threats from excessive rains are being addressed in Rotterdam. It has constructed water storage facilities and is incorporating "blue-green corridors" into the urban environment. These "blue-green corridors"—watercourses and ponding areas—are created to minimise urban floods, enhance biodiversity, and enhance the quality of life in the city while facilitating natural hydrological processes like groundwater replenishment. Additionally, Rotterdam boasts more than 130 000 m2 of green rooftops. Finally, through above-ground rainfall drainage, the system's drainage capacity is improved. The combined effects of all these actions are reducing drainage peaks.

How can the value of ecosystem services in NBS stormwater management be determined and its implementation in practice be improved?

To gain local support and avoid conflict, NBS planning should be grounded in the local context and reflect stakeholder priorities. All stakeholders - policymakers, landowners, practitioners implementing the schemes and beneficiaries - must be identified and brought together to identify their goals, values and priorities and develop a shared vision for the area. Involving stakeholders and communities in this process also helps to understand the institutional and emotional aspects of spatial planning.

The following phase is to assess the various possibilities to achieve spatial coherence, equitable delivery and cost-effectiveness when prospective opportunities to deploy NBS to address societal and environmental challenges have been identified. There are many evaluation tools available; they typically compare asset maps before and after interventions and quantify the change in the capacity for delivering ecosystem services as a score, a percentage change, or a biophysical or monetary value. These methods also enable scenario analysis to test future policy approaches motivated by various planning goals, such as a trade-off between developers' desires for placemaking close to the development and the requirement for significant investment in flood regulation upstream of the urban conurbations.

To maximise potential investment streams and reap the rewards of policy drivers, NBS must be planned and implemented across policy domains including environment, planning, transport, business and rely on a variety of mechanisms e.g. net gain calculations, local plan policies, nature recovery networks. The success of NBS interventions must be continuously monitored and assessed after deployment in order to enable adaptive management if required in response to change. The funding for long-term administration and monitoring of NbS should be included in projects and the maintenance and management staff should receive the necessary training.

To conclude

Multidisciplinary and inclusive partnerships can encourage the adoption of NBS as a solution to climate-related problems. Combining resources, abilities and information can foster and accelerate interactions between many facets of society. Participating citizens in urban decision-making can improve city livability, reveal NBS implementation options and foster ownership and stewardship. Innovative technologies, like natural capital accounts, can enhance the development of NBS by assisting in the inclusion of many stakeholder perspectives in urban planning and policymaking. Mutual understanding and the development of trust can lay the groundwork for cooperative action. Gaining support from the corporate sector and maximising public investment in NBS can be accomplished by creating reliable business models that evaluate the values of nature at the local and landscape level and show a trustworthy return on investment.

To generate more widespread support for NBS at the city level, it is necessary to build a more robust evidence foundation on the numerous benefits, particularly the cost-effectiveness of nature-based initiatives. Experts in quantifying the qualitative and quantitative economic, social and ecosystem services can help make the worth of a city's natural resources more visible and encourage the use of NBS in urban planning and management. Sharing these kinds of case studies and lessons can be a solid foundation for promoting NBS and encourage further collaborations and financial investments in NBS.

How well the Rainproof and Water Sensitive messages have reached residents is ambiguous. Thus, further study must be done to understand better public awareness, knowledge and opinions of the concerns and activities and their participation in the solutions. In case study neighbourhoods, surveys might be carried out near numerous sustainable urban drainage systems to learn more about this. For upcoming financial estimates of ecosystem services, research on the potential environmental effects of NBS features is crucial. Further study of the economic consequences of natural elements is required due to the limited scope of economic modelling on environmental effects as ecosystem services.

The results offer an effort to close the knowledge gap on nature-based approaches to urban stormwater management by fusing theory and practice. Since this relationship is context-specific, it is still challenging to understand and translate from theory to practice. As a result, providing universally applicable recommendations is difficult. The findings led to new inquiries and gave suggestions for extended research. This study demonstrates that valuing nature for NBS and its ecosystem services is an intriguing phenomenon with a growing but still lacking theoretical foundation. It also demonstrates positive trends in practice, which calls for additional study to enhance the building of climate-proof communities.

