Scaling Up Nature-Based Solutions for Flood Resilience

A Case Study Research About Suitable Governance Arrangements in Urban Areas

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November 2021
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Scaling Up Nature-Based Solutions for Flood Resilience. A Case Study Research About Suitable Governance Arrangements in Urban Areas

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Master Thesis Environmental and Infrastructure Planning

University of Groningen, Faculty of Spatial Sciences

November 2021

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Summary

Lately, German communities faced natural catastrophes such as the pluvial floods in July 2021. While the Ruhr area was spared from these floods that devastated nearby regions, the event illustrated the urgency of adapting to climate change. Scaling up nature-based solutions (NBS) such as stream restoration and sustainable urban drainage systems can play a key role for building flood resilience while tackling environmental, social, and economic challenges in the region.

As NBS are cross-sectoral projects addressing multiple objectives at the same time, a variety of actors need to join forces. This thesis therefore identifies suitable governance arrangements for scaling up NBS in urban areas by analyzing four case studies in the German Ruhr area. Through interviews and document analysis it investigates how stakeholders work together, allocate responsibilities, and deal with arising controversies.

In the four case studies, negotiating compromises between water management, biodiversity, and recreation represents a main challenge. In the current governance arrangements, public actors initiate and lead the projects, though the research shows that stronger private involvement would be important for scaling up NBS.

The governance arrangements need to be flexible enough to deal with the uncertainty around NBS and to adapt as necessary. In addition, the results underline that implementing NBS require responsible parties to collaborate despite institutional fragmentation. Close partnerships and early collaboration prove to be key. Governance arrangements that foster knowledge exchange and provide competent support can be highly valuable. Another conclusion is that stakeholders need to be willing to learn and experiment in order to implement NBS at scale.

Acknowledgements

The author would like to thank the thesis supervisor and coordinator for their support and flexibility throughout the research process. She is also immensely grateful to all interview partners for their time, materials, and confidence, and for their inspiring thoughts on nature-based solutions.

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Abbreviations

EGLV: Emschergenossenschaft und Lippeverband

NABU: Naturschutzbund Deutschland

NBS: Nature-based Solutions

PfV: Planfeststellungsverfahren

RVR: Regionalverband Ruhr

SUDS: Sustainable Urban Drainage Systems

ZI: Zukunftsinitiative

The title photo showing the Emscher river in Duisburg was kindly provided by Markus Bechauf.

Thesis word count: 21.000.

Content

1. Introduction: The need for flood resilience and the promises of nature-based solutions

In July 2021, heavy rainfall caused devastating floods in western Germany. More than 180 people died as the water flooded houses, submerged roads and washed away infrastructure (Bundeszentrale für politische Bildung, 2021). Picturesque streams like the Ahr had transformed into torrents that washed through valleys, leaving behind little but rubble and mud (see Figure 1). Within 24 hours, the affected regions experienced more rainfall than they would usually see in a month.

The Ruhr area, an agglomeration in the German state of North-Rhine Westphalia, is located close to the disaster zone but was spared from this level of precipitation (von Schirp, 2021b). The 11 cities and 4 counties of the region are home to more than 5 million people. During the July floods, the communities experienced tense days as streams and rivers rose to dike crests, filled up retention basins, and flash floods found their ways into buildings (see Figure 1) (von Schirp, 2021a, 2021b; Weckenbrock & von Schirp, 2021).

Figure 1: The village Schuld was partly destroyed by the river Ahr (Source Christoph Reichwein)

Figure 2: The Emscher-Auen, a flood retention basin in the Ruhr area, avoided downstream floods in July 2021 (Source: Wolfgang Knappmann)

Nonetheless, the problem is not new to the area. In the last years, municipalities in the region were increasingly affected by catastrophic floods. For example, extreme rainfall in 2008 caused immense damages at the university in Dortmund. Within 2.5 hours, more than 200 liters of rain per square meter had fallen over the western parts of the city (Schaefer et al., 2020). Moreover, the region is facing severe other impacts from climate change, such as heat waves and droughts. Together, these climate impacts are already causing considerable economic losses and impair ecosystems and human well-being. With increasing climate risks in the years to come, cities in the Ruhr area face the challenge to adapt to these climatic changes, for example by reducing flood risk, retaining water for times of drought, and regulating air temperatures (Nickelsen et al., 2020; Umweltbundesamt, 2019).

In addition to the challenges of climate change, alarming rates of biodiversity loss demand action. For example, a study indicating that the mass of insects in German nature reserves declined by 75% between 1989 and 2014 caused societal outcry (Hallmann et al., 2017). In the post-industrial Ruhr area, these climatic and ecological challenges coincide with wider societal issues. Many municipalities in the region are struggling with high debt-burdens, economic decline, and a lack of livability. In disadvantages neighborhoods, rates of unemployment and child poverty are high, and so are environmental burdens from traffic, pollution, and climate impacts (Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen, 2020).

1.1 The potential of nature-based solutions

Typically, so-called grey infrastructure solutions like flood walls, water retention basins and air-conditioning are used to address increasing flood risks and temperatures. Such solutions are, however, usually expensive and resource-intensive, have only sectoral benefits, and increasingly fail to deal with a changing climate (Kabisch et al., 2017; Somarakis et al., 2019). For example, conventional wastewater treatment plants are often overloaded during extreme precipitation, which leads to environmentally damaging sewerage overflows (Kabisch et al., 2017).

Nature-based solutions (NBS) are an alternative approach to deal with a changing climate. They are defined by the European Commission as *"solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience"* (European Commission, n.d.). NBS can improve flood resilience and climate adaptation in various ways. For instance, floodplains give rivers space to handle large volumes of water, green roofs retain rainfall, and urban parks regulate temperatures and allow for water infiltration (Somarakis et al., 2019).

Even though the term NBS (or "naturbasierte Lösungen" in German) is barely used in German planning discourse, stakeholders in the Ruhr area are implementing a variety of projects that qualify as NBS (EGLV, 2021c; Naumann et al., 2015; Nickelsen et al., 2020). By far the largest project is the restoration of the Emscher and Lippe rivers from polluted wastewater channels to healthy rivers. The restoration includes dike relocations, re-meandering, and nature-based flood retention areas (EGLV, 2021c). Cities in the Ruhr area are also working on sustainable urban drainage systems (SUDS) where a network of natural structures is integrated into the landscape to deal with rainwater (Emschergenossenschaft, 2021).

However, the July floods illustrate the urgency of increasing the flood risk management efforts in the region. The water boards analyzed that the flood protection measures would have been unable to cope with the same rainfall volumes that devastated nearby regions, and that such a rainfall event would have caused damages of more than EUR 600 million (Leyk, 2021). For one thing, the planners acknowledge the need to improve the flood protection from the Emscher river and its tributaries through dike strengthening, flood retention basins and floodplains. In addition, the experts underline the urgent need to transform the Ruhr area into a "sponge city" by increasing water retention and infiltration through decentral measures (von Schirp, 2021b).

1.2 Research aim and questions

These assessments point to the great potential of using NBS to make the Ruhr area more flood resilient. Yet, there is a knowledge gap in science and practice how to scale up these solutions. Policy-makers and planners have decades of experience with traditional, grey infrastructure, but face uncertainties in relation to NBS. Currently, there is a lack of knowledge about the performance, governance and implementation of NBS (Bauer et al., 2012; Busker, 2020; Egusquiza et al., 2019; Kabisch et al., 2017; Pahl-Wostl, 2019).

How to plan, implement and manage NBS that foster flood resilience? Which stakeholders need to be involved and how can they work together? What factors enable or hinder NBS projects? Finding answers to this question can help planners and policy-makers to scale up NBS and meet societal challenges. For researching these questions, governance arrangements are a key concept. Termeer et al. (2011) define governance arrangements as "the ensemble of rules, processes, and instruments that structure the interactions between public and/or private entities to realize collective goals for a specific domain or issue" (p. 161).

This study aims to identify suitable governance arrangements for NBS that contribute to flood resilience. The main research question is therefore:

> **"What governance arrangements can facilitate the upscaling of nature-based solutions for increased flood resilience of urban areas?"**

To facilitate answering this question, the thesis also addresses three sub-questions (also see Figure 3). The first question is **"what is flood resilience in the Ruhr area, and how can different nature-based solutions contribute to this resilience?"**. It provides insights into the context of water management and flood resilience in the region and helps to understand the role of NBS.

The second question is **"how do stakeholders organize connectivity, allocate responsibilities and deal with controversies in their current governance arrangements for NBS?"**. Termeer et al. (2011) consider these aspects of connectivity, responsibilities and controversies important elements of analyzing governance arrangements. This question therefore forms the basis for studying suitable governance arrangements for NBS.

The third question is **"what are the governance-related barriers and success factors for the uptake of nature-based solutions in the Ruhr area?"**. It sheds light on difficulties related to NBS, and factors that help stakeholders implement such projects. The question helps to identify pitfalls that should be avoided in governance arrangements, and it indicates enabling factors that stakeholders can take advantage of to scale up NBS.

Figure 3: Overview of the research questions

Collectively, the questions help to better understand the roles of different actors from state, community and market, such as municipalities, residents, and real estate developers. Thus, the research can ultimately help to implement nature-based projects that improve flood resilience while providing additional benefits to the community

The goal of this research is to identify governance arrangements that are suitable for scaling up water-related NBS in the Ruhr area. The insights can be particularly valuable for government authorities, urban planners, climate adaptation scholars and policy advisors. By better understanding place-specific barriers and success factors for NBS, they can actively work to create an enabling environment for these solutions. The research can contribute to overcome the reliance on grey infrastructure and ultimately to address several societal challenges like livability, biodiversity, and environmental justice.

2. Theoretical framework: Flood resilience, nature-based solutions, and their governance

This chapter presents the theoretical framework for answering the research questions. It first introduces the concept of flood resilience and related developments in the German Ruhr area, such as the restoration of the Emscher river. Afterwards it explains the meaning of NBS, its relation to similar concepts, and what NBS are most relevant in the Ruhr area.

The next section examines the governance of NBS. First it presents different governance modes, such as hierarchical, traditional public administration and more collaborative network governance. Then it introduces the concept of governance arrangements, which forms a key element for the research. The final part of this chapter deals with the governance-related barriers and success factors for NBS, and presents the conceptual model derived from the theory.

2.1 Flood resilience in the Ruhr area: history, present and trends

What does flood resilience mean?

Resilience is a fuzzy, multi-interpretable concept. Davoudi et al. (2012) define resilience as *"the ability of social-ecological systems to change, adapt, and, crucially, transform in response to stresses and strains"* (p. 302). Restemeyer et al. (2015) identify robustness, adaptability and transformability as three core elements of flood resilience. First, robustness is about the ability of the socio-ecological system to avoid and resist floods. Robustness features most prominently in flood resistance strategies that aim to avoid floods, but it is also an important aspect of a flood resilient city.

Secondly, adaptability is about adjustments that make the city less vulnerable to floods. For example, buildings can be elevated or made water-proof to make sure they are not damaged in case of floods. This aspect requires the participation of various public and private stakeholders.

Thirdly, transformability means the transition to a new system *"when ecological, economic, or social structures make the existing system untenable"* (Walker et al., 2004, p. 3). Restemeyer et al. (2015) interpret transformability as a city's ability to "live with the water" instead of fighting it. They further underline that building flood resilience is a complex and challenging task. It requires a change in the mindsets of planner, policy-makers and citizens (Restemeyer et al., 2015).

What are key developments related to flood resilience in the Ruhr area?

As illustrated in Chapter 1, cities in the Ruhr area, and Germany in general, are facing severe negative impacts from climate change. They need to urgently adapt, for example by mitigating flood risks and retaining water (Umweltbundesamt, 2019).

While there are many projects in the Ruhr area that are related to flood protection, renaturation, and water management, two developments stand out: The restoration of the Emscher river system and an increasing attention for rainwater management.

Restoring the Emscher river system

No description of the water management and current developments in the Ruhr area would be complete without touching upon the restoration of the Emscher river. The Ruhr area was once the industrial center of Germany and used the Emscher river to dispose of industrial and residential wastewater. To reduce the risks of flooding and health issues with the contaminated water, the river and main tributaries were lowered, straightened and set into concrete beds in the early 20th century (see Figure 4) (Scheck et al., 2013). Later, some of the tributaries were put into underground tubes to avoid odour nuisance.

Figure 4: One of the Emscher tributaries that was transformed into an open sewage channel (Source: Paulina Budryte)

In the late 20th century, the open sewage system became unsuitable for social, ecological, and aesthetic reasons. Over the last decades, the river has undergone a fundamental transformation and has become a symbol for urban renewal, and economic, social and environmental change (Perini, 2017). The restoration of the Emscher river comprises three main aspects:

(1) the construction of an underground sewage system and decentralized wastewater treatment plants,
(2) the renaturation of rivers and streams for increased biodiversity, water cycle improvements and green corridors, and
(3) the separation of rainwater and wastewater to reduce the need for wastewater treatment and to improve water balances (Scheck et al., 2013).

After considerable efforts and investments of more than EUR 4.5 billion, the Emscher river will finally be free from wastewater in 2021 (Kurmann, 2021). The improved water quality will allow to gradually improve the ecological status of the streams by removing the concrete structures,

making more room for the water, and creating ecological hotspot across the river basin (Semrau et al., 2009). Figure 5 shows a restored strip up the Emscher river in Dortmund.

Figure 5: The restored upper reaches of the Emscher river in Dortmund (Source: EGLV)

Managing rainwater for climate resilience

Apart from restoring the Emscher river and its tributaries, municipalities in the Ruhr area face the challenge to reduce risks from flash floods. In the urban areas with large sealed surfaces, high water runoff causes property damages and overloads sewage canals and treatment plants. Stakeholders therefore aim to strengthen natural water cycles by increasing water retention, infiltration, and evaporation (EGLV, 2021d). For example, new urban developments are include swales to manage rainwater, and streams that once merged with the mixed sewage system are unbundled and brought back to the surface (EGLV, n.d.).

2.2. Nature-based solutions: Theory and practice

This study aims to identify governance arrangements that can help to scale up NBS that increase urban flood resilience. The following section defines the term NBS and clarifies its function as an umbrella term for other notions like green and blue infrastructure, building with nature, and ecosystem-based adaptation. It also introduced an approach for classifying NBS and explains which type of NBS is most relevant in the Ruhr area.

What are nature-based solutions?

Nature-based solutions (NBS) are an approach to deal with societal challenges like climate change. They are defined by the European Commission as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience" (European Commission, n.d.). The Commission further defines that NBS "bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions", and that NBS must benefit biodiversity and support the delivery of ecosystem services.

What do the different elements of this definition mean for NBS and their contribution to flood resilience? (based on Kabisch et al., 2017; Somarakis et al., 2019)

- Inspired and supported by nature: NBS include the protection, restoration or creation of ecosystems. They cover a wide range of activities like preserving intact wetlands, restoring degraded coastal mangroves, and creating new green roofs and parks in cities.
- Cost-effective: Over their entire lifecycle, NBS are usually cheaper than grey infrastructure solutions that deliver the same or similar services. For example, it can be cheaper to build a green space that controls, retain and filters rainwater than expanding the sewer system.
- Environmental, social and economic benefits: A key feature of NBS is the delivery of multiple benefits and avoided costs. For example, an urban green space retains water, offers habitat and water cycle functions, provides space for recreation and exercise, contributes to increased real estate values, and avoids flood damages.
- Help build resilience: NBS like the described green space help cities to withstand climate impacts like extreme rainfall. In addition, NBS can themselves be more resilient to climate impacts than grey-built infrastructure.

NBS are a fuzzy concept with multiple meanings. While the definition by the European Commission emphasises all three pillars of sustainability, other scholars and organizations set the focus on nature conservation and restoration. For example, the International Union for Conservation of Nature (IUCN) defines NBS as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016, p. 5).

In a systematic literature review, Ershad-Sarabi et al. (2019) find that NBS definitions more commonly focus on sustainable development. In about three quarters of their reviewed papers, NBS were defined as solutions which simultaneously meet environmental, economic and social objectives. For this reason, the definition by the European Commission is used in this study.

The term NBS is relatively new. It was first used in 2008 in the context of finding solutions that help to mitigate and adapt to climate change while providing sustainable livelihoods and biodiversity benefits (Eggermont et al., 2015). In 2009, the IUCN used NBS in a paper for the United Nations Framework Convention on Climate Change. Afterwards, scientists and policy-makers rapidly took up the concept. They viewed NBS as an innovative approach to create green growth while dealing with climate change (Eggermont et al., 2015).

How are NBS related to other concepts?

The concept of NBS is related to several other notions like green and blue infrastructure, building with nature, ecosystem-based adaptation, and ecosystem services (Nesshöver et al., 2017). NBS function as an umbrella term for many ecosystem-related approaches that are described in the following (Kabisch et al., 2017). These concepts all strive to better consider the value of nature in policy-making. Table 1 aims to better understand NBS by unraveling the variety of concepts that form part of it. A more detailed description of the concepts can be found in Annex E.

Key concepts related to NBS	Concept summary
Ecosystem services: The goods and services provided by nature	The concept of ecosystem services helps to understand how natural systems benefit humans. Ecosystem services are defined as the goods and services provided by nature (TEEB, 2010). These can be provisioning services (like water, food or building material), cultural services (like opportunities for recreation or a sense of belonging), regulatory services (e.g., temperature regulation or flood protection) and supporting services (such as nutrient recycling) (Alcamo et al., 2003; Somarakis et al., 2019). The concept of ecosystem services is considered a good way to design and assess NBS.
Ecosystem-based adaptation: Adaptation policies that incorporate ecosystem services	Ecosystem-based adaptation means "adaptation policies and measures that take into account the role of ecosystem services in reducing the vulnerability of society to climate change, in a multi-sectoral and multi-scale approach" (Vignola et al., 2009, p. 692). Measures of ecosystem-based adaptation are, and should be, part of NBS. This is important to make sure that the solutions are themselves adapted to climate change, and to foster societal adaptation (Nesshöver et al., 2017).
Green / blue infrastructure: A network of blue and green features	Green/blue infrastructure is defined as a "strategically planned and managed, spatially interconnected network of multi-functional natural, semi-natural and man-made green and blue features" that can include "agricultural land, green corridors, urban parks, forest reserves, wetlands, rivers, coastal sand other aquatic ecosystems" (European Commission, 2013, p. 3). The concepts of green / blue infrastructure and NBS are closely related and can sometimes be used synonymously. However, there is a difference between the focus on physical infrastructure and the broader term solutions that covers a variety of actions (Nesshöver et al., 2017).
Building with nature: A design approach for building water-related NBS	Building with Nature is a design approach to realize water-related NBS for societal challenges. It harnesses the forces of nature to benefit economy, society and the environment (Eekelen & Bouw, 2020). A systemic perspective and the inclusion of natural processes lies at the core of Building with Nature. The concept forms a sub-set of NBS and can be helpful for developing water-related NBS that entail intense human interventions.

Table 1: Key concepts related to NBS

How do NBS look like in practice? What types of NBS are there?