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Appendix

Coding tree

Climate adaptation: Awareness	(2)
Climate: adaptation: Implementation	(2)
Economic: Awareness	(3)
Economic: Implementation	(3)
Ecosystem: Awareness	(2)
Ecosystem: Implementation	(2)
Equality: Awareness	(1)
Equality: Implementation	(1)
Governance: Awareness	(3)
Governance: Implementation	(3)
Health: Awareness	(1)
Health: Implementation	(1)
Participation: Awareness	(1)
Participation: Implementation	(1)
Water Management: Awareness	(2)
Water Management: Implementation	(2)

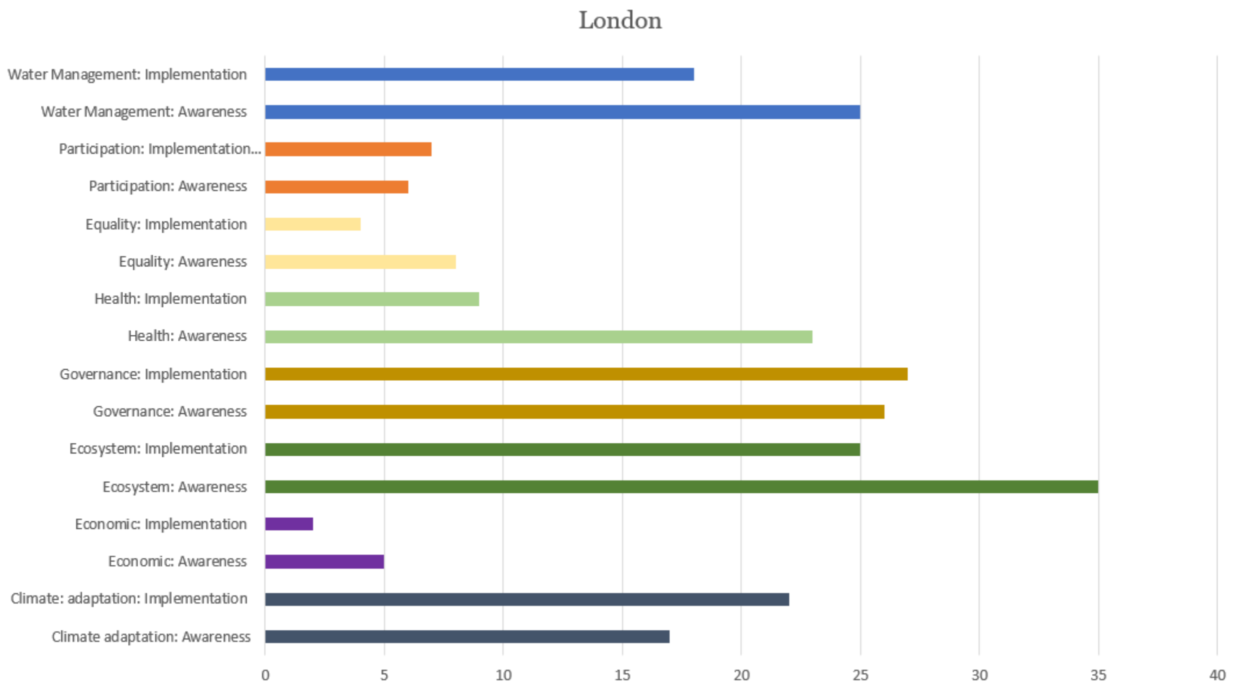
Overview Atlas.ti basic coding tree

Climate adapataion (I) - Carbon	28	0	[Climate: adaptation: Implementation]
Climate adapataion (I) - Heat i...	29	0	[Climate: adaptation: Implementation]
Climate adaptation (A) - Carbon	29	0	[Climate adaptation: Awareness]
Climate adaptation (A) - Heat...	39	0	[Climate adaptation: Awareness]
economic (A) - efficency	5	0	[Economic: Awareness]
economic (A) - jobs	13	0	[Economic: Awareness]
economic (A) - urban regener...	5	0	[Economic: Awareness]
economic (I) - efficency	2	0	[Economic: Implementation]
economic (I) - jobs	1	0	[Economic: Implementation]
economic (I) - urban regenerat...	4	0	[Economic: Implementation]
Ecosystem (A) - biodiversity	39	0	[Ecosystem: Awareness]
Ecoystem (A) - eco services	31	0	[Ecosystem: Awareness]
Ecoystem (I) - biodiversity	34	0	[Ecosystem: Implementation]
Ecoystem (I) - eco services	10	0	[Ecosystem: Implementation]
equality (A) - accessibilty	16	0	[Equality: Awareness]
equality (I) - accessibility	12	0	[Equality: Implementation]
Governance (A) - financing	8	0	[Governance: Awareness]
Governace (A) - Stakeholder	19	0	[Governance: Awareness]
Governance (A) - ISWM	14	0	[Governance: Awareness]
Governance (I) - financing	10	0	[Governance: Implementation]
Governance (I) - ISWM	9	0	[Governance: Implementation]
Governance (I) Stakeholder	34	0	[Governance: Implementation]
health (A) - Attendance	41	0	[Health: Awareness]
health (I) - Attendance	18	0	[Health: Implementation]
participation (A) - community...	16	0	[Participation: Awareness]
participation (I) - community i...	18	0	[Participation: Implementation]

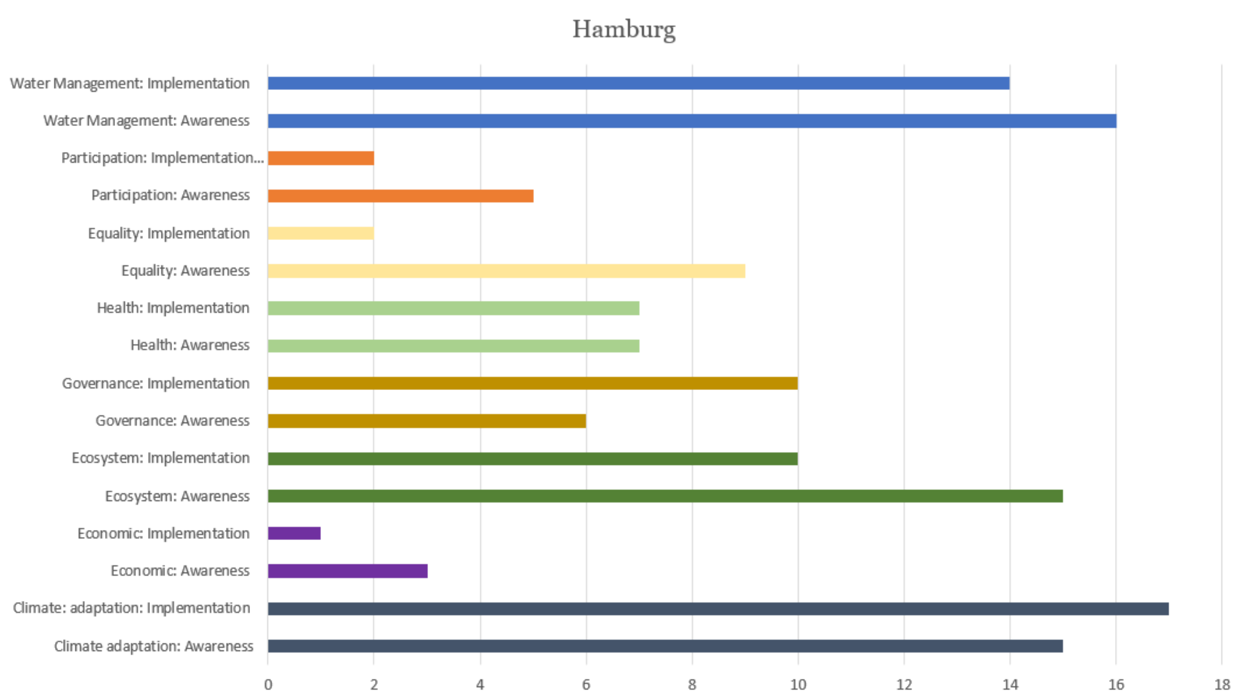
participation (I) - community i...	18	0	[Participation: Implementation]
water management (A) - NBS	26	0	[Water Management: Awareness]
water management (I) - NBS	53	0	[Water Management: Implementation]
water managemet (A) - Pluvial...	37	0	[Water Management: Awareness]