As indicated in the table above, NBS include a wide range of actions from the preservation of pristine ecosystems to the creation of entirely new ones. Eggermont et al. (2015) developed a typology for classifying NBS. As can be seen in Figure 6, they propose to characterize NBS along two gradients:

- "How much engineering of biodiversity and ecosystems is involved in NBS?"
- "How many ecosystem services and stakeholder groups are targeted by a given NBS?" (Eggermont et al., 2015, p. 244)

While the level of engineering forms the x axis, the stakeholders and services form the y axis. Based in these gradients, the authors define three main types of NBS:

- **Type 1 NBS involve no or minimal interventions in ecosystems.** Such solutions aim to maintain or improve the delivery of ecosystem services inside and outside of the protected ecosystems. It implies the delivery of multiple ecosystem services to various stakeholder groups. Example of type 1 NBS are the protection of coastal mangrove ecosystems for flood protection, biodiversity and livelihoods, or the conservation of Natura2000 areas.
- **Type 2 NBS entail management approaches that develop sustainable, multifunctional ecosystems and landscapes.** The intensive or extensive management improves the delivery of ecosystem services compared to conventional approaches. Compared to type 1, this type of NBS implies an increased provision of fewer ecosystem services to fewer stakeholders. Examples include projects to increase the diversity of tree species to increase forest resilience, or agroforestry.
- **Type 3 NBS comprises managing ecosystems in very intensive ways or creating new ecosystems.** Such solutions are related to concepts like green and blue infrastructure and can aim to restore heavily degraded areas. Type 3 NBS seek to maximize the delivery of selected ecosystem services for key stakeholder groups. Examples include green roofs, intensively managed urban parks, or the restoration and re-opening of degraded streams.

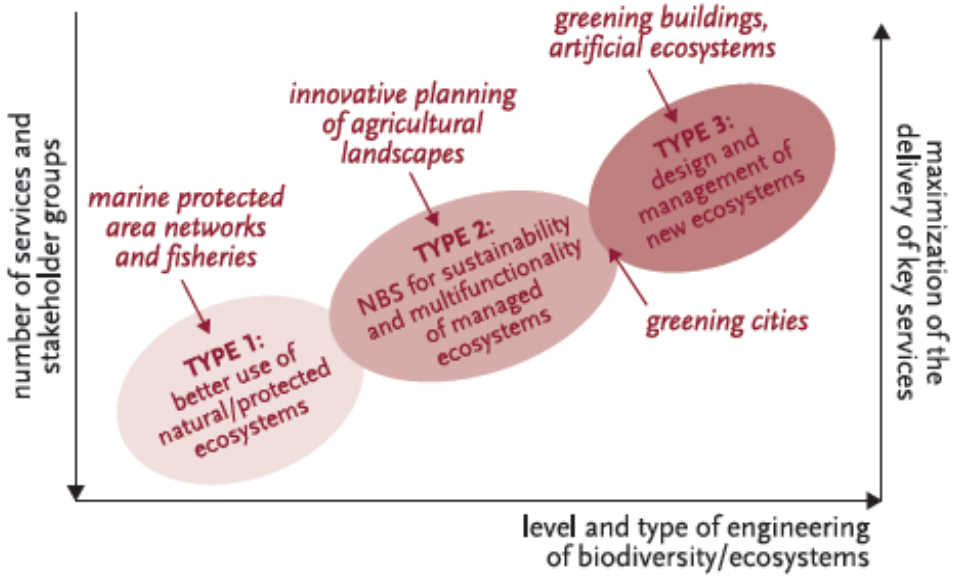

Figure 6: Schematic representation of the three types of NBS (Eggermont et al., 2015)

The Ruhr area was once the German center of heavy industry. Even though all coal mines are closed by now and only a few steel mills are still in operation, the legacy of the industrial past remains omnipresent. The rapid economic growth (and decline) in the region left behind a heavily degraded landscape. A few decades back, the Emscher river was little more than a stinking, open sewage canal. The soil in the region is largely contaminated, and mining damages keep causing issues. Type 3 NBS that aim to restore heavily degraded ecosystems or to create new ones are therefore the most relevant type for the Ruhr area.

It is important to note that the three types of NBS are complementary to each other. Types 3 NBS are not better than type 1, they just have different characteristics (Eggermont et al., 2015). Somarakis et al. (2019) provide an extensive list of NBS based on these three types (p. 190 ff.). The case studies in this thesis focus on the restoration and re-meandering of streams, the creation of floodplains, and sustainable urban drainage systems. All of these projects represent types 3 NBS.

2.3 The governance of NBS: Governance modes and arrangements

This study aims to identify suitable governance arrangements for scaling up NBS. The following chapter therefore introduces the concept of governance and presents diverse governance modes. It describes different roles of governmental, community and market actors, and discusses which governance modes are considered appropriate for NBS. It then explains the notion of governance arrangements and how these can be analyzed.

Overview of relevant governance modes for NBS

The concept of governance is considered a valuable approach for climate adaptation and NBS and has received increasing attention in recent years (Bauer et al., 2012; Egusquiza et al., 2019; Kabisch et al., 2017; Termeer et al., 2011; Zingraff-Hamed et al., 2020).

According to Arnouts et al. (2012), "the essence of governance is the extent to which governmental and / or non-governmental actors are involved in governing" (Arnouts et al., 2012, p. 44). They call this perspective governance modes. As NBS are a relatively new concept, their governance modes do not have their own body of scientific literature. Scholar analyzing NBS therefore draw on literature about public sector governance models and environmental governance (McQuaid et al., 2021).

In the last years, scholars have identified a wide range of governance modes that are relevant for NBS (Zingraff-Hamed et al., 2020). For example, Arnouts at al. (2012) distinguish between hierarchical governance, closed co-governance, open co-governance, and self-governance. Their work focuses on nature policy. Pahl-Wostl (2019) identifies three modes of water governance: hierarchical, network and market governance. Similarly, Vatn (2010) differentiates between hierarchies, markets, and community-based approaches for governing ecosystem services. These examples illustrate that the roles of different actors from government, market and community are often the basis for defining governance modes.

Egusquiza et al. (2019) characterize the governance of NBS based on the leading actor of the project, the levels of participation of non-government actors, and the degree of poly- or monocentric governance. Based on these characteristic and existing governance theories, they find five clusters of governance modes for NBS (Egusquiza et al., 2019; McQuaid et al., 2021):

- **Traditional public administration:** In this cluster of governance modes, the government is the lead actor. Decisions are made in a hierarchical, top-down 'command and control' style. The governance mode relies on bureaucratic structures and emphasizes the rule of law. It can include participatory planning elements, such as mandatory public participation.
- **New Public Management**: In this mode of governance, government and market parties work closely together. They use contract forms like Public-Private-Partnerships (PPPs) to implement projects. The cluster of governance modes also covers schemes of business-led self-regulation like voluntary agreements.
- **Private-Private-Partnerships:** In this form of governance, community and market parties play the key role for NBS project. The governance mode includes partnerships between NGOs and businesses, incentive schemes created by NGOs, and Sustainable Local

Enterprise Networks. Lemos and Agrawal (2006) call this type of environmental governance private-social-partnerships.

- **Societal resilience**: This governance mode involves community and government actors. The cluster includes shared governance by government and community (co-management), and schemes with strong community engagement, like grass-roots initiatives and forms of self-governance.
- **Network governance:** Governance arrangements in this cluster involve government, market and community actors. It includes collaborative and adaptive governance and adaptive co-management. In collaborative governance arrangements, the government brings stakeholders together to develop NBS, but keeps the formal authority. In adaptive governance and co-management, the focus is more on learning from experience and adapting NBS decision-making processes accordingly.

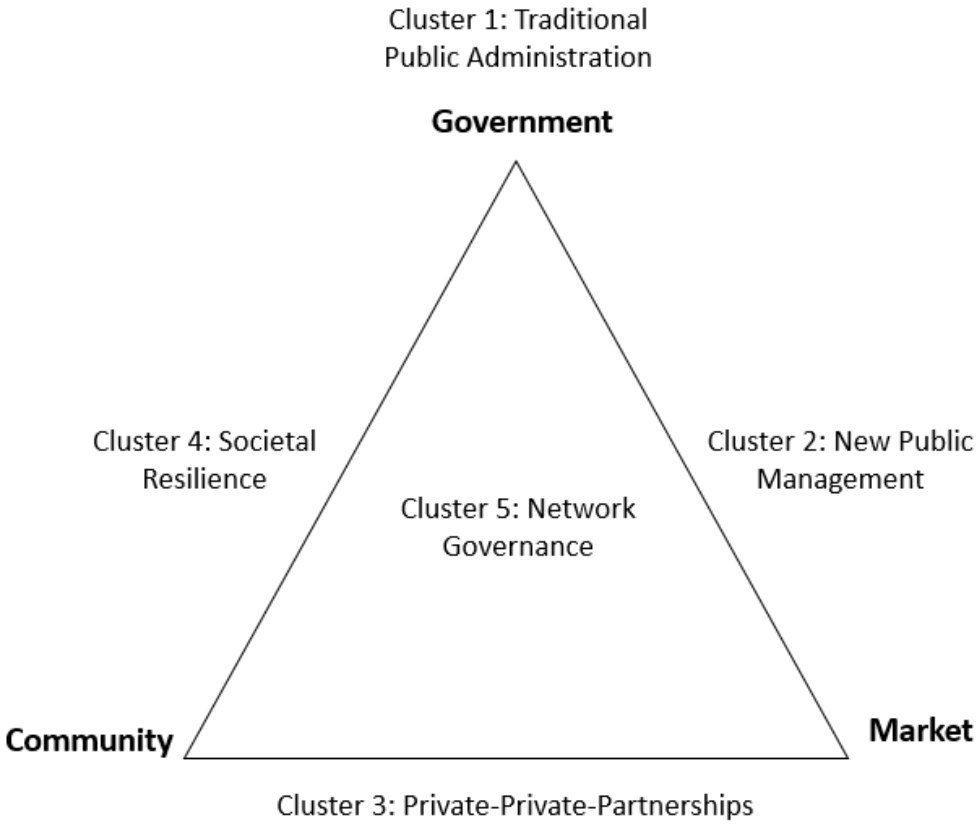

Figure 7: Five clusters of governance modes based on Egusquiza et al. (2019) and McQuaid et al. (2021)

Figure 7 visualizes the five clusters of governance modes in relation to their key actors from government, community and market. The figure is adapted from Egusquiza et al. (2019) and McQuaid et al. (2021), who call it the Key Actors Governance Framework.

What is important for the governance of NBS? Which governance modes are considered suitable for NBS?

Scholars underline that planning and managing NBS is complex and needs to deal with uncertainty (Egusquiza et al., 2019; Frantzeskaki, 2019; Kabisch et al., 2017; Nesshöver et al., 2017; Somarakis et al., 2019): As NBS are a relatively new concept and stakeholders are more used to grey, engineered infrastructure, there is little experience with NBS, and uncertainty how to go about such projects. In addition, NBS are by definition multifunctional and shall deliver environmental, economic and social benefits (European Commission, n.d.), thus requiring the integration of various societal issues. They form part of complex ecological system, which requires a good understanding of ecosystem processes (Nesshöver et al., 2017). According to Egusquiza (2019), suitable governance modes for NBS therefore need to foster the engagement of diverse stakeholders, facilitate coordination across sectors, draw on transdisciplinary knowledge, and support innovation and learning.

Based on these points, Egusquiza (2019) consider the cluster of network governance as particularly suitable for NBS. This cluster includes collaborative and adaptive governance and adaptive co-management. Frantzeskaki (2019) also underline value of collaborative governance for NBS in urban areas. By embracing the collaboration of diverse stakeholders and adapting to changing circumstances, such governance modes can address NBS complexity and uncertainty.

Egusquiza (2019) also consider the governance clusters of societal resilience and private-private partnerships suitable for NBS, without clearly specifying in which ways these governance modes fulfil the criteria mentioned above.

The governance modes included in the clusters of new public management and traditional public administration are considered less suitable for NBS (Egusquiza et al., 2019). The authors explain this conclusion with the risk aversion of private parties to invest in innovative, more uncertain approaches like NBS. They also conclude that traditional, top-down public administration can fall short in coordinating large NBS that cross multiple jurisdictions. Franszeskaki highlight that urban planners need to be open to collaborative governance of NBS that allows for mutual learning with diverse actors, and new management arrangements. Traditional public administration with its dominant government actors and focus on formal procedures in unlikely to satisfy this need of NBS.

The governance modes described above form the basis for a general analysis of the way NBS are governed in the Ruhr area. However, the concept of governance arrangements allows to analyze NBS on a more detailed scale and is therefore introduced in the following.

Governance arrangements

Termeer et al. (2011) define governance arrangements as "the ensemble of rules, processes, and instruments that structure the interactions between public and/or private entities to realize collective goals for a specific domain or issue" (p. 161). This study aims to identify suitable governance arrangements for scaling up NBS. It will therefore have a closer look at the relevant public and private stakeholders, their interactions around NBS, and the rules, processes and instruments that structure these interactions.

In their work on the governance of climate adaptation, Termeer et al. (2011) present three concepts that can guide the analysis and design of suitable governance arrangements:

- organizing connectivity,
- (re)allocating responsibilities, and
- dealing with controversies.

The first concept, organizing connectivity, is about bringing actors, issues, sectors, and scale levels together to realize climate adaptation options. According to Termeer et al. (2011), successful governance arrangements for climate adaptation need to connect different policy domains, different levels or scales of authority, support leadership, and facilitate pilot projects and experimentation. These issues are not only relevant for climate adaptation, but also for the NBS. Diverse authors underline the need for cross-scale and cross-sectoral cooperation, local leadership, and learning-by-doing (Busker, 2020; Kabisch et al., 2017; Naumann et al., 2015; Somarakis et al., 2019; Zingraff-Hamed et al., 2020). Therefore, the thesis pays special attention to this topic of organizing connectivity.

The second concept by Termeer et al. (2011) is about re-allocating responsibilities as well as costs and benefits. On the one hand, governance arrangements need to skillfully allocate responsibilities to appropriate parties, which is often challenging. For example, stakeholders need to define who builds and maintains a project. On the other hand, the arrangements should properly allocate the costs and benefits of climate adaptation measures. This includes instruments like taxes and economic incentives. Scholars and practitioners highlight that the allocation of responsibilities, costs and benefits of NBS is highly challenging (Busker, 2020; Kabisch et al., 2017; Naumann et al., 2015; Somarakis et al., 2019). This study will therefore consider these issues when searching for suitable NBS governance arrangements.

The third concept, dealing with controversies, is about coping with conflicting perspectives and contested knowledge. The literature about NBS rarely mentions this topic, but various disputes might be relevant for NBS in the Ruhr area. For instance, the industries building conventional grey infrastructure could oppose a shift to NBS, urban areas face land use conflicts, and developments like climate change are contested concepts in part of the German society.

2.4 Barriers and success factors to scaling up NBS

In order to better understand the governance of NBS, this study examines barriers and success factors for such projects. This chapter therefore aggregates governance-related enablers and hindering factors found in the academic literature.

Governance-related barriers

Despite promising experience with NBS in urban areas, scholars like Egusquiza et al (2019) detect significant knowledge gaps and economic and governance barriers to scaling up the use of NBS for climate adaptation. The main governance barriers identified in the literature are inadequate regulations, institutional fragmentation, and issues with public participation. Other barriers that are partly related to the governance of NBS are inadequate financial resources, path dependency, limited land and time availability, and uncertainty about the implementation and effectiveness of NBS (Ershad Sarabi et al., 2019). Figure 8 illustrates these barriers for the uptake of NBS. They are explained in more detail below.

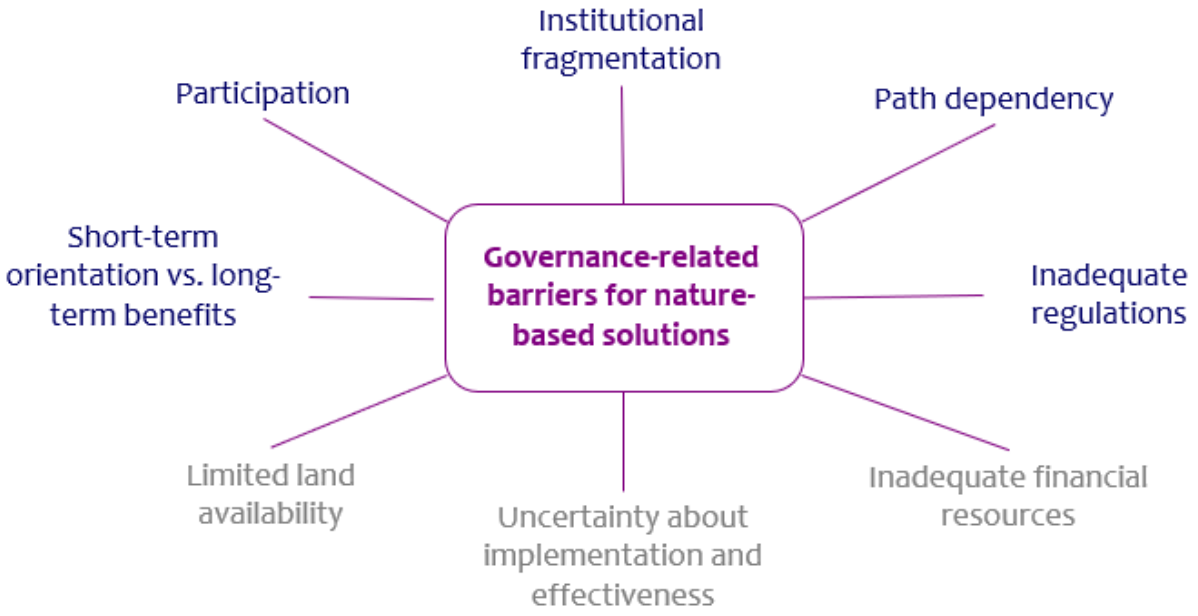

Figure 8: Barriers for the uptake of NBS. Barriers that are only partly governance-related are written in grey (author's own illustration)

Institutional fragmentation[1]

(Bauer et al., 2012; Egusquiza et al., 2019; Ershad Sarabi et al., 2019)

Ershad Sarabi et al. (2019) also call this barrier sectoral silos, while Bauer et al. (2012) refer to a lack of vertical and horizontal policy integration. One the one hand, institutions follow their own procedures and visions and use different sectoral language. This can hamper the collective development of NBS. On the other hand, responsibilities are split among several departments and

[1] To avoid an overload of references and keep the text readable, the referencing style in this chapter deviates from the rest of the study. References with common findings are summarized at the beginning of each section.

institutions. For example, there are separated departments for urban development, green space, and water management in municipalities, contributing to a lack of collaboration between these sectors. Responsibilities are also often distributed among different levels of government and spatial scales. For instance, national, regional, and municipal authorities all deal with flood risks in Germany. This institutional fragmentation can lead to a lack of collaboration and coordination. It can also cause uncertainty about who is responsible for planning, building, and maintaining NBS, and who should be involved in the process.

Inadequate regulations

(Egusquiza et al., 2019; Ershad Sarabi et al., 2019; McQuaid et al., 2021)

The uptake of NBS can be hindered by regulations that were developed for grey infrastructure projects. Rigid legal frameworks and bureaucracy are also obstructing the uptake of NBS. For example, one proposal for improving the flood protection standards of the Dutch Afsluitdijk focused on NBS. However, the plan for creating new dunes and salt-marshes seawards of the existing dam was rejected for regulatory reasons. Despite offering environmental as well as socio-economic benefits, the regulations for the adjacent Natura2000 Wadden Sea area impeded the project (Busker, 2020).