Atlas.ti categories of awareness and implementation and selected policy codes

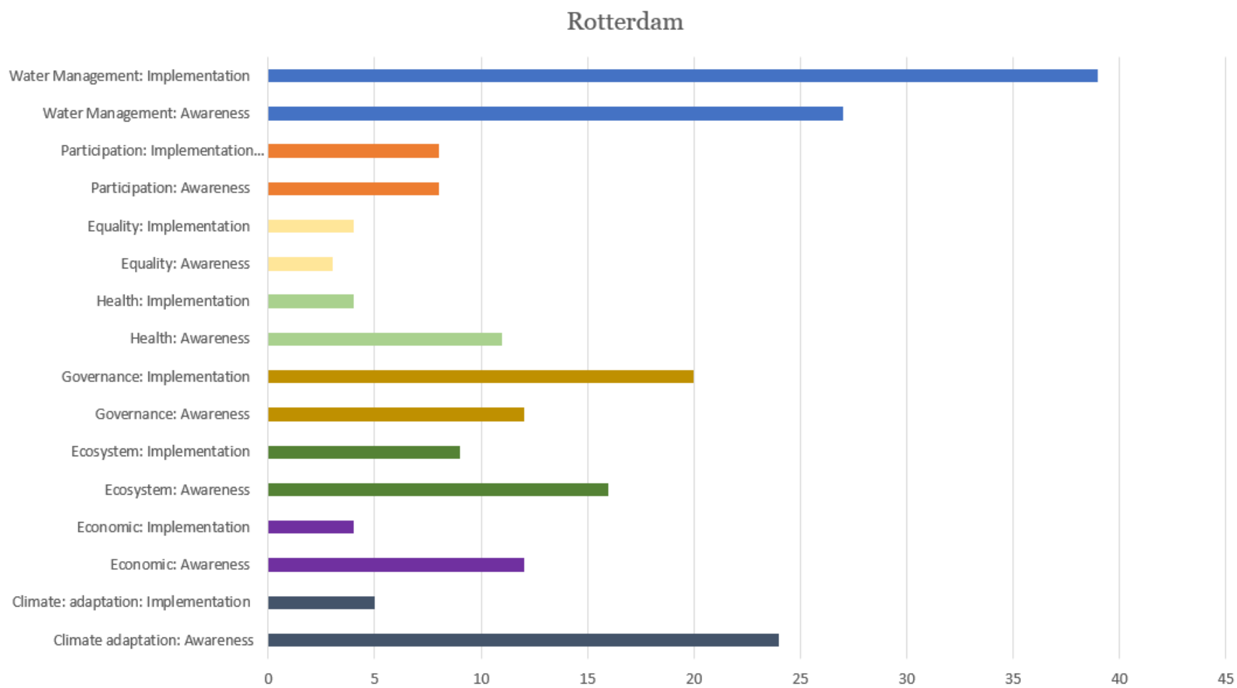
Results



Number of codes selected by indicator for London



Number of codes selected by indicator for Hamburg



Number of codes selected by indicator for Rotterdam