Path dependency

(Ershad Sarabi et al., 2019; Kabisch et al., 2017)

Public decision-makers, urban planners and engineers are accustomed to using grey infrastructure. If they need to tackle a societal challenge like increasing flood risks, the default choice is usually grey infrastructure, not a nature-based or hybrid solution. This barrier for using more NBS is closely related to the mindsets and previous experience of stakeholders. In addition, policy-makers tend to prioritize new urban developments over the preservation or restoration of NBS and the services they provide (Kabisch et al., 2017)

Multi-stakeholder governance / Participation

(Bauer et al., 2012; Kabisch et al., 2017; McQuaid et al., 2021)

Another barrier to the increased uptake of NBS is related to the involvement of multiple stakeholders. Scholars underline that the high number of stakeholders that are relevant for NBS projects can lead to complex governance structures. When numerous actors from different sectors work together, the project can be hampered by unclear responsibilities, a feeling of apathy, and mismatching goals.

Despite these challenges, it is crucial for NBS that diverse actors take part in their planning, implementation and maintenance. A lack of participation of non-state actors can reduce the acceptance and feeling of ownership of NBS. Inadequate participation also reduces the access to vital local knowledge and capacities. Public authorities might have little experience with collaborative forms of governance, which hinders NBS projects.

Short-term orientation vs. long-term benefits

(Egusquiza et al., 2019; Ershad Sarabi et al., 2019; McQuaid et al., 2021)

NBS are usually highly cost-effective over their life cycle and provide considerable environmental and socio-economic benefits. However, NBS need time to fully develop their ecosystem services and benefits. For example, it can take years for plants and animals to settle and grow in a newly created ecosystem. This long-term orientation of NBS is hard to match with short-term political agendas and short election and budget cycles, which can cause a lack of political support and financial resources. A high urgency of infrastructure investments may also be a barrier for NBS. Under high pressure to deliver a service, policy-makers might favour grey infrastructure solutions that can quickly provide the service in a familiar way.

Other barriers that are partly related to the governance of NBS

The literature review pointed to various barriers for NBS that are not directly related to governance but can still be important for governance arrangements, such as project funding our doubts about the implementation of NBS.

Inadequate financial resources

(Ershad Sarabi et al., 2019; Kabisch et al., 2017; Naumann et al., 2015)

A lack of funding for NBS is a barrier that is at least indirectly related to governance. Scholars underline that public budgets alone cannot stem the necessary investments for NBS. A reliance on public funding is severely hampering their uptake. For example, many municipalities in the Ruhr area carry a heavy debt burden and there is strong competition for the scarce budgets (Ministerium für Heimat, Kommunales, Bau und Gleichstellung des Landes Nordrhein-Westfalen, 2021). In addition, there are few specific funding opportunities for NBS, which makes it hard for motivated municipalities to mobilize extra funds. Furthermore, NBS need long-term maintenance, which can hamper their uptake when stakeholders lack the necessary long-term resources and commitment.

Experience with NBS around the world shows that the projects often lack a "bankable business case" (Busker, 2020; Kabisch et al., 2017; Somarakis et al., 2019). This is closely related to the diffuse benefits of NBS: Their benefits are usually spread across multiple disciplines like flood risk reduction and human health. Moreover, NBS projects usually benefit diverse public and private actors simultaneously. When the investment is only considered from a sectoral perspective and funding comes from one discipline, NBS might not appear as worthwhile investments.

Limited land availability

(Ershad Sarabi et al., 2019)

Limited available space can be another barrier for scaling up NBS. To deliver the expected services and benefits, NBS usually require more land. Especially in densely populated areas a lack of available space can hinder NBS.

Uncertainty about implementation and effectiveness of NBS

(Bauer et al., 2012; Busker, 2020; Egusquiza et al., 2019; Ershad Sarabi et al., 2019)

A lack of information or uncertainty about NBS is frequently mentioned in the literature as a main barrier for the uptake of NBS. The barrier includes doubts about the planning, implementation and management of NBS, uncertainty about their effectiveness, and an inadequate knowledge base. The concept is only known to a small community of scholars, planners and decision-makers, which hampers the uptake of NBS.

NBS are innovations that deal with complex socio-ecological systems, which contributes to uncertainties. For one thing, there is a lack of comprehensive information about creating, implementing and managing these solutions. A shortage of evidence about the effectiveness of NBS in specific contexts and over longer time periods adds to this uncertainty.

Governance-related success factors

While the barriers to scaling up NBS appear relatively well defined in the academic debate, the success factors seem to be more scattered and vaguer. The following section aggregates the governance-related success factors and enablers from the literature, grouped around these themes:

- Partnerships among stakeholders and organizations
- Knowledge sharing and valuation
- Planning processes and legislation
- Experimentation and learning

Figure 9 illustrates these success factors for the uptake of NBS. The factors overlap in parts.

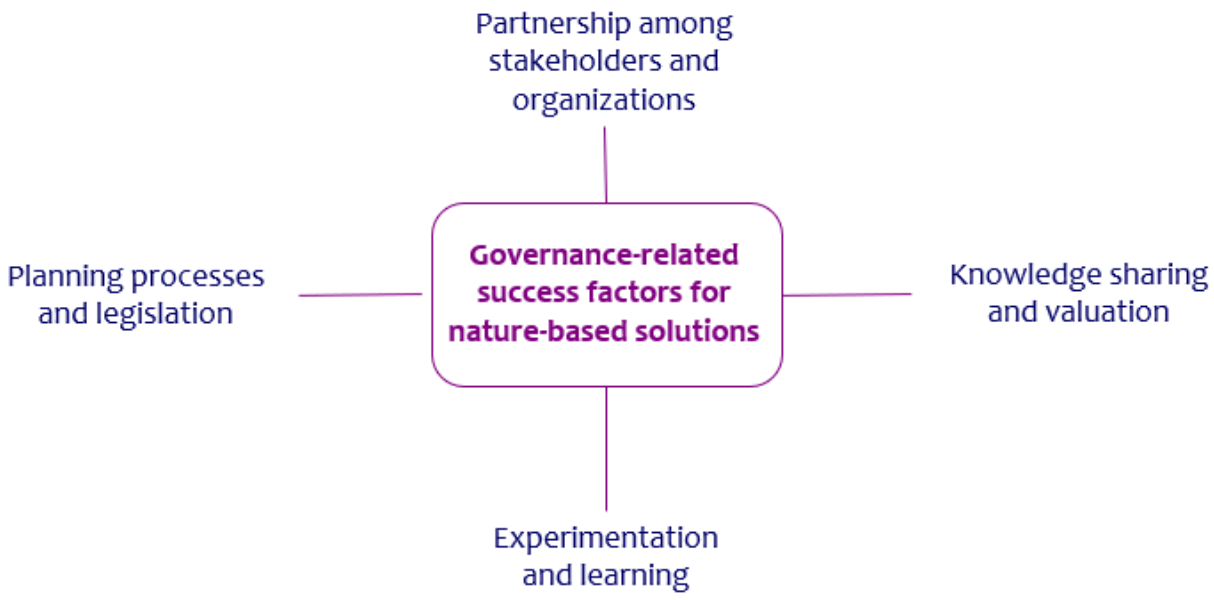

Figure 9: Success factors for the uptake of NBS (author's own illustration)

Partnerships among stakeholders and organizations

(Egusquiza et al., 2019; Ershad Sarabi et al., 2019; Kabisch et al., 2017; Naumann et al., 2015; Nesshöver et al., 2017; Somarakis et al., 2019)

The partnership among actors is the most frequently mentioned enabler for NBS. It forms a common theme across many publications and means the close collaboration of stakeholders and organizations from different levels as well as from the same level. Such partnerships are considered crucial to ensure that NBS successfully deal with complex challenges and provide their multiple benefits.

In summary, partnerships facilitate NBS in three ways: The provide local perspectives and improve the plans (substantive benefits), generate support for the plans (instrumental benefits), and enhance the legitimacy of the planning process (normative benefits) (Nesshöver et al., 2017).

In networks or partnerships, different actors can form a common understanding of societal challenges and NBS as an approach to address them. Such a shared understanding is important for developing a common vision and implementing successful NBS. Scholars underline the importance of intensive coordination between actors. In some case, a specific role for coordination can be beneficial. For example, the local government can fulfill this role and bring relevant stakeholders together.

While the involvement of non-state actors is important for NBS, local authorities play a key role. Their political, regulatory and financial support seems to be crucial to realize NBS. For example, Zingraff-Hamed et al. (2020) underline the political importance of local champions. When actors collaborate closely, they can also get improved access to necessary resources and capacities such as technical expertise, financial means, contacts to other actors, political influence, and regulatory power. For example, local governments and private parties can combine their authority, expertise and financial capacity in public private partnerships to implement NBS projects that would otherwise not be feasible.

Another success factor for NBS projects is related to adequate communication. Scholars like Naumann et al. (2015) highlight the need to conduct regular and targeted public relation work and to ensure high transparency. They also point out that building trust among stakeholders is important to project success.

Scholars use a diversity of governance-related concepts to describe partnerships that facilitate NBS, such as co-creation, participation, self-governance, grassroots initiatives, PPPs, network / network governance, and adaptive governance. In these partnerships, non-state actors like citizens, non-governmental organizations (NGOs) and companies play a key role. While they would initiate and lead NBS in arrangements of self-governance or grassroots initiatives, other notions like network governance and participation include a stronger role for the government.

Planning processes and legislation

(Ershad Sarabi et al., 2019; Kabisch et al., 2017; Naumann et al., 2015; Somarakis et al., 2019)

Planning processes and regulations can hinder NBS projects, but they can also be a success factor. Supportive, clear regulations on a regional, national, or supra-national can foster the uptake of NBS. For example, the EU water framework directive demands a good ecological status of water bodies,

which motivates NBS such as river restoration projects. Local regulations about sustainable drainage systems or green roofs also prove to facilitate NBS implementation. Scholars also underline that a key enabler for NBS is their integration into planning processes, for example through strategic plans.

Moreover, they identify the implementation of hybrid solutions as a success factor for NBS uptake. Such hybrid solutions combine elements of engineered, grey infrastructure with nature-based elements. For example, dikes are increasingly reinforced with vegetated foreshores, or wastewater treatment plants include constructed wetlands to further improve water quality. Hybrid solutions can be more cost-efficient than creating the same level of services with purely grey infrastructure. In addition, they offer the added social and environmental benefits of NBS. While this success factor is mostly a biophysical one, it highlights the need to avoid static black-and-white thinking that considers grey and nature-based solutions as incompatible.

Economic instruments and incentives can also support NBS. For example, such instruments can influence private actors by changing fees and charges or by limiting activities affecting nature.

Experimentation and learning

(Egusquiza et al., 2019; Ershad Sarabi et al., 2019; Frantzeskaki, 2019; Kabisch et al., 2017; Naumann et al., 2015)

As NBS are a relatively new concept and most communities have little experience, experimentation and learning are crucial for NBS uptake. According to Frantzeskaki (2019), "experiments show a visible and tangible action that is accessible, invites discussions and can alter thinking and perceptions" (Frantzeskaki, 2019, p. 102). Experiments, pilot projects, and living labs offer concrete impacts on the ground, can spark societal awareness and discussions, and help to generate much needed evidence about NBS.

They provide the opportunity to practice the implementation of NBS in diverse stakeholder arrangements, and to learn from mistakes without major losses. Scholars underline that this aspect of learning from NBS and adapting planning processes is crucial and should be embraced in adaptive governance approaches. Experimenting with NBS despite the existing knowledge gaps requires an open mindset. Planners and policy-makers need to be open to such new ideas and willing to deviate from strict standards if needed.

Knowledge sharing and NBS valuation

(Egusquiza et al., 2019; Ershad Sarabi et al., 2019; Frantzeskaki, 2019; Kabisch et al., 2017; Somarakis et al., 2019)

Education and training about NBS for policy-makers and planning professional can also enable NBS. When key stakeholders appreciate the benefits of NBS and learn how to better deal with their complexity and remaining uncertainties, they can better use the concept in their practice.

Integrated valuations of NBS costs and benefits are another enabler for NBS. High-quality NBS provide multiple environmental, economic and social benefits over their lifecycles. But often, policy-makers can only base their decisions on the costs for infrastructure development. More sophisticated assessment tools that integrate the benefits of NBS are considered important for mobilizing support and financial resources.

2.5 Conceptual model: Governance arrangements for scaling up NBS

This study analyzes suitable governance arrangements for scaling up NBS that contribute to increased flood resilience. Governance arrangements thus form the central piece of the research. As explained before and shown in Figure 10, the arrangements will be studied by looking at how the stakeholders work together (connectivity), allocate responsibilities, and deal with controversies.

The governance arrangements are influenced by governance-related barriers and success factors. In order to successfully implement NBS projects, the governance arrangements need to take advantage of success factors and find ways to overcome the barriers.

The suitable governance arrangements then allow to implement more NBS. The focus lies on NBS type 3 that are related to water. Such projects involve the intensive management and creation of ecosystems. The characteristics of the NBS project can influence the suitable governance arrangements, as the projects can involve different stakeholders, tasks, and challenges. Finally, implementing more NBS contributes to increased flood resilience of urban areas.

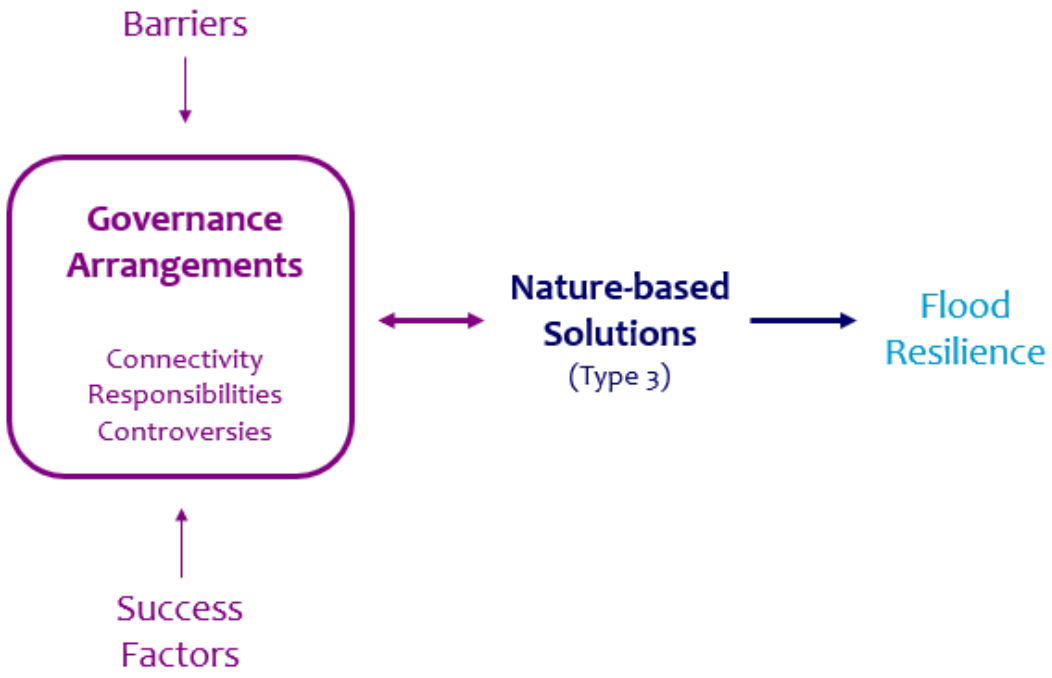

Figure 10: Conceptual model (author's own illustration)

3. Methodology

This study aims to identify suitable governance arrangements for scaling up NBS in urban areas by looking at projects in the German Ruhr area. It investigates how NBS can contribute to flood resilience, what governance arrangements are currently used for such projects, and which factors are supporting or hindering NBS. The following section describes the chosen approach of case study research, provides a short introduction of the case studies, and explains how data was collected and analyzed.

3.1 Research methodology: Case study research

Choosing a qualitative research approach

One step in designing the research was so decide between a quantitative and qualitative approach, and different methodologies. Quantitative research aims to "quantify a research problem, to measure and count issues and then to generalize these findings to a broader population" (Hennink et al., 2020, p. 17). It needs large samples, uses methods like surveys and polls, and applies statistical analysis. Quantitative research is best suited for answering questions about quantities, frequencies, and correlations (Hennink et al., 2020).

Qualitative research, in contrast, seeks "a contextualized understanding of phenomena, explain behaviour, and beliefs, identify processes and understand the context of people's experiences" (Hennink et al., 2020, p. 17). It needs a small number of participants and collects data in in-depth interviews and discussions. Qualitative research helps to understand behaviour and opinions from the perspective of the study participants, to understand processes and context, and to study complex issues (Hennink et al., 2020).

The aim of this research is to identify suitable governance arrangements for scaling up NBS. The objective is not to measure existing approaches to NBS governance and to generalize it to a bigger context, but to gain an in-depth understanding the governance and stakeholder's experiences. In addition, governance and NBS strongly dependent on their spatial, legal and institutional context, and a qualitative research approach is therefore most suitable.

Case study research as a qualitative research method

Case study research allows for an in-depth analysis of NBS projects in their context, which makes is a useful method for this study. (Yin, 2014). A case study approach fits the research problem if the phenomenon of interest can be studied outside its natural setting, the study needs to focus on contemporary events, there is no need to control or manipulate subjects or events, and when there is an established theoretical base for the phenomenon of interest (Gagnon, 2010). All these conditions are fulfilled for the research interest of this thesis. For example, NBS are a relatively new approach that requires a focus on contemporary projects, and there is a theoretical base for NBS and their governance.

Validity and reliability in case study research

To ensure a high quality of the findings, case study research needs to follow rigorous scientific standards (Yin, 2014). In particular, the research must follow systematic procedures to guarantee the validity and reliability of the results.

Reliability refers to the repeatability and consistency of the research observations (Yin, 2014). It means that other research should arrive at similar conclusions if they studied the same phenomenon with the same methodology. Several aspects are important to reach reliable results (Gagnon, 2010): the researcher needs to carefully choose the informants, describe the process of doing to, and provide a list and description of the informants. In addition, the study should describe the characteristics of the research setting, and it should be transparent about the definitions of the concepts used in the study.

Validity refers to the connection between the research results and reality (Yin, 2014). It means that the researcher has measured what was planned and produced descriptions and explanations that match the observations (internal validity). It also refers to the transferability of the results to other cases (external validity). Validity is reached through a well-documented, consistent interpretation of the evidence. For developing valid results, it is particularly important to use as many sources of information as possible, present evidence is a transparent manner, and to make sure that the selected cases fit the concepts and problem under study (Gagnon, 2010).

Case selection criteria

Selecting suitable cases studies is a vital step of the research. The usefulness of the results largely depends on choosing a relevant research setting. Therefore, it is important to establish suitable case selection criteria and invest time into finding good cases (Yin, 2014). The idea behind choosing the case studies is to find the most informative cases, not to develop a statistically representative sample. The main reasons for selecting a case should be that is has specific or shared characteristics that are of interest for the study (Gagnon, 2010).

For multiple-case studies, scholars recommend to study four to ten cases (Gagnon, 2010). This allows to draw conclusion from the set of cases. Case study research can only be successful if the researcher can obtain the necessary information about the cases. The availability of data is therefore an important factor in choosing cases. Considering the limited available time and capacity of the researcher, she therefore aimed to recruit up to 6 case studies.

The unit of analyses for the research is characterized by the spatial boundary, theoretical scope, and timeframe. The theoretical scope is based on a literature study of the key concepts of NBS and flood resilience. All selected cases need to fulfil the definition of NBS and contribute to flood resilience. The area of the regional planning authority of the Ruhr area, called Regionalverband Ruhr (RVR) forms the spatial boundary (see Figure 11). All cases in this study are located in this agglomeration.

The research focuses on cases that are currently under implementation or have been completed in the last 5 years. Regarding the timeframe, only case studies are selected that are concretely planned, currently being implemented or already completed.

Figure 11: The Ruhr area including cities, counties, and rivers (Source: Regionalverband Ruhr)

Based on these considerations and the theoretical framework, the following selection criteria were used to choose the cases for this thesis Table 2.

Selection criteria	Description
NBS project	The case fulfils the fundamental aspects of the NBS definition: it is inspired or supported by nature, provides environmental, social, and economic benefits.
Contribution to flood resilience	The case is explicitly designed to reduce flood risks, and / or helps to regulate the water cycle and raise awareness for water-issues.
Located in the Ruhr area	The case is located in the Ruhr area
Contemporary project	The case is concretely planning, is being implemented, or was completed no more than 5 years ago.
Availability of information	Key informants can be identified and are willing to participate. Additional information is available via websites, media coverage, and / or planning documents.
Variety	The cases differ in their physical characteristics, stakeholder constellations, and focus or objectives.

Table 2: Case study selection criteria

Potential case studies were identified by searching the websites of public authorities, exploring NBS databases, exploring ongoing research projects, and reviewing materials on the Emscher river restoration. In addition, the researcher contacted experts in the regional planning authority, municipal water authorities and Dortmund's university to learn about relevant NBS projects and the level of available information.

Various projects related to rainwater management were identified on a platform of the water board (EGLV, n.d.) and on the website of municipalities. For example, rainwater was integrated into urban development projects like the Grüne Mitte Essen and businesses decoupled their roofs from the sewage system and built rain gardens. However, these case studies either did not fulfil the NBS definition, had very limited information available, or they were implemented many years ago, which would have hampered data collection.

The researcher also browsed the case study databases[2] of international NBS initiatives. Despite their multitude of entries, the databases did not include NBS projects that fit the case selection criteria.

Several other projects were considered as case studies but had to be turned down because possible interview partners were unavailable and documents about the cases were not available digitally. This included, for example, the green roof strategies in the cities of Dortmund and Bottrop, and projects related to the Emscher river restoration.

In the end, four case studies were selected for further research. The are shortly presented in the following section.

[2] Case study databases consulted:

https://oppla.eu/case-study-finder
https://platform.think-nature.eu/case-studies
https://networknature.eu/network-nature-case-study-finder
https://emscher-regen.de/index.php?id=8

3.2 Introducing the case studies

Table 3 shows an overview of the selected cases. The are shortly introduced in the following.

Case	What	Where
Emscher-Auen	Flood retention basin, wildlife hotspot, recreation	Dortmund
Emscher-Land	Landscape park with restored Emscher river and stream, recreation, co-management planned	Castrop-Rauxel / Recklinghausen
Katernberger Bach	Stream restoration, integration into local green corridor, focus on community engagement and urban regeneration	Essen
Zukunftsinitiative Wasser in der Stadt von morgen	Regional collaboration for sustainable water management	Ruhr area

Table 3: Selected case studies

Emscher-Auen

The Emscher-Auen are a new flood retention basin of the Emscher river (see Figure 12) (EGLV, 2021f). The floodplains are located in the upper reaches of the Emscher on the borders of Dortmund and Castrop-Rauxel. Construction started in 2011 and is planned to finish in 2021.

The Emscher-Auen provide considerable benefits for flood protection, biodiversity and recreation. The four basins with a total area of 33 hectares will be able to retain 1.1 million cubic metres of water when the project is completed. In the final stage, the Emscher river will be allowed to meander freely in the basins, unless flood events require closing the flood gates and damming up the water. In the last years, the floodplains have developed into valuable wetland ecosystems that are home to a variety of plants and animals. The Emscher-Auen also attract migrating birds. With cycling and pedestrian paths around the basins and a café, the project is a local recreation area.

Figure 12: The flood retention basin Emscher-Auen is a local wildlife hotspot and recreation destination (Source: EGLV)

Emscher-Land

The project Emscher-Land is an intercommunal landscape park with diverse elements (EGLV, 2021a). When finished in 2023, it will include a "blue classroom" to explore a restored stream and a 30-hectare park where people can experience water and nature. The project also comprises a regional bicycle path along the Emscher river, the construction of a new 400-meter-long cycling bridge, and a vineyard. Part of the park are supposed to be managed and used by the local community, for example for horticulture or bee-keeping. Emscher-Land will be part of the International Gardening Exhibition in the Ruhr area in 2027 (Regionalverband Ruhr, 2021).

Figure 13: Construction of the Emscher-Land park next to the Emscher river and the Rhein-Herne canal (Source: EGLV)

Katernberger Bach

The Katernberger Bach is a community-oriented stream restoration project (EGLV, 2021b). The Katernberger Bach is a small stream in the North-Eastern part of Essen that eventually flows into the Emscher river. The stream was historically used to discharge wastewater and flowed in underground tubes since the 1980s. After freeing it from wastewater in the course of the Emscher restoration, the stream is now being re-integrated into a green corridor. On a stretch of about 1 kilometer, the stream will flow in a near-natural bed, thus improving the ecological status of the water body and regulating natural water cycles.

A central feature of the project is the involvement of the local community and the integration into urban regeneration efforts (EGLV, 2020). Since the design phase in 2015, residents could participate in various events, and many ideas have been integrated into the plans. The redesigned park with the Katernberger Bach will partially open in autumn 2021. Figure 14 shows the green corridor and the local community celebrating the start of the construction works in 2019.

Figure 14: Community event celebrating the beginning of the Katernberger Bach restoration (Source: EGLV)

Zukunftsinitiative

The Zukunftsinitiative (ZI) is a regional initiative for sustainable water management in the Ruhr area (EGLV, 2021d). It aims to foster sustainable urban development and climate resilience. Under the title "water in the city of tomorrow" (in German: Wasser in der Stadt von morgen), the initiative focuses on regional cooperation, knowledge transfer and exchange, as well as the implementation of water-related projects. In a memorandum of understanding of the initiative, the municipalities in the Ruhr area formally agreed to improve their water management. For example, they aim to increase water evaporation by 10%, decouple 25% of all sealed surfaces from the sewer system, and to improve flood resilience (EGLV, 2021e). Diverse projects supported by the ZI qualify as NBS, such as nature-based rainwater management and green roofs. Figure 15 shows how rainwater from a hospital in Recklinghausen was decoupled from the sewer system and is now integrated into the green space.

Figure 15: Rainwater management in a hospital park (Source: EGLV))

3.3 Data collection framework and techniques

According to Yin (2014), case study researchers should follow three rules when gathering evidence. First, they should use multiple sources. This allows to analyze a variety of information, identify patterns, and come to valid results. The research for this thesis therefore includes interviews with several people from different authorities and teams. Most of them are not only familiar with their own projects and the local context but could also provide information about some of the other case studies. In addition, data was collected from diverse documents.

Secondly, researcher should create a database so that other people could, if necessary, review and verify the study. The software MaxQDA or was used to store the collected data in an orderly fashion. MaxQDA is designed for qualitative data analysis and is helpful for storing, organizing, and analyzing different kinds of data, such as audio files, texts and pictures.

Based on the third rule for gathering evidence, it is important to maintain a chain of evidence to demonstrate the reliability of the data. The chain of evidence should cover the situations how the data was collected and allow to track the evidence all the way from the start of the research to the conclusions. The study therefore includes information about the circumstances of data collection. Details about the conducted interviews and analysed documents can be found below.

Semi-structured interviews

As the researcher did not have an established group of informants in the Ruhr area, the data collection proceeded step by step via "snowballing". In this sampling method, key informants are asked whether they know any other relevant interview partners and provide the contact details to the researcher, and so on (Hennink et al., 2020). This procedure has the advantage that it uses insider knowledge to identify more participants, and that requests for participation in the interviews are backed by a trusted person.

In practice, the researcher first explored a variety of relevant NBS projects in the region and the related stakeholders. After several emails and phone calls, a first round of interviews was conducted to learn more about ongoing NBS developments and to identify promising projects and informants. These interviews proved very valuable for obtaining contacts for the next round of more case-specific interviews.

The snowballing technique was particularly helpful for getting in touch with people whose affiliation with the case studies and contact details were not published online. However, the approach bore the risk of selecting a sample of overly similar participants (Hennink et al., 2020). To counteract this, the researcher purposefully chose interviewees from different departments, authorities and organizations. Yet, the sample could not fully represent the diversity of public and private stakeholders that was envisioned.

Table 4 presents the interviews that were conducted to learn more about the governance of NBS and the four case studies. The interviews were complemented with phone calls with the coordinator of a nature conservation association and a green infrastructure expert from the regional planning authority RVR.

Interviewee	Interview focus	Date
Regional planning authority RVR (1 representative, phone call only)	Green infrastructure, projects and stakeholders in the Ruhr area	May 26, 2021
Water authority Dortmund (1 representative)	Emscher-Auen, Zukunftsinitiative, stream restoration, regulatory framework	June 2, 2021
Urban drainage enterprise Dortmund (1 representative)	Zukunftsinitiative, rainwater management	June 10, 2021
Coordinator for Zukunftsinitiative and Emscher-Land (1 representative from EGLV)	Zukunftsinitiative, regional governance, Emscher-Land	June 15, 2021
Project managers Emscher-Auen (2 representatives from EGLV)	Emscher-Auen, regulatory framework	June 22, 2021
Project manager Katernberger Bach (1 representative from EGLV)	Katernberger Bach, Zukunftsinitiative, stream restoration, citizen participation	June 25, 2021
Project managers Emscher-Land (2 representatives from EGLV)	Emscher-Land, co-management	June 28, 2021

Interviewee	Interview focus	Date
Department of urban renewal, Essen (1 representative)	Katernberger Bach, citizen participation	July 13, 2021
Farmer (1 person)	Emscher-Land, co-management	July 16, 2021
Coordinator nature conservation association NABU (1 representative, phone call only)	Emscher-Auen, biodiversity projects, cooperation between public and civic entitites	Sept. 17, 2021

Table 4: List of interviews and complementary phone interviews

Semi-structured interviews formed the basis for collecting data. In a semi-structured interview, the interviewer asks precise questions, but allows considerable leeway for the respondent and the development of the interview (Atteslander et al., 2010). The interviewer asks open-ended questions based on an interview guide. The order of the questions can be adapted during the interview, and mostly serves to make sure that all relevant topics are covered during the talk.

A semi-structured interview allows for a relatively natural exchange and is not meant as a static question-and-answer interrogation. This is important because the richest information about informants' experiences is usually not provided in direct answers to the interviewer's questions, but rather in casual explanations and aspects that come up on the side (Gagnon, 2010).

An interview outline was developed to guide the interviews. It covered questions about specific case studies, the governance arrangements used, and existing barriers and success factors for NBS (see Annex

Annex A: Interview guides). The interview guide was adapted for each interview to tailor it to the specific project, interviewee, and points of interest.

All interviews were carried out via video-meetings in Zoom or MicrosoftTeams due to contact and travel restrictions caused by the COVID-19 pandemic. The online meetings allowed the easy recording of the interview audios, and a relatively personal interaction. Some interviews were preceded by phone calls. In the beginning of each interview, the researcher presented her professional background, introduced the topic of the thesis, explained the purpose of the interviews, and asked for consent to use the results. She also explained the key concepts such as NBS and governance because not all respondents were expected to be familiar with these terms.

All interviews were conducted in German. This allowed the respondents to express their experiences freely and without a language barrier. Gathering the data in German did, however, require considerable changes in the wording of questions and concepts. For example, the English term NBS is barely used in German practice, and neither is the German equivalent "naturbasierte Lösungen". The researcher therefore often paraphrased this concept. The terms of governance arrangements and flood resilience also had to be explained and paraphrased.

All interview recordings were transcribed to make the content easily assessable as a written text. During the non-verbatim transcription, the oral speech was polished to create a readable text

closer to written language. As the further analysis of this study focused on the content of the interviews, not linguistic details such as grammatical errors or pauses, this approach was most suitable. Special attention was paid to maintaining the meaning of the sentences after any modifications of the grammar. All transcripts include time stamps for each paragraph, which allows to go back to the original audio recording at any time. To facilitate further analysis, names and locations in the transcripts were not anonymized.

Document analysis

The researcher examined a variety of documents about the case studies, such as official planning proposals and permits, event documentations, academic publications, blog articles and press releases. 11 documents were studied in detail as they met the following criteria:

- The document gives insight into the physical characteristics of the project and its context (such as project descriptions, proposals, maps), and / or
- The document includes information about the planning process and stakeholder's responsibilities (such as project permits, strategies documents).

The documents were either publicly available on the internet, or kindly provided by the interview partners. Table 5 presents an overview of the documents that were analysed, while Annex B contains more detailed descriptions.

Case study	Document name and reference
Emscher-Auen	Project permit (Bezirksregierung Arnsberg, 2007)
	Ecological concept of the Emscher river restoration (Semrau et al., 2009)
Emscher-Land	Project application (Jung & Krath, 2018)
	Project description (EGLV, 2018)
Katernberger Bach	Integrated neighborhood development concept, 2020 update (Stadt Essen, 2020)
	Project posters for public participation (EGLV, 2020)
Zukunftsinitiative	Letter of intent 2014 (EGLV et al., 2014)
	Documentation: Expert forum 2018 (EGLV, 2019)
	Project plan 2020+ (Zukunftsinitiative, 2019b)
	Documentation: Forum agile administration 2019 (Zukunftsinitiative, 2019a)
	Goals and fields of action (Zukunftsinitiative, 2019c)

Table 5: Documents selected for analysis

3.4 Data analysis and interpretation

The collected data was arranged in the database. To analyse this heap of data, Gagnon (2010) recommends going back and forth between three activities: purging the data, coding it, and analyzing it.

Purging the data

As described before, the interviews were transcribed and cleaned up into readable texts. This step was crucial to bring the conversations into a format that can be analyzed. When cleaning up the data, sections not relevant for further analysis were removed (Gagnon, 2010). For example, the interviews ended with organizational agreements and farewells that were considered obsolete for the next steps.

Inductive and deductive coding in MaxQDA

In the next step, the data was coded in the software MaxQDA 2020. Coding is a widely used technique for qualitative data analysis (Gagnon, 2010). It means that a code is assigned to a selected part of the data, such as a part of a transcript (Kuckartz, 2016). Codes function as labels to issues, topics, or concepts in the data (Hennink et al., 2020). They summarize text segments in one or a few words and helps to describe, explain, systemize, and organize the data.

Before working through the interviews, the researcher developed a set of theory-based, deductive codes (Kuckartz, 2016). This set of codes was developed in English based on the existing body of literature about the topics of interest. For example, the codes refer to the barriers for scaling up NBS and ways how stakeholders allocate responsibilities and deal with controversies. While coding the interviews and documents, the researcher developed complementary data-driven, inductive codes (Kuckartz, 2016). These labels captured other relevant issues that came up, for example about the local context and peculiarities of the German legal framework. To concisely capture the issues, some codes were created in German. An overview of the coding scheme can be found in Annex C.

Data analysis

For analyzing the data, the researcher needs to get immersed in the data and search for emerging patterns. This means looking whether evidence from various sources converges towards similar conclusions (Yin, 2014). During the data collection process, the researcher already began to note patterns and possible explanations. This formed the basis for a detailed within-case analysis guided by the research interest. In addition, the different cases were compared. This was done by selecting categories relevant for the research questions and then looking at differences and similarities between the cases (Gagnon, 2010). Annex D presents the resulting table that summarizes and compares the findings from the four NBS case studies.

Guided by the research interest on suitable governance arrangements for water-related NBS, the comparing table includes information on

- Involved stakeholders,
- Dominant governance modes,
- The project's contribution to flood resilience,

- Governance arrangements for designing and planning NBS, and for implementing and managing NBS,
- Ways to organize connectivity, allocate responsibilities, and deal with controversies,
- Encountered barriers and success factors.

Data interpretation

For interpreting the data about the case studies, researchers need to use their intuitive understanding, creativity and imagination (Gagnon, 2010). This includes looking at the evidence from a more abstract perspective and interpreting underlying meanings of the patterns previously identified (Yin, 2014). Gagnon (2010) recommends carrying out three interconnected activities for interpreting the data: generating proposed ideas, checking them against the data, and comparing them with existing literature.

The first activity, generating ideas, is about finding plausible explanations for the observed phenomena. At this stage, the researcher turned to the theoretical background for inspiration and can employ creativity and intuition. The resulting proposed explanations were then checked against the data. For example, explanations are checked against all cases, and cross-case differences are analyzed. Ideas that do not fit the evidence had to be rejected. Lastly, the researcher compared the explanations with the existing literature. This step aims to contribute to theory by identifying and analyzing differences between existing theory and the proposed explanations.

4. Research findings: Nature-based solutions in the Ruhr area

This chapter presents the findings from the interviews and document analysis and answers the three sub research questions:

1. What is flood resilience in the Ruhr area, and how can different nature-based solutions contribute to this resilience?
2. How do stakeholders organize connectivity, allocate responsibilities and deal with controversies in their current governance arrangements for NBS?
3. What are the governance-related barriers and success factors for the uptake of nature-based solutions in the Ruhr area?

Based on these results, the main research question about suitable governance arrangements for NBS will be addressed in chapter 6.

4.1 Flood resilience and NBS in the Ruhr area

As described in chapter 2.1, flood resilience comprises three elements: robustness, adaptability, and transformability (Restemeyer et al., 2015). As explained in the following, all three components are represented in the case studies, but their form in the Ruhr area differs slightly from theory. Flood resilience efforts, including NBS projects, strongly focus on avoiding and resisting floods. At the same time, the transformation of the region is characterized by the Ruhr area's post-industrial transformation. Adaptability efforts take a broader perspective than just making the region less vulnerable to floods and instead aim to increase climate resilience.

Building robust flood protection

In the Ruhr area, flood resilience is closely related to improved protection from the Emscher river and flash floods. In July 2021, devastating floods in western Germany highlighted the need to not only maintain existing protections, but to adapt to flood risks that increase exponentially. The highly urbanized surroundings of the Emscher river contribute to very high peak discharge volumes during intensive rainfall. Retaining these water masses is key for downstream flood safety.

NBS like the Emscher-Auen give the river room to spread out and allow to regulate and slow down the river flow. At the same time, ecological hotspots like the Emscher Auen accompany the river like a string of pearls and provide large open space for nature and recreation.

Adapting to floods and other climate impacts

According to Restemeyer et al. (2015), adaptability is about adjustments that make cities less vulnerable to floods, such as water-proofing buildings to avoid flood damages. In the case studies, this dimension of flood resilience was absent. However, private properties and the preparation of the built environment against flood risks were not the focus of this research. It is therefore possible that this dimension if flood resilience was not found because of a different focus of the research design.

In the Ruhr area, adaptability takes a slightly different form: When discussing flood resilience and water management, the stakeholders emphasised broader goals of making the region climate resilient. Planners and policy-makers aim to leverage investments in stream restoration and water management for wider societal goals: creating a livable, biodiverse region that can deal with a changing climate and offers opportunities to all. The efforts for climate and flood resilience therefore include a social dimension of raising awareness for climate adaptation, creating synergies for urban renewal, and empowering communities to shape their environment. The Katernberger Bach is an example how a NBS can not only provide ecological benefits, but also spark change in a deprived neighborhood.

Transforming back into a more natural water system

Walker et al. (2014) understand transformability as the transition to a new system "when ecological, economic, or social structures make the existing system untenable" (p. 3), while Restemeyer et al. (2015) interpret it as a city's ability to live with the water instead of fighting it. In the Ruhr area, recent floods showcased that the current flood protection system is not up to the challenges of climate change. Considering additional concerns for biodiversity and the need for urban renewal, the current system of water management can indeed be considered as untenable.

Planners and policy-makers already acknowledged the need for change and embarked on a transition from banning the water underground in grey infrastructure to managing it in a system with more natural features. The challenge in the Ruhr area is about transforming a completely man-made system back into natural or hybrid ecosystems where possible. Up to date, many streams run in underground sewage canals or in straight concrete beds. Rainwater is often mixed with wastewater, which creates pressure on treatment plants while natural water cycles are deprived of readily available fresh water.

NBS help to create a continuous network of water bodies that take up water and provide valuable wildlife habitats. In the next years, more streams like the Katernberger Bach will be freed from their concrete beds and underground channels to lead the region's transformation. Green roofs, rain gardens, swales and other NBS also form part of the emerging, more natural system of dealing with water. However, the interviewees underlined that this transformation is restricted by local mining damages, pollution, and the highly urbanized landscape. For example, mining damages lead to unpredictable underground water flows and can inhibit installing NBS that increase water infiltration.

4.2 Governance modes used in the case studies

This chapter provides an overview of how the four case studies are governed. It gives insights into the roles of governmental, community, and market actors in the projects based on the theoretical framework of governance modes for NBS. This consideration prepares a more detailed analysis of the governance arrangements that follows in Chapter 4.3.

Chapter 2.3 introduced several governance modes. Egusquiza et a. (2019) formed five clusters of governance modes in relation to NBS: Traditional public administration, new public management, private-private partnerships, societal resilience, and network governance. These clusters are characterized by different leading actors, the levels of participation of non-government actors, and the degree of poly- or monocentric governance. To gain a first understanding of the governance of the fours case studies of this thesis, they are matched with these clusters (see Figure 16).

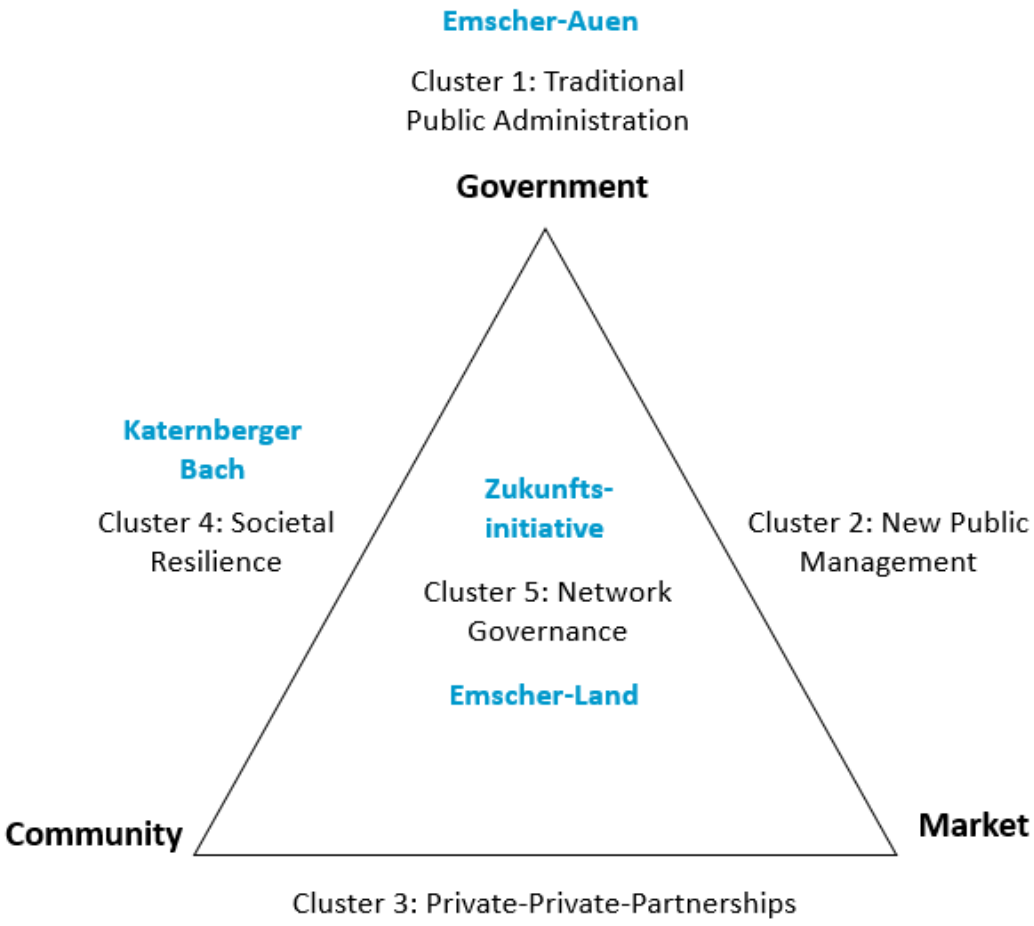

Figure 16: The case studies and their governance modes

Emscher-Auen

The Emscher-Auen, a biodiverse flood retention basin, fits clearly within the cluster of Traditional Public Administration. Public authorities are undoubtedly the leading actors: The project is executed by the regional water board EGLV, and local and regional authorities are responsible for permits and oversight. Non-governmental nature conservation associations are also involved.

Crucially, the Emscher-Auen were planned and approved in a highly formal administrative procedure, called Planfeststellungsverfahren (PfV). In such a PfV, all relevant public and private parties are invited to comment on the plan, and their interest are carefully weighed. The procedure includes an environmental impact assessment and mandatory public participation. In the end, the responsible authority granted permission for the project, including several subsidiary permits and compensations.

Katernberger Bach

The Katernberger Bach, a stream restoration project, fits within the cluster Societal Resilience. Redesigning the stream and the surrounding green corridor forms the backbone of urban renewal and community development in the socially deprived neighborhood of Essen-Katernberg. The project is characterized by a close collaboration of public and private parties, such as EGLV, the city of Essen, religious groups, schools, and local associations.

While EGLV is responsible for the technical aspects of restoring the stream, community actors are key for planning and using the surrounding green area. In the many workshops and participation events, local people and civil society organizations brought forward their ideas. Most of these were integrated into the project, such as a playground, a bee-garden, an outdoor gym, and a place to explore the stream. These elements are funded through a cooperation between city, EGLV and the state government, called "Gemeinsam für das Neue Emschertal", as well as through funds for urban renewal. When the Katernberger Bach is completed in autumn 2021, community actors will voluntarily support its maintenance, and offer activities such as bee-keeping workshops or outdoor sports.

Emscher-Land

The landscape park in Castrop-Rauxel, the Emscher-Land, is harder to match with the governance clusters. It fits best into the cluster Network Governance, as there are community and market parties involved apart from the public authorities. The park is designed as a space for nature and recreation but also for economic use. Different sections will be made available to entrepreneurs and initiatives, such as meadows for cattle and sheep farming, gardens for horticulture, and an orchard.

However, these community-based elements are yet to develop in practice. Currently, Emscher-Land is clearly led and implemented by public authorities. Emscher-Land will be part of the International Gardening Exhibition (IGA) in the Ruhr area in 2027, which involves a variety of public and private stakeholders

Zukunftsinitiative

The Zukunftsinitiative Water in the City of Tomorrow (ZI), a regional governance initiative, fits well within the cluster of Network Governance. The ZI includes two branches: One is about making the Ruhr area more climate resilient (ZI KRIS), the other focuses on community engagement around the Emscher restoration (Gemeinsam für das Neue Emschertal).

The cooperation and activities of the Zukunftsinitiative fit Egusquiza et al. (2019)'s description of collaborative governance. The ZI brings together a large group of governmental and non-governmental stakeholders, such as EGLV, municipalities, and housing corporations, and private property owners. It was initiated by the public stakeholders to improve cooperation, knowledge

transfer and project implementation related to urban water management. The core stakeholders meet regularly to discuss goals and tasks based on their responsibilities. Their work is supported by the newly created ZI Service Facility of EGLV.

Conclusion about governance modes in the case studies

In all four case studies, government actors take a key role as project initiators and formal authority. Many different public authorities are involved in each project, covering different levels and sectors of government. These public authorities are the main project funders.

The cases all contain technical water-management elements that are mainly in the hands of public stakeholders. On top of that, some of the project comprise more community-oriented elements involving non-governmental stakeholders. None of the cases fit with the clusters of Private-Private-Partnerships and New Public Management. This is because public bodies are engaged in all cases, and there is very little market involvement.

4.3 Governance arrangements: Connectivity, responsibilities, controversies

The following section presents the current governance arrangements in the NBS case studies by analyzing how the stakeholders organize connectivity, allocate responsibilities, and deal with controversies. The section thus aims to answer sub-question two. Table 6 provides an overview of the main findings from the four case studies. A more detailed version of this table can be found in Annex D.

Case	Connectivity	Responsibility	Controversies
Emscher-Auen	Designated coordinators, clear roles, internal collaboration, Emscher masterplan	Formally defined based on "Planfeststellungs-beschluss" and sectoral tasks	Collaboration through designated coordinators, compromises between NBS functions
Katernberger Bach	Coordination of wishes and implementation, respect and fair play, dual leadership team, existing networks, face-to-face interaction	Pass responsibilities to those who can handle it, established roles of project partners, clear agreements with private parties	Persistence, creative solutions, accountability by asking experts to justify their decisions
Emscher-Land	Established networks, negotiation of incentives, designated coordinators, common vision	Formal agreements for privately managed areas, negotiating of costs and responsibilities	Creativity and flexibility, formal agreements, compromises to reconcile uses
Zukunfts-initiative	ZI services facility, early collaboration in phase zero, network building, governance transformation, high-level commitments	Municipalities responsible for local action, flexible responsibilities based on interests and capacities, separation between public and private tasks	Dialogue with policy-makers, communication strategy, clear goals and high-level commitments, strong legal basis

Table 6: Summary of government arrangements in the case studies

How do they organize connectivity?

Project management

In all case studies, project management is designed to facilitate collaboration between key stakeholders. For example, the project managers of EGLV and the city steer the Katernberger Bach project as a dual leadership team to make sure their activities are well aligned. The case studies all show designated coordinators and clear roles, which seem to facilitate both internal and external work. For example, the project managers function as the points of contact for communication, to gather and coordinate wishes from the local community, and to guide the diverse subprojects, stakeholders, and departments.

In some cases, these coordinating roles were recently created to facilitate much needed cooperation. For example, to ease the exchange with nature conservation associations, EGLV is funding a 50% position at NABU, one of the major associations in this field. This person is responsible for collecting wishes and doubts from all nature conservation associations, and for working closely together with EGLV. Within the ZI, EGLV created a new service facility to assist municipalities with water-related projects. The ZI emphasises the importance of collaborative, cross-sectoral planning in the early, conceptual phase of NBS, and assists municipalities with implementing this practice.

Networks and partnerships

Strong internal and external networks play an important role in organizing the collaboration of stakeholders in the case studies. Inside the public sector, it helps the project staff to have access to expertise and direct connections to relevant authorities. For example, Dortmund's environmental authority hosts multiple specialist authorities, such as the municipal water, landscape, and soil protection authorities. This bundling under one roof facilitates coordinated action of these sectoral authorities. On an inter-communal level, the governance initiative ZI specifically fosters network building of public servants from different municipalities.

The Katernberger Bach project builds on strong, well-established networks in the local community. For years, diverse public and private stakeholders have already been working together on neighborhood renewal and the established institutions such as the local steering committee now prove to be very valuable.

Guiding rules and visions

Across the case studies, stakeholder cooperation is guided by a common vision or goal: The Emscher-Auen form part of the regional masterplan for the Emscher river restoration, the Katernberger Bach forms synergies with the integrated neighborhood development concept, and the members of the ZI have committed to diverse ecological and governance-related goals.

However, the Emscher-Land project illustrates how highly ambitious goals can be challenging. Its project proposal presents ambitious goals of using the project for apprenticeships, empowerment and to have the project maintained by the local community. The current project managers are struggling to realize these ambitious plans, which are a requirement for project funding.

In complex projects with diverse uncertainties, fair and mutually agreed "rules of the game" seem to be important for organizing connectivity. Despite high ambitions for participative projects, also expert judgements and personal concerns of colleagues need to be taken seriously. For example,

restored streams can only be open to the public when water experts deem it safe. Respecting such judgements needs to form the basis for collaboration within public authorities and with private parties.

Several interviewees stated that public participation should be adapted to a degree that is acceptable for the respective project managers. In case of hesitant colleagues, trying out limited public participation could help to build appreciation for the benefits of involving the local community. Such experimentation can also allow to incrementally increase public participation. For example, governance experts from EGLV described that other departments increasingly involve local artists and school children is designing project's outer walls. While creating a feeling of ownership in the community, such measures seem to reduce vandalism and maintenance needs. The example illustrates the growing openness for community involvement, even though major decisions of project design are still made by the public authorities.

How do they allocate responsibilities?

In the Emscher-Auen and partly in the ZI, responsibilities are formally defined or officially agreed upon. For example, the formal planning decision for the Emscher-Auen lists detailed responsibilities of EGLV, and all Emscher municipalities have committed to strive towards the ZI goals in their activities. When working with private stakeholders in the other case studies, responsibilities for management and maintenance were partly fixed in formal lease agreements.

The project managers of the Katernberger Bach found an effective way to hold other departments accountable and realize citizen's wishes. The leading planning team from EGLV and the city collected ideas from the community, such as a traffic light to cross a busy road and passed them on to the responsible colleagues. When these departments refused implementing the wishes, the responsible experts were asked to explain their reasons to the community in person. This fostered accountability and political pressure and helped to realize several elements in the projects that were first deemed unfeasible.

However, allocating responsibilities and costs is rather challenging in other case studies. Especially in projects with tight maintenance budgets, it was difficult to negotiate a balance between public interests to outsource maintenance, and private needs for cost effectiveness. Allocating liability and maintenance responsibilities for multi-functional spaces also proves to be highly challenging, which can lead to project designs with sole public or private responsibilities. This finding fits the academic recognition that managing the boundaries between governmental and non-governmental stakeholders is a key challenge in collaborative planning (Westerink et al., 2017)..

How do they deal with controversies?

The NBS case studies are located in a densely populated area, aim to fulfil various functions, and involve stakeholders with diverging interest. To be successful, the project managers need to deal with the resulting controversies about the project plans and their implementation.

Little surprisingly, finding compromises between water management, ecology and recreation is a key approach for doing so. Compromises in the case studies include visitor guidance to minimize disturbance for wildlife and adapting water management structures to include natural habitats. In the Emscher-Auen, having a designated coordinator between EGLV and nature conservation associations helps to find compromises between required water management functions and biodiversity.

At the same time, being persistent and creating necessary pressure also helped to deal with controversies in the case studies. The Katernberger Bach highlights the need to develop creative, out-of-the-box solutions to realize NBS with diverse benefits. Due to safety and maintenance regulations, several project elements desired by the local community were challenging to implement. Yet, the project team managed to realize several areas for play and recreation through creative design solutions.

Asking experts to directly justify their positions to the local community was another instrument that helped to overcome internal controversies. Other authorities successfully draw on a strong legal basis to enforce water-related improvements. Clear goals and political commitments also seem to help overcoming controversies.

4.4 Barriers and success factors for uptake of NBS in the Ruhr area

This chapter aims to answer the third sub-question about governance-related barriers and success factors for NBS. An overview of the main results for each case study can be found in a comparing table in Annex D.

Governance-related barriers for the uptake of NBS in the Ruhr area

The interviews and document analysis revealed a range of barriers that hinder the NBS case studies, covering the topics of time, uncertainty, complexity, and mindsets. The case studies differ in their governance modes, goals and characteristics, and so do their main barriers: The flood retention basin Emscher-Auen faces challenges related to regulations and mismatching goals of stakeholders. The governance initiative ZI fosters the cooperation of departments and the widespread implementation of NBS. Little surprisingly, the barriers for this project are mostly related to the sectoral structure of administration. The planners of the Emscher-Land landscape park aim for close involvement of private stakeholders in managing the project, and this participation poses a main challenge. Similarly, involving the local community is a core part of the Katernberger Bach project, and realizing this in public authorities with sectoral responsibilities proved to be challenging.

Figure 17 illustrates the barriers identified in the case studies and their relation to the findings from the literature review in Chapter 2.4. The case study analysis confirms several barriers from the theory, such as issues related to institutional fragmentation and regulations. At the same time, the NBS projects highlighted barriers that were less pronounced in the literature, for example related to mismatching goals.

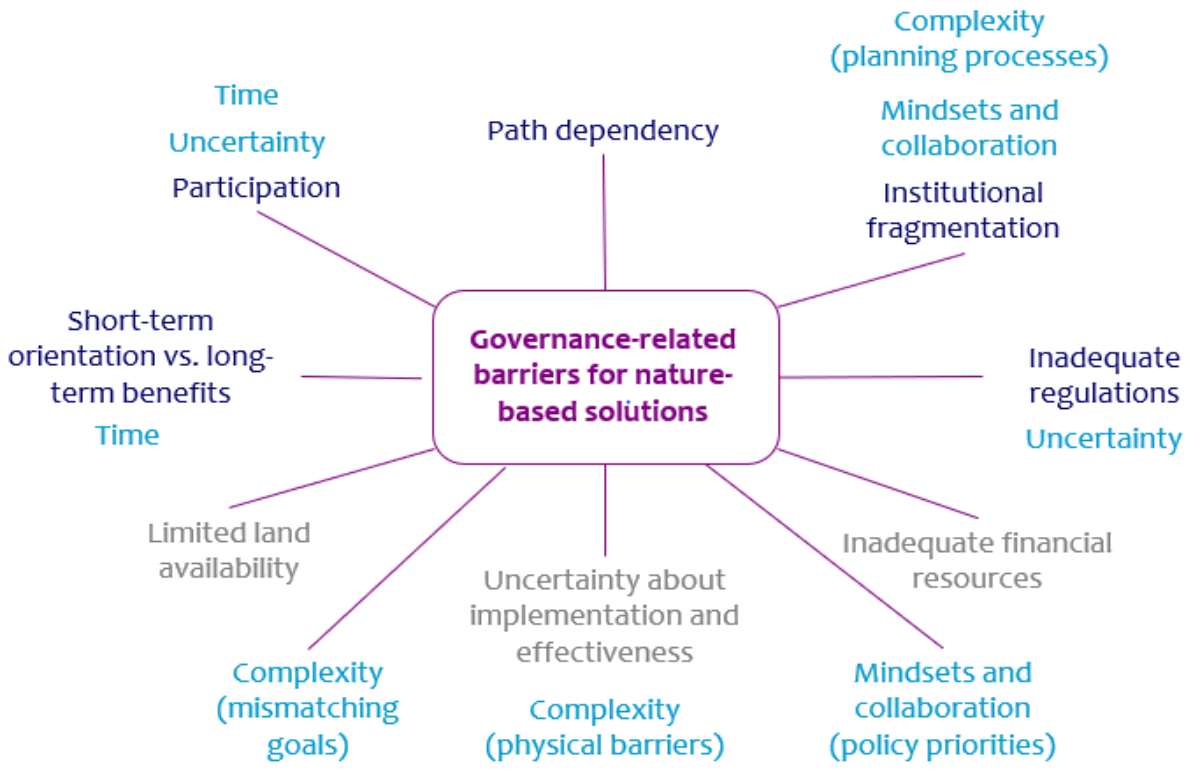

Figure 17: Barriers for NBS from the literature review (dark blue and grey) and the case study research (light blue) (author's own illustration)

Time: Long planning processes, private engagement, mismatch of time horizons

The case studies Emscher-Auen, Katernberger Bach and Emscher-Land face barriers related to time, even though for different reasons. Planning and implementing the case studies took many years, in case of the Emscher-Auen even decades. In the Emscher-Land, previous delays now put the staff under considerable pressure to finalize the project within a tight funding deadline.

The long planning and implementation processes require staff and financial means, which are scarce in public authorities in the Ruhr area. Climate adaptation and extensive public participation are usually no mandatory tasks for the departments, so it can be challenging to organize capacities to realize projects like the Katernberger Bach when public resources are urgently needed for other political priorities.

Time issues also hamper private involvement in governing NBS. On the one hand, private involvement in projects like Emscher-Land can barely be determined years in advance, which causes uncertainty and leads to a risk of unsuitable plans. On the other hand, private stakeholders find it difficult to participate in years of planning when the project's benefits are still far away.

The literature review on barriers for scaling up NBS indicated that the short-term focus of political agendas can be difficult to reconcile with NBS that only unfold their benefits in the longer term (see chapter 2.4). While this barrier was also notable in the Emscher-Land project, the case studies reveal that this is by far not the only time-related barrier.

Uncertainty about regulations, funding, and responsibilities

Most case studies grapple with uncertainties related to regulations, funding, and responsibilities. For instance, there is no regulatory certainty about temporary wildlife habitats in NBS: Over the long years of construction, rare species can settle in NBS projects like the Emscher-Auen, and while this is positive for biodiversity, it poses the risk that the final completion of the projects is stopped to avoid disturbing the wildlife.

Another example is that planners of multi-functional spaces lack clear guidance on questions of liability and design, which poses a challenge in the ZI. Uncertainty about the development and success of private involvement forms another barrier for NBS projects such as the Emscher-Land. Despite careful preparations, planners cannot be sure which private parties will participate, what that cooperation will entail, and whether it will endure.

The literature review pointed to inadequate regulations as one barrier for NBS, and the case studies confirm this barrier and its contribution to uncertainty about NBS. While the literature highlighted uncertainty about the effectiveness of NBS as an important barrier, the case studies seem to be mainly challenged by uncertainty about rules and private involvement

Complexity: Diversity of goals, complex planning processes, and physical constraints

The case studies illustrate the complex planning processes for NBS. Stream modification projects mostly undergo a highly formalized, comprehensive planning procedure (Planfeststellungs-verfahren), requiring year-long assessments and stakeholder consultation. While this procedure is time consuming, is creates legal certainty and clear instructions for projects like the Emscher-Auen. Other projects require a variety of plans and permits, for instance related to land use planning, neighborhood development plans, sectoral permits, and funding proposals, which was a challenge for the Emscher-Land.

The NBS in the Ruhr area are expected to fulfil a variety of goals for different stakeholders. A challenge across the case studies is to balance water management, recreational use, and nature conservation. For example, the Emscher-Land is challenged to reconcile its function as an ecological hotspot with the recreational use through the international gardening exhibition. For each project, stakeholders thus need to negotiate priorities and find viable compromises. While this challenge of mismatching goals was prominent in the case studies, it was rather absent in the NBS literature.

In the Ruhr area, physical barriers add to the governance-related complexity of NBS. Among other things, widespread contamination of soils and mining damages partly impede restoring natural water cycles, and the Emscher and her tributaries only have minimal natural water discharge because of their urbanized surrounding. In the theory, the space requirements of NBS were mentioned as a barrier and part of the complexity of NBS. In the case studies, which are mainly developed on publicly owned land, this aspect was less pronounced.

Sectoral thinking and political priorities

Most interviewees emphasized sectoral thinking and a lack of cross-departmental collaboration as a main barrier for integrated NBS projects. Timely, successful implementation requires contributions of a wide range of public authorities and departments. This was particularly pronounced in the Katernberger Bach, but also in der Emscher-Land and ZI cases. Especially in municipal administrations, strong hierarchies, lethargy and separated sectoral responsibilities are

considered a barrier for integrated NBS. These challenges correspond to a main barrier from the literature review: institutional fragmentation, also referred to as sectoral silos.

The interviewees expressed a need for transformation in public administrations towards more collaborative, agile, flexible ways of working. According to them, some colleagues are afraid to makes mistakes, change existing procedures, or allow open public participation. At the same time, all interviewees stressed that positive change is already happening, including increasing appreciation of public participation, integrated planning, and NBS.

Diverging stakeholder interests and priorities are another barrier to NBS in the Ruhr area. For instance, policy-makers and public parties often prioritize housing developments on scarce spaces in the densely populated region, instead of giving room to multi-functional NBS and climate adaptation. This barrier is most notable in the ZI and was also described in the literature.

Governance-related success factors for the uptake of NBS in the Ruhr area

In addition to the barriers, the case study analysis revealed a variety of factors that facilitate the successful governance of NBS. This includes creativity, a firm legal basis, close collaboration, knowledge transfer, and high-level support. Figure 18 illustrates the success factors identified in the case studies and their relation to the findings from the literature review in Chapter 2.4.

Figure 18: Success factors for NBS from the literature review (dark blue) and the case study research (light blue) (author's own illustration)

The case studies reflect several aspects from previous studies, such as the paramount importance of partnerships and learning. Yet, they also emphasize new elements, such as the facilitating role of high-level support for NBS and a formal German planning procedure.

For the Emscher-Auen project, the formal Planfeststellungsverfahren was a success factor, while the Emscher-Land project highlighted the need for more flexible, adaptive planning. The Katernberger Bach is facilitated by a close collaboration between a variety of stakeholders and their willingness to find creative solutions. The Zukunftsinitiative showcased the value of knowledge exchange partnerships.

Creativity, compromises, courage

A key success factor across the case studies is the stakeholder's willingness to compromise. This is essential to reconcile the multiple goals and requirements for the multifunctional NBS, and was also highlighted in other studies. For example, all stakeholders of the Emscher-Auen collaborated to find a solution for how the plans for the final construction phase of the flood retention basin can balance the needs of water management and local wildlife.

Several interviewees stressed that in the densely populated Ruhr area with its pollution and mining damages, purely nature-based flood resilience projects are barely feasible. Hybrid solutions that combine grey-built infrastructure with nature-based elements can therefore be a viable compromise. This success factor, the combination of approaches, already came up in the literature, and was apparent in the Emscher-Auen, Katernberger Bach and Zukunftsinitiative.

The NBS also show how the courage to try out new ideas and stick to them during long, uncertain planning processes is another success factor. The case study Katernberger Bach highlights how a creative "just-do-it-attitude" can be key to make NBS unfold their full potential for the community. To mention just one example, residents wished for a "beach playground" on the stream's edge. The idea would have failed due to regulations requiring frequent maintenance of the sand. However, the responsible project managers and departments managed to realize the wish by calling it a "mud bank" and using gravel-material that does not fall under the maintenance regulations for playgrounds.

In the theoretical framework, this success factor for NBS was summarized as "experimentation and learning". Frantzeskaki et al. (2019) highlighted the value of experiments, pilot projects and living labs for trying out NBS and practicing stakeholder cooperation. In the Ruhr area, the restoration of the Emscher river system is already firmly embedded in the institutions and does not involve many pilots and experiments. Yet, the NBS case studies fulfil a similar role, allowing stakeholders to learn about NBS while fostering flood resilience on the ground.

Firm legal basis

Most stream modifications need to undergo the formal Planfeststellungsverfahren. While this comprehensive procedure takes time and effort, it also ensures that the interests of all stakeholders are carefully balanced, and that the project can be implemented on a stable legal basis. This proves to be a success factor for projects such as the Emscher-Auen or the restoration of Emscher tributaries, as it fosters certainty, clearly allocates responsibilities, and helps to

prioritize water management and ecological improvements. Other studies on NBS did not point to this success factor. The reasons might be that the Planfeststellungsverfahren is very specific to the German context. Interestingly, this formal procedure was developed for major grey infrastructure projects like roads, but also proves valuable for nature-based alternatives.

Another regulatory success factor for water-related NBS is the strong, superior legal basis of the EU water framework directive and the German federal water cycle law. They require water bodies to have a "good ecological status" and have priority over state and local laws. This provides water authorities with an extraordinarily strong lever to integrate water-related requirements into other projects. For example, building permits can be bound to the resurfacing and ecological improvement of streams traversing the respective area. As described in Chapter 2.4, previous studies already demonstrated that a supportive legal framework such as the EU water framework directive helps to scale up NBS, which can be confirmed from the case studies.

Close, trusting collaboration in partnerships

A close collaboration of relevant stakeholders is another success factor. Interviewees highlighted the importance of trustful, enthusiastic relationships where departments and authorities work towards common goals. The projects are also facilitated by experienced staff with a good understanding of their institutional context. The case studies illustrate the benefits of long-standing collaborations. For example, the Katernberger Bach project draws on established networks and governance structure of an urban renewal program, and public and private actors of the Emscher-Land landscape park know each other from previous projects.

These findings match the key success factor identified in the literature review: Partnership among stakeholders and organizations. As described in the theory, close collaboration allows actors to access important technical expertise, financial resources, and contacts. For example, the cooperation in the Zukunftsinitiative helps the NBS stakeholders by mobilizing funding, a platform for exchange, and technical assistance.

Expertise and knowledge transfer across sectors and localities

Some case studies are managed by teams that span areas of expertise, institutions, and / or localities. This helps to combine the necessary experience for the complex NBS project and to be able to "speak the language" of other stakeholders.

Another success factor for water and climate adaptation projects in the Ruhr area is the ZI. It functions as a central facility for knowledge transfer, networking, and technical support. Crucially, it's working groups and initiatives also offer a "safe space" where motivated public servants can develop and implement new ideas for NBS. As indicated in the literature, the training and knowledge exchange in the ZI helps stakeholders to appreciate the benefits of NBS and to use the approach in their daily practice, despite its complexity.

High-level support and motivated staff

The case studies show that high-level support from policy-makers and managers is a success factor. The interviews and data analysis underline the advantages of political support, positive media coverage, and backing from superiors. High-level support also represents a success factor because financial support through state, federal and EU programs forms a major source of funding for the

NBS projects. However, the mid-level civil servants and stakeholders are at least equally important, as they are the ones responsible for the practical implementation.

This success factor was less clear in the literature. Yet, it is somewhat related to stakeholders' willingness to experiment and learn, as this is an element of the necessary high-level support and on-the-ground motivation that facilitated NBS. There is also a link to the success factor of partnerships, which can generate support from other organizations and access to resources.

5. Discussion of the results

This chapter takes a closer look at key results and discusses their meaning and relation to theory. For one thing, it addresses a tension between different functions of NBS and indicates that balancing diverse interests is an inherent challenge to NBS. It is also discussed that the case studies all show dominant roles of public actors, with limited levels of private involvement. The following section thus points out how this finding is related to the research design and explores how governance arrangements with leading private stakeholders could look like.

The chapter also deals with a lack of cross-sectoral collaboration and explores how adaptation mainstreaming can help to address this main finding from NBS literature and the case studies. In addition, it discusses the need for adaptive planning of NBS and its relations to concepts like adaptive management and adaptive governance. The final section of the chapter considers opportunities and limits to transferring the results to other settings.

5.1 The challenge of balancing water management, biodiversity, and recreation

A common challenge in the case studies is to find compromises between water management, recreational uses, and nature conservation. To overcome mismatching goals and realize projects, the stakeholders need to constantly negotiate priorities and trade-offs. In contrast to its strong impact on the case studies, this aspect is less clear in the literature on the governance of NBS and related barriers. This could be explained by the fact that the studied papers dealt with NBS governance on an abstract, theoretical level, while this challenge is of a more practical nature.

In the studied literature, Nauman et al. (2015) form an exception by explicitly bringing up this tension between uses as a challenge for creating acceptance for NBS. They mention possible conflicts of uses between infrastructure, agriculture and tourism, and nature conservation, thus underpinning the result from the case studies.

The finding is probably transferable to most NBS in urban areas that foster flood resilience: For one thing, competing spatial demands are characteristic to cities, where scarce spaces need to accommodate many uses. Moreover, NBS are by definition multifunctional, as they "simultaneously provide environmental, social and economic benefits" (European Commission, n.d.). Negotiating compromises and balancing diverse interests is thus an inherent challenge to NBS projects.

5.2 Government roles in collaborative planning of NBS

In all studied NBS projects in the Ruhr area, government actors take initiating and leading roles. They govern the projects in styles corresponding to traditional public administration, network governance, and societal resilience (see Chapter 4.2). In non of the examples, societal or corporate actors fulfilled dominant roles, as it would be the case in the governance modes of private-private partnerships and new public management.

In the case studies, nature conservation associations and other civil society organizations, citizens, and public authorities were merely invited to collaborate based on the leading authorities' plans to develop the water-related projects. The leading government actors are taking the main decision-making power, but the societal stakeholders can list wishes, comment on plans, and get involved in project design and management.

Westerink et al. (2017) distinguish two types of collaborative spatial planning: One approach with government actors in the lead and participation of societal stakeholders, and another approach of self-governance of societal actors where government bodies merely take participating, process facilitating roles. In the Ruhr area, collaborative planning of NBS clearly corresponds to the first style with strong public stakeholders. It is also related to Frantzeskaki et al.´s (2019) insight that collaborative planning of NBS might at first require a leading role of public authorities, which could later change into an enabling role.

Considering the selection of cases for this study, these outcomes are not surprising. The case studies were identified through interviews with staff from public authorities as well as internet research. The interviewees were, logically, most familiar with their own projects and could provide rich information and further contacts. Therefore, such publicly managed projects were chosen as case studies, even though this caused a bias towards governance arrangements with leading public authorities.

When searching for suitable case studies in the Ruhr area, neither the contacts nor extensive desktop research could identify recent water-related NBS projects headed by private or societal stakeholders. This can have diverse reasons. For example, the responsibilities for water-management and flood resilience lie with public authorities, public bodies mainly own relevant green spaces around water bodies, and funding for NBS projects often comes from public support programs.

5.3 Stronger private involvement in NBS

The question remains how governance arrangements with strong private roles could look like. Considering that private parties own most properties in urban areas, exploring such efforts appears highly relevant. The case studies showed that the governance arrangements are often shaped by the available funding opportunities. This following section therefore explores financing options for NBS that point to governance arrangements with stronger roles of private actors.

The Natural Infrastructure for Business platform, for example, aims to build the business case for private investments in NBS. Its case studies illustrate situations where private companies initiate and fund NBS projects that are in their own business interests. For instance, the automobile conglomerate Volkswagen supported reforestation and improved water management in Mexico to stabilize the water supply for its factories (van Ham & Klimmek, 2017).

Payments for ecosystem services can be a similar approach for privately led NBS initiatives. In such schemes, a party pays money to a landowner or farmer for managing their land in a way that provides certain ecosystem services, like water filtration or retention (Somarakis et al., 2019; Uzsoki et al., 2021). For example, a company (or city) struggling with floods could pay upstream landowners to implement farming practices and other NBS measures that retain water and reduce flood risks.

Within cities, the real estate sector could be a catalyzer for climate resilience by combining new developments with NBS that support the water cycle, such as green roofs and rain gardens (Legrand, 2021). While the sector could benefit from increased real estate values through these measures, such engagement can be further supported by tax incentives and regulations from public authorities (Somarakis et al., 2019).

However, scholars like the authors of the State of Finance for Nature report (United Nations Environment Programme, 2021) underline that knowledge transfer and financial incentives from government agencies will often be necessary for scaling up NBS on private properties. This implies that even in projects led by private parties, the governance arrangements will include the participation of public entities.

5.4 Cross-sectoral collaboration

Fragmented responsibilities and sectoral thinking represent a major challenge for NBS. In case studies such as the Emscher-Land or the local projects of the Zukunftsinitiative, it takes considerable effort from the project managers to organize the collaboration between the relevant stakeholders. The research confirms that institutional fragmentation is indeed a main barrier for multifunctional NBS. A recent study on climate resilience in the Ruhr area highlighted that overcoming sectoral responsibilities forms a major challenge in developing the regional network of green infrastructure (Nickelsen et al., 2020).

To deal with this challenge, scholars bring forward the concept of adaptation mainstreaming (Bauer et al., 2012; Wamsler et al., 2017, 2020). Adaptation mainstreaming means considering climate risks in all sectoral policy-making and practice. Wamsler et al. (2017) underline that to implement urban NBS, climate issues should be considered in all policy areas. While NBS need to be mainstreamed at the local, operational level, it is also important to institutionalize climate adaptation so it becomes a standard procedure.

In the Ruhr area, cities like Dortmund already embarked on this journey by creating working groups and developing a new climate adaptation strategy. Yet, the current levels of institutional fragmentation show that there is still a long way to go until NBS and climate adaptation are commonly considered across all departments and authorities. Wamsler et al. (2017) also recommend to design NBS that address multiple hazards and purposes, like floods, heat islands, and recreation. The case studies in the Ruhr area already fulfil multiple functions and indicate that this is indeed a useful approach.

5.5 Adaptive planning

The case studies show that planning and implementing NBS can take many years and that the suitable governance arrangements need to be both durable and flexible. Over time, regulations and funding conditions can change, stakeholders might join or disappear, and political priorities can shift. This leads to considerable uncertainty that obstructs NBS. To develop NBS despite this uncertainty, stakeholders need to be open for experimentation and learning: Both theory and case studies underline how important it is that the actors are willing to try out new solutions, learn about NBS, and learn how to be collaborate with others (Egusquiza et al., 2019; Ershad Sarabi et al., 2019; Frantzeskaki, 2019; Kabisch et al., 2017; Naumann et al., 2015).

Scholars bring forward concepts such as adaptive management and adaptive governance to cope with uncertainty. There is a confusing mass of definitions for these approaches. In essence, adaptive governance seems to focus on the need for flexibility to deal with complexity and uncertainty, while adaptive management focuses on learning-by-doing (Armitage et al., 2010; Hasselman, 2017; Somarakis et al., 2019). The case studies in the Ruhr area already embraced this need for flexibility and learning, yet it might be worthwhile to further explore how the described governance concepts can guide governance arrangements for NBS.

5.6 Transferability of results

NBS is an umbrella term for many concepts like ecosystem-based adaptation, green / blue infrastructure, and building with nature (see chapter 2.2. on NBS). Insights from this study could therefore also inform projects developed under such related concepts.

The four case studies from the Ruhr area create new ecosystems or manage ecosystems in intensive ways. As explained in chapter 2.2. on NBS, this means that they represent type 3 NBS within the typology developed by Eggertmont et al. (2015). Such projects include a high level of engineering and are designed to deliver selected ecosystem services to a small stakeholder group. Type 3 NBS are often influenced by existing regulations for new developments and infrastructure, such as building laws about how to manage rainwater or remodel a stream. For NBS type 1 and 2, which are about protecting and better using natural and managed ecosystems, the legal framework might differ. For example, upstream agricultural land management to reduce downstream flood risks might depend on regulations for agriculture and nature conservation. This implies that not all findings for NBS type 3 can be generalized to all NBS projects, even though some insights might be valuable for all types.

The results from studying the case studies are in several ways specific to the German and regional context, which limits their transferability. For one thing, the available funding schemes strongly influence the governance arrangements in the case studies. The stakeholders often work together to mobilize funding from diverse local departments as well as regional, national and international funding programs. As Germany is a federal state with strong local self-government, such funding opportunities differ greatly across the country. In other urban regions than the Ruhr area, distinct funding schemes and better equipped public budgets might therefore lead to different governance arrangements.

Furthermore, the governance arrangements in the case studies are based on German laws and practices for planning processes. For example, rules on public participation often shaped which stakeholders were involved in which stage of the planning process and how much importance was attached to their views. In case of the Emscher-Auen, the planners had to conduct Planfeststellungsverfahren, which is specific to the German planning system and only applies to major infrastructure projects. The findings can therefore only be transferred to NBS in other countries in a limited way, as the planning systems and laws might differ.

However, the German water balance law that proved important for scaling up NBS is based on the EU water framework directive. The EU countries implemented the directive into their laws, which means that its main principles, demanding the protection and ecological development of water bodies, are valid across national boundaries. This implies that a strong legal basis for water-related NBS is also given outside of Germany and that governance arrangements across Europe can harness this potential.

6. Conclusion: Governance arrangements for scaling up NBS

In recent years, German communities faced catastrophic floods, droughts, and heat waves. While the Ruhr area was spared from the summer floods that devastated nearby regions in July 2021, this event illustrated the urgency of adapting to climate change. Planners, policy-makers and citizens increasingly acknowledge that the Ruhr area needs to become more flood resilient. NBS can contribute to this resilience in various ways while bringing additional societal and environmental benefits. However, harnessing the potential of nature for flood resilience requires the collaboration of diverse stakeholders.

This study aims to identify suitable governance arrangements for scaling up NBS in urban areas by analysing four case studies in the Ruhr area. It investigated how stakeholders work together, allocate responsibilities, and deal with arising controversies. The research also examined how NBS can contribute to flood resilience in the Ruhr area, and which factors are supporting and hindering such projects. After the previous chapters presented the findings for these different aspects, this concluding chapter brings together the strands of research to answer the main research question.

6.1 Suitable governance arrangements for scaling up nature-based solutions in urban areas

Here we come back to the main research question: What governance arrangements can facilitate the upscaling of nature-based solutions for increased flood resilience of urban areas? Governance arrangements are defined as "the ensemble of rules, processes, and instruments that structure the interactions between public and/or private entities to realize collective goals for a specific domain or issue" (Termeer et al., 2011, p. 161). This conclusion will answer the research question by reflecting upon the different elements of this definition: the collective goals, the interactions between public and private stakeholders, as well as the key rules, processes, and instruments that shape the interactions. Figure 19 presents an overview of the key conclusions.

As shown in Figure 19, common goals are an important element of governance arrangements. In the definition by Termeer et al. (2011), the collective goals merely function as the end goal of governance arrangements, as the purpose for stakeholder interaction. Yet, this study indicates that common goals can also structure the interactions and form an instrument for successful collaboration.

As seen in the Ruhr area, the goals of becoming more climate resilient and transforming into a green metropolis provide high-level guidance for many stakeholders. They help policy-makers, authorities and communities to work together across municipal and sectoral borders and represent one instrument of organizing collectivity. While the Ruhr area draws on the regional masterplan for restoring the Emscher river, green infrastructure plans, and commitments to the climate resilience targets of the Zukunftsinitiative, a diversity of plans like climate adaptation strategies or green infrastructure masterplans could have a similar guiding effect elsewhere.

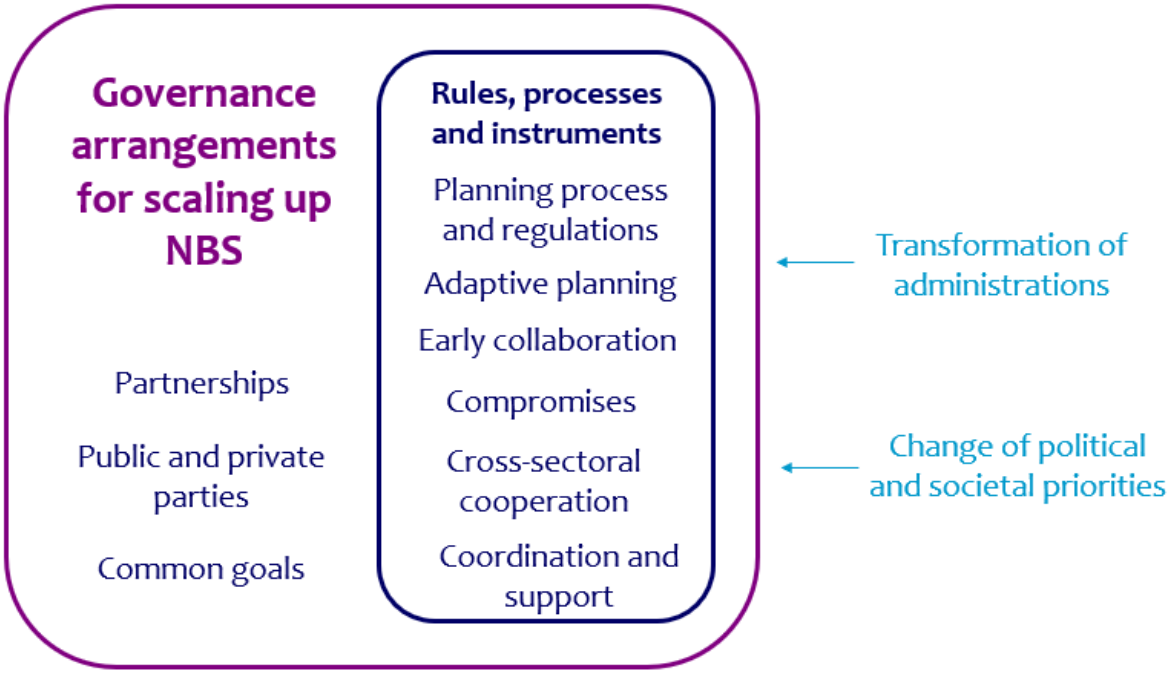

Figure 19: Characteristics of suitable governance arrangements for NBS, and supporting factors (author's own illustration)

The interactions between public and/or private entities represent another element of governance arrangements. Confirming a core finding from the literature review, the case study research underlines the crucial role of partnerships between NBS stakeholders. Joint efforts to develop NBS bring at least three advantages: 1) it creates safe spaces where motivated individuals are empowered to develop innovative projects, 2) it helps to mobilize funds, and 3) it provides interdisciplinary expertise.

Crucially for scaling up NBS, joint efforts from multiple authorities and municipalities help finance projects which could otherwise not be realized. In the Ruhr area, joint funding proposals of all Emscher municipalities create the political weight that helps to win project grants. The collaboration of different public entities, such as EGLV and the municipal departments, allows to crowd in funding from diverse source that one party alone could not mobilize.

As illustrated in Figure 19, this study identified a variety of rules, processes and instruments that influence how stakeholders interact to reach their common goals. For example, early cooperation with climate adaptation experts is key to integrate NBS into other planning projects. The research also highlights the supporting role of regulations related to the European Water Framework Directive and emphasizes the need for cooperation across sectors and institutions, for instance through adaptation mainstreaming. The whole set of rules, processes and instruments that form part of suitable governance arrangements for NBS is presented below.

In addition to these conclusions, the study points to two contextual factors that can create an enabling environment for governing NBS: a transformation of administrations, and a change of political and societal priorities. These supporting factors are explained at the end of this chapter.

Rules, processes, and instruments

Early collaboration in conceptual planning phases

Early and ongoing collaboration between stakeholders forms an important element of suitable governance arrangements for NBS. Collaboration in partnerships helps to formulate common goals and strategies, and it is important for project development: NBS such as restored streams have specific spatial demands, for instance related to suitable locations and space requirements. The interviewed experts underlined that these physical requirements need to be incorporated into urban development plans as the plans' backbone.

As an illustration: a housing plan can be arranged around a restored stream that follows the natural terrain but integrating such a water body into an existing plan without consideration of the terrain is nearly impossible. It is therefore important that authorities and departments responsible for water management and climate adaptation already have a say in early conceptual phases of planning projects.

Coordination and support

Applying for the multitude of funding opportunities and developing complex NBS projects can easily exceed the capabilities of a single department or municipality. A conclusion of this research is therefore that it can be beneficial to establish a more centralized entity that provides technical support and shares knowledge. The literature review already pointed to the importance of coordinating the efforts of different actors, and the case studies showed the great value of having designated coordinators and a central support facility. For example, the Zukunftsinitiative serves as the central point of contact for questions about climate resilience and water management, handles funding applications for municipalities, and strives to empower other NBS stakeholders.

Formal planning processes and strong legal foundations

The EU water framework directive and the respective German water balance law require water bodies to be in good ecological status and forbid degradation. For many water-related projects, public authorities thus have an extraordinarily strong legal basis to impose measures that protect and positively develop water resources. For example, they can oblige real estate developers to restore formerly piped streams on their properties if they want to build new houses.

The case studies revealed that this legal basis is an important success factor and strong lever to implement measures that contribute to flood resilience. To fully take advantage of this legal basis in diverse urban development projects, it seems important that skilled staff and authorities are already involved early in the planning process.

The literature review pointed out that regulations both hinder and support the uptake of NBS. While the case studies mainly point to the supportive function of regulations like the European Water Framework Directive, they also confirm that regulations such as inflexible biodiversity regulations can restrict NBS.

Cooperation across sectors and institutions

The case studies showed that fragmented responsibilities and sectoral thinking in public administrations often hinder multifunctional NBS. This confirms the challenge of institutional fragmentation, a key barrier identified in the academic literature.

Governance arrangements for multi-functional NBS need to embrace planning processes and instruments that bring together stakeholders from different institutions, sectors, fields of expertise, and places. The case studies show some examples, such as the regional collaboration in the Zukunftsinitiative, designated coordinators in institutions, and project teams that unite sectoral expertise and competences. Drawing on the academic debate, concepts such as policy integration and adaptation mainstreaming can be useful to create governance arrangements that overcome the institutional fragmentation.

To implement NBS that span the areas of responsibilities of diverse stakeholders, the governance arrangements also need mechanisms to hold relevant parties accountable, even when they are not part of the core project team. One communication tool found in the case studies appears particularly useful to create such accountability: Project managers can ask the officials to directly explain their reasons to the local community. This principles of "letting those defend a decision who made it" has two advantages. First, having such transparent, first-hand explanations can help other stakeholders understand why certain elements might not be feasible. Second, it creates political pressure to overcome barriers and to find solutions.

Adaptive planning

Planning and implementing NBS can take many years due to public participation, complex construction works, and challenging political and funding frameworks. The projects therefore require durable governance arrangements with committed stakeholders who persistently guide the project.

At the same time, the project managers need flexibility and some creativity to deal to changing circumstances. Over the years, regulations might change, project partners join or disappear, and political priorities can shift. The governance arrangements need to be able to cope with this uncertainty and adapt as necessary. In conclusion, this underlines the value of adaptive governance and adaptative management for NBS.

Both the literature review and the case study analysis highlight that learning and experimentation are crucial for scaling up NBS. It eases the projects when stakeholders are willing to try out new solutions and open to learn about the NBS and how to collaborate with others.

Negotiating compromises between different functions and demands

To scale up NBS, the planning processes and project teams need to find a balance between diverse demands. This study finds that negotiating compromises with different stakeholders is a core task and an important element of suitable governance arrangements.

In the Ruhr area and likely in other urban areas, three groups of functions are competing for space and priority: 1) Water management and flood resilience, 2) ecology and biodiversity, and 3) recreational and economic uses.

When planning NBS for improved water management, the necessary technical and legal requirements need to be safeguarded. For instance, the project might have to handle a certain volume of water or fulfil safety requirements. But wherever possible, planning multifunctional NBS requires flexibility to also accommodate other environmental and societal needs and maximize the delivery of various ecosystem services.

Community participation and co-management

In the publicly led case studies, community participation functions as a tool to mobilize the diverse benefits of NBS, for example for biodiversity, education, livability, and social cohesion. The case studies indicated that the future users need to be involved early in the project planning to realize these benefits. This fosters a feeling of ownership and helps to create projects that meet the needs of the local community. In addition, involving the local community can build up political support and pressure that helps to overcome potential barriers.

Meaningful engagement of interested stakeholders such as nature conservationists, beekeepers, farmers, and civil society organizations also helps to integrate local and specialist knowledge. Incorporating the demands of private actors into the project design is particularly important if they shall use and maintain the NBS later on.

In relation to the last point, another conclusion from the research is that governance arrangements for flood-resilience projects need to recognize the limits to private maintenance. If commercial parties are to take responsibility for maintenance, they need arrangements that are economically viable and not a losing game. This might require financial support from public sources for activities like extensive agriculture. The case studies indicate that early collaboration between public planners and potential private users is key to develop co-managed NBS. To function properly, watersides, meadows, playgrounds, bee gardens etcetera need to be designed based on their user's knowledge and needs.

Supporting factors for governing NBS

Besides these elements of suitable governance arrangements, two contextual factors can be important for scaling up NBS: A transformation of public administrations, and a change of political and societal priorities.

Transformation of administrations

Implementing NBS in traditional public administrations with strong sectoral divisions, hierarchies and rigid procedures proves challenging. Integrated NBS that increase flood resilience while providing opportunities for nature and recreations seem to be easier to realize in more collaborative, flexible settings. This was clear in the Ruhr area, where the interview partners highlighted the need for change within their public authorities. They also acknowledged that a shift in mindsets and ways of working is already happening, for example facilitated by the regional initiative on agile administration.

A transformation of administration that supports suitable governance arrangements for NBS could include, among other things:

- A greater appreciation for meaningful citizen participation in project planning as well as management. In the Ruhr area, this shift is notable in the recognition that citizen participation can reduce the maintenance efforts for NBS by creating a feeling of ownership and responsibility.
- A stronger integration of climatic and environmental demands into planning decisions, for example through standard early coordination with those responsible for water management, or by integrating NBS into projects as a default. In the Ruhr area, public administrations started to introduce such early participation in the so-called phase zero.
- Increased openness in administrations to develop projects despite uncertainty. This could include trying out new ideas for multifunctional spaces and to develop NBS projects even though private stakeholders cannot be bound years in advance.

Change of political and societal priorities

The case studies in the Ruhr area illustrated the value of political support for NBS projects, and a prevalent lack of it. A shift in political and societal priorities could support scaling up NBS for flood resilience in at least three ways:

- Increased awareness for the need to adapt to climate change, support biodiversity and to become more flood resilient can improve the position for NBS projects.
- A shift in political priorities based on such awareness can help to preserve and develop green spaces, instead of prioritizing urban developments. Possibly, a shift in priorities towards NBS could be supported by studies that value not just the costs of NBS, but also their avoided costs and additional benefits.
- Increased awareness and priority on climate adaptation and flood resilience can mobilize crucial funds for developing new projects and maintaining a large number of NBS.

6.2 Further research needs

In future studies it would be valuable to explore governance arrangements with stronger private involvement. The case studies investigated in this thesis are publicly funded and private parties mainly contribute in non-monetary ways. However, greatly scaling up NBS to mitigate and adapt to climate change, stabilize biodiversity, and support sustainable livelihoods requires investments far beyond public means (United Nations Environment Programme, 2021). Innovative financing tools like resilience bonds or payments for ecosystem services could possibly fund NBS projects that reduce flood risks. More research into the governance of such financing schemes, also outside of Germany, could help scaling up NBS despite budgetary constraints.

In the analyzed four case studies the stakeholders successfully worked together to develop multifunctional projects that improve flood resilience while providing ecological and social benefits. Yet, the interviewees stressed that the cross-sectoral collaboration on NBS projects is often difficult. Future research could have a closer look at NBS projects that worked out less well.

The results of this study focus on type 3 NBS in urban areas, and it would be relevant to research governance arrangements for other types of NBS. Type 1 and 2 NBS provide a wider range of ecosystem services to more diverse stakeholder groups, which indicates considerable governance challenges.

7. Reflection

In a retrospective, the research questions turned out to be too big to fully answer it in the scope of this thesis. Investigating suitable governance arrangements already involved a variety of elements, such as connectivity, responsibilities, controversies, rules, processes, and instruments. In combination with the barriers and success factors and the contribution of NBS to flood resilience, the topic was very broad, and the conclusion therefore only provide a partial answer to the questions. While this study mainly deals with publicly led governance arrangements, insights into arrangements with stronger private roles would be important for scaling up NBS.

In addition, it was complicated to research governance arrangements and NBS in a German context where these concepts are barely present in the planning practice. Instead, the discourse in the Ruhr area focused more on related concepts like green infrastructure, rainwater management, or agile administration. Especially in the beginning of the research, it was a challenge to explain the concepts and to show their relevance to stakeholders.

Getting in touch with relevant interview partners was also challenging, especially in the early phases of the research process. The first round of interviews was very helpful to gain confidence about the selected research approach, to identify the final case studies and relevant interview partners.

Even though the "snowballing" technique for finding case studies and interview partners worked well within the water board EGLV and some city administrations, not all relevant project stakeholders were open to share their experiences. Especially in departments that are only loosely involved in the projects, for example to oversee biodiversity regulations, it was not possible to organize interviews. People were probably reluctant to engage because the interviews would have touched upon project-related controversies and internal affairs, and because time for interviews can be scarce in understaffed teams.

From a personal perspective, writing the thesis was challenging due to high workloads, time pressure and a lack of fellow students in the same situation. Unfortunately, travel restrictions related to COVID-19 complicated visits to the case studies. On the good side, the pandemic had already normalized video-meetings so that that all interviewees were readily available to use this medium. It was also a great help that the thesis supervisor provided the flexibility and support to write the thesis under the personally demanding circumstances.

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Annex

Annex A: Interview guides

These interview guides are translated from the original German versions used in the interviews.

First round of interviews: Exploratory focus

Introduction

- Introduction by interviewer: Personal background, topic of the thesis, explanation of key concepts, purpose of the interview
- Consent for recording and use of the interview
- Introduction interviewee: Could you please briefly introduce yourself and your tasks?

Governance

- What are the tasks of your agency in relation to NBS and climate adaptation?
- Which rules, processes and instruments are relevant for planning NBS?
- When planning NBS, how do you collaborate with other public / private stakeholders?
- How is your agency involved in the transformation of the Emscher river system?
- Are there overarching strategies or initiatives in the region that promote NBS / climate adaptation?
    - What is the role of the Zukunftsinitiative for NBS projects?

Learning about current developments and projects

- Which NBS projects from your city and the Ruhr area could be interesting for further investigation?
    - What is the project about, where is it, when was it done, are there materials, who are relevant contacts?

Barriers and success factors

- Which factors are hindering NBS in the Ruhr area? What is challenging for you?
- Which factors are facilitating NBS in the Ruhr area? What is working well?
- In your opinion, what would have to change in order to implement more NBS?

Closing

- Is there anything you would like to add or ask?
- Arrange sharing of additional project materials and contacts.
- Thank you for the interview

Second round of interviews: Project focus

Introduction

- Introduction by interviewer: Personal background, topic of the thesis, explanation of key concepts, purpose of the interview
- Consent for recording and use of the interview
- Introduction interviewee: Could you please briefly introduce yourself and your tasks?

Learning about the case study

- Introduction to the project: What is the project about? How does in contribute to flood resilience and climate adaptation? How is the current status?
- Who is involved in the project, and how is it funded?

Governance

- What are the roles and responsibilities of the actors involved?
- How do you organize the collaboration between different actors?
- How do you deal with controversies and conflicts?
- How would you characterize the role of the local community for the project? How are the local people involved?
- Which planning processes, instruments and rules are important for the project?

Barriers and success factors

- Which factors hinder are hindering the project and NBS in general? What is challenging for you?
- Which factors are facilitating the project and NBS is general? What is working well?
- In your opinion, what would have to change in order to implement more NBS?

Closing

- Is there anything you would like to add or ask?
- Arrange sharing of additional project materials
- Thank you for the interview

Annex B: Documents selected for analysis

Documents selected for analysis		
Case study	**Document name and reference**	**Description and reason for selection**
Emscher-Auen	Project permit (Bezirksregierung Arnsberg, 2007)	Project approval ("Planfeststellungsbeschluss") issued by the district government, including technical specifications, responsibilities of different stakeholders, and reactions to inputs from public participation.
	Ecological concept of the Emscher river restoration (Semrau et al., 2009)	Journal article about the Emscher river restoration, presenting the planning process and the ecological concept that guides the restoration. The Emscher-Auen form one of the ecological hotspots defined in the concept.
Emscher-Land	Project application (Jung & Krath, 2018)	Report describing the Emscher-Land project, its design elements, and context. The report was part of the application for EU funding.
	Project description (EGLV, 2018)	Detailed description of the Emscher-Land project, including project goals, implementation steps, and the roles of various stakeholders. The document formed an attachment to the project funding application.
Katernberger Bach	Integrated neighborhood development concept, 2020 update (Stadt Essen, 2020)	Report describing completed and planned projects in Essen Katernberg, including an analysis of the neighborhood and measures for community engagement and green spaces. The concept was approved by the city council and forms the basis for considerable state investment.
	Project posters for public participation (EGLV, 2020)	Posters about the Katernberger Bach project, presenting the planning process from 2015 to 2020. The posters also summarize results from diverse citizen participation activities.
Zukunftsinitiative	Letter of intent 2014 (EGLV et al., 2014)	Letter of intent by EGLV, municipalities, and state ministry to cooperate in the Zukunftsinitiative. Insights into high-level cooperation, goals, and guiding principles
	Documentation: Expert forum 2018 (EGLV, 2019)	Detailed event documentation from yearly ZI expert convention. Insights into specific projects and means of knowledge transfer.

	Project plan 2020+ (Zukunftsinitiative, 2019b)	Project plan listing upcoming activities and goals, agreed upon by municipal heads of departments and EGLV. It provides insights into specific, main measures of the ZI.
	Documentation: Forum agile administration 2019 (Zukunftsinitiative, 2019a)	Event documentation from ZI initiative on agile administration, involving EGLV, municipalities, water boards. It provides insights into challenges, experiences and organization of governance transformation.
	Goals and fields of action (Zukunftsinitiative, 2019c)	Overview of ZI goals related to climate resilience, and fields of action related to creating integrated projects. It provides insights into goals, approaches and instruments.

Annex C: Coding scheme

Umbrella Code	Deductive Codes	Additional Inductive Codes in German
Barriers	Physical barriers Financial barriers Regulatory barriers Institutional barriers	Komplexität Zeit
Success factors	Learning & knowledge Regulations, planning process Partnerships	Kreative Lösungen
Connectivity, collaboration	Sectors and scales Partnerships	Agile Verwaltung Zukunftsinitiative Gemeinsame Ziele
Responsibilities	Planning Construction Maintenance	Öffentliche vs. private Zuständigkeit Klare Absprachen
Controversies		Politische Prioritäten Nutzungskonflikte Kosten Kommunikation
Flood resilience	Flood protection	Klimaanpassung Wasserhaushalt
NBS		Hybride Lösungen Multifunktionale Flächen
Practicalities		Kontaktpersonen Relevante Projekte Nützliche Quellen

Annex D: Case study results

	Emscher-Auen	Katernberger Bach	Emscher-Land	Zukunftsinitiative
Main stakeholders	EGLV, city of Dortmund, + district government, NABU	EGLV, city of Essen, + state government	EGLV + municipalities, RVR, state government, private parties	EGLV, Emscher municipalities, state ministry
Dominant governance modes	Public Administration	Societal Resilience	Network Governance	Network Governance
Contribution to flood resilience	Flood retention basin, designed to retain 1.1 million cubic metres of water, needed due to high peak discharge volumes of the Emscher river + evaporation, slows down discharge, biodiversity, recreation	Re-surfacing of piped stream section, natural water cycle with infiltration, evaporation, retention. Releases stress from sewage system. Neighborhood suffers from heat island, lack of livability and green spaces.	Dike relocation, creation of floodplain and stream estuary, ecological focus area of Emscher river, contributing to natural water cycle	Regional coordination and promotion of integrated water management and climate adaptation. Knowledge transfer and support.
Governance arrangements for designing and planning NBS	**Formal procedure** and plan covering Emscher restoration, sewage canal, and ecological focus areas. **Masterplan:** Emscher restoration guided by masterplan that provides goals, guiding principles, and organized agreement of all stakeholders. Masterplan forms basis for planning of subprojects like Emscher-Auen.	**Early and ongoing citizen participation** for different target groups. Inclusion of citizens' ideas and wishes into plans. **Close collaboration** between EGLV and Essen's team for neighborhood development. **Teamwork:** Core team of EGLV, city, landscaping office, and community moderators, with involvement of other	**High ambitions** to involve diverse non-governmental stakeholders in the planning process and design of the park, but this was neglected over long period of time. Lack of continuity within the team. **Co-creation:** End-users should have been involved earlier and continuously to ensure appropriate design. **Part of overarching project:** Joint implementation of	**Promote "phase zero"** (collaborative, cross-sectoral planning in early, conceptual project phase). **Interdisciplinary teams** and networks across sectors and institutions. Foster **knowledge transfer and cooperation.** **ZI Service Facility** supports municipalities (network, guidance, organizes funding).

	Collaboration of EGLV and authorities with nature conservation associations, facilitated through designated coordinator. Mandatory involvement of water authorities for projects affecting water.	departments and stakeholders where needed. High-level support from policy-makers and chairman.	integrated concept Emscherland 2020 based on cooperation agreement of EGLV, RVR, and 4 local municipalities. Organized by steering committee, led by EGLV.	
Governance arrangements for implementing and managing NBS	Based on formal roles and responsibilities	**"Sponsorships":** citizen and civil society organization take responsibility for activities and maintenance of project elements. **Combination of funds and programs**, such as urban renewal, green space, water management.	**Commercial, private use** of project subsections (farming, education, beekeeping…). **Employment and education:** Cooperation with job creation agencies, to employ and educate people in landscaping and maintenance (collaboration agreements with EGLV). **Joint implementation** of integrated concept Emscherland 2020 based on cooperation agreement of EGLV, RVR, and 4 local municipalities. Organized by steering committee, led by EGLV.	Create interdisciplinary teams / networks. Foster **knowledge transfer** and cooperation. Separation between public spaces under public maintenance, and private projects. **ZI Service Facility** supports municipalities.
How do they organize connectivity?	**Designated coordinator:** EGLV sponsors position of coordinator at nature conservation association to facilitate cooperation between water management and conservationists.	**Fair play:** Create and stick to clear rules of the game that work for all parties. Respect expert judgements and personal concerns of colleagues.	Builds **on established partnerships** and networks with private sector. **Negotiate incentives** to make participation economically viable for private parties (such	**ZI Service Facility** for coordination and support. **"Phase Null"** (collaborative, cross-sectoral planning in conceptual project phase). **Network building** (regular meetings, focused work in

	Clear roles: project manager guides all stakeholders, is point person for external communication. **Internal collaboration:** EGLV staff for technical and ecological aspects, maintenance, communication. Environmental department in Dortmund houses various specialist authorities. **Masterplan** for Emscher restoration as informal, sound basis for stakeholder collaboration across sectors and the whole region.	**Coordination**: EGLV and city gather people's wishes and concerns and coordinate their implementation with different departments. **Project management**: "Doppelspitze" / dual leadership of team leaders from EGLV and city. **Networks**: Build on existing, strong networks in the neighborhood. **Face-to-face interaction:** On-site meetings and events to answer questions, coordinate project, find solutions. Integration into concepts and initiatives: Integrated neighborhood development concept brings together diversity of sectors and projects.	as direct sales, publicity, allowances). **Designated coordinator(s)** at EGLV to guide subprojects and multitude of stakeholders and departments. **Common vision** helps, all authorities need to work towards shared goals (landscape park part of overarching Emscher-Land project). Explicit aim to combine ecology, social benefits, and commercial use, therefore collaboration with diverse stakeholders.	expert groups, sharing of contact details). Regular, targeted meetings (expert networks and panels, city coordinators, department heads). Explicitly fosters governance transformation ("agile Verwaltung"). High-level commitment: Letters of intent and informal planning documents foster regional cooperation and local action.
How do they allocate responsibilities?	Formally defined: Based on hierarchy and formal responsibilities (in planning process, implementation, and operation)	Pass **responsibility** to those who can handle it, and follow up: EGLV and city coordinate wishes and concerns, but experts have to explain why something is impossible, which creates pressure and accountability. **Clear coordination**: project partners know their roles and responsibilities.	**Privat stakeholders** to take responsibility for maintenance of their areas (formal lease agreements). **Challenging negotiations** how to share costs and responsibilities between private stakeholders and EGLV. Regional planning authority grants EGLV much freedom for project implementation.	**Clear, specific goals and responsibilities** (all municipalities responsible for rainwater decoupling, events, green roof strategies…). Flexible allocation of public responsibilities for projects based on interests and capacities. Separation between public spaces under public maintenance, and private

		With external, private partners: regular meetings, clear agreements.	High level support, but also pressure to involve stakeholders and deliver results.	projects, no mixed responsibilities.
How do they deal with controversies?	**Designated coordinator**: EGLV sponsors position of coordinator at nature conservation association to facilitate cooperation between water management and conservationists. **Compromises:** meetings with EGLV, authorities, engineers, and conservationists to find compromise between required water management function and biodiversity. Water authority avoids taking sides in conflicts, tries to organize agreements after conflicting parties had their discussions. In other projects: EGLV avoids legal issues with biodiversity by preventing species to settle on project sites.	**Persistence** in the face of barriers, and develop creative, out-of-the-box solutions. **Pressure and accountability**: negative answers only accepted for good reasons, experts have to directly justify their positions, which creates pressure from policy-makers and citizens.	Creativity and flexibility / **adaptive management** to deal with stakeholder needs and unexpected developments. **Formal agreements** to create legal certainty and accountability. **Compromises** to reconcile ecological and recreational functions (limited visitor numbers, visitor guidance).	Communication strategy (sensitize about need for climate adaptation and benefits of NBS projects). Dialogue with policy-makers (e.g. field visits, showcase NBS projects). Clear goals and (high level) commitments to overcome resistance. For projects affecting water bodies: authorities enforce federal laws to protect and improve ecological status of water bodies.
What are governance-related barriers for NBS?	**Biodiversity:** 1. "Artenschutzrecht": conflicts with biodiversity regulations, responsible authorities, legal uncertainty.	**Administrations** of EGLV and municipalities: hesitance towards participation remains. Sectoral thinking, difficult collaboration across departments. Limited will and capacity for participation.	**Complex project** (ecological, social and economic goals, many subprojects and stakeholders, high level of ambitions).	Structure and mindsets of administration: **strong hierarchies, sectoral thinking** (need for transformation). **Scarce resources** (staff, time, funds).

	2. Diverging interest of nature conservationists and water management. **Conflicting uses:** undisturbed nature vs. intensive recreational use. **Political will and mindsets:** Policy-makers and private sector prioritize construction and follow personal interests; do not appreciate nature and climate adaptation. **Time:** Project planning and implementation took many years (about 20 years). Rigidity: Formal rules and procedures lack flexibility to deal with natural, unexpected developments.	People are afraid to make mistakes, and perceive participation as a disturbance. **Funding**: funding opportunities limited and linked to certain areas, organizing funds takes effort. **Time**: participation and project implementation take years. Administration lacks capacity to plan and build.	**Uncertainty** about private involvement (who, when, for what, stability). Change of EGLV staff, discontinuity in the planning process. **Time:** 1. change of staff caused time pressure to comply with funding conditions. 2. some NBS elements take years to become economically interesting for private sector. 3. Contracts with private parties barely possible in advance, need to be negotiated in parallel to implementation. Complex, cumbersome planning processes and funding arrangements.	**Complexity** of challenges and uncertainty about developments and solutions. **Regulatory uncertainty** and restrictive policies (e.g. for multi-functional spaces, funding). Funds strictly earmarked for sectoral, public purposes, little flexibility. Applying for funding is cumbersome and partly requires **regional cooperation**. NBS implementation and upscaling needs effort and motivation from all staff members, not just managers. Climate adaptation is not a mandatory, core task for authorities. Clear-cut, sectoral staff positions vs. need for cross-sectoral work.
What are governance-related success factors for NBS?	**Strong planning decision** based on formal, comprehensive procedure ("Planfeststellungs-verfahren"). **Long-standing collaboration** and experience with each other's needs and requirements.	Existing, long-standing **partnerships** of professionals and civil society though urban renewal program, including urban renewal steering group and community moderators. **Persistency and creativity:** develop creative solutions to make the impossible possible.	Ambitious project has much to offer, can bring **diverse benefits** to multiple stakeholders. **Creativity and flexibility** to make plans work out. **Perseverance** to keep up public-private cooperation and deal with long, unpredictable planning processes.	**"Just do it" attitude**, courage and creativity. **Encouragement and safe space for new ideas and project preparation**, and teamwork to realize innovative projects. High level support from policy-makers and superiors. Networks of motivated experts.

	In-house expertise across sectors (technical, ecological, communication…). **Willingness to compromise.** **Firm basis** of masterplan Emscher restoration and formal planning decisions avoid questioning fundamentals such as ecological focus areas.	**Trusting, enthusiastic collaboration** of the project partners. **Good planning office** for participation and harmonized plans: one landscape architecture office develops plans, and is tasked with and good at citizen participation. **Participation as a specific job:** landscape architecture office is contracted and remunerated for participation. **Funds** available for community projects ("Verfügungsfond"). Multipliers who promote the project (e.g. policy-makers, civil society organisations, children).	**Collaboration** with state authorities to fund and implement ambitious project.	Increasing change of mindsets in authorities towards integrated projects with added value. Knowledge exchange and learning (meetings, working groups, tools & manuals, publications). Common language for processes and projects (phase zero, integrated projects, climate islands, green-blue infrastructure…). Established culture of cooperation (long-standing cooperation, trustful and open relationships). Common regional regulations to send clear signal about NBS goals to private parties. Funding through ZI / state support, wastewater fees.

Annex E: Concepts related to NBS

NBS function as an umbrella term for many ecosystem-related approaches:

Ecosystem services

The concept of ecosystem services helps to understand how natural systems benefit humans. Ecosystem services are defined as the goods and services provided by nature (TEEB, 2010). These can be provisioning services (like water, food or building material), cultural services (like opportunities for recreation or a sense of belonging), regulatory services (e.g., temperature regulation or flood protection) and supporting services (such as nutrient recycling) (Alcamo et al., 2003; Somarakis et al., 2019).

Ecosystem services are closely related to the notion of natural capital: If natural capital represents the stock of assets, ecosystem services are the flows of benefits obtained from these assets (Nesshöver et al., 2017). Estimating the ecosystem services allows to illustrate the (economic) value of ecosystems, which policy-makers can use to make better decisions about nature conservation and infrastructure development. For example, the ecosystem services provided by the Saloum Delta in Senegal support the livelihoods of more than 100,000 people. Among others, the mangroves filter water, prevent erosion, and support fish stocks. Over the next 40 years, the Delta can provide more than EUR 5 billion in ecosystem services if it is properly protected (Bassi et al., 2020)

The concept of ecosystem services is considered a good way to design and assess NBS. However, it is important to consider a broad range of services and stakeholders (Nesshöver et al., 2017).

Ecosystem-based adaptation

Ecosystem-based adaptation means "adaptation policies and measures that take into account the role of ecosystem services in reducing the vulnerability of society to climate change, in a multi-sectoral and multi-scale approach" (Vignola et al., 2009, p. 692). Ecosystem-based adaptation involves governments, local communities, NGOs and private companies. Together, they address pressures on ecosystem services (like climate change and land use changes) and manage ecosystems to foster the resilience of people and economy to climate change (Vignola et al., 2009).

Ecosystem-based adaptation comprises a wide range of measures, such as green corridors for urban ventilation and cooling, river restoration for flood risk reduction, and adapted plant choices in green areas to deal with droughts (Geneletti & Zardo, 2016).

Ecosystem-based adaptation aims to make communities less vulnerable to climate impacts. A systemic approach to understanding the relationships between society and nature is key for this concept (Nesshöver et al., 2017). It emphasizes the complexity of socio-economic systems and the role of change and resilience. Ecosystem-based adaptation also underlines the need for an inclusive, participatory approach. The involvement of stakeholders and consideration for diverging interests is considered particularly important.

Measures of ecosystem-based adaptation are, and should be, part of NBS. This is important to make sure that the solutions are themselves adapted to climate change, and to foster societal adaptation

(Nesshöver et al., 2017). Scholars also call this aspect the "double insurance" of NBS (Kabisch et al., 2017).

Green / blue infrastructure

Green/blue infrastructure is defined as a "strategically planned and managed, spatially interconnected network of multi-functional natural, semi-natural and man-made green and blue features" that can include "agricultural land, green corridors, urban parks, forest reserves, wetlands, rivers, coastal sand other aquatic ecosystems" (European Commission, 2013, p. 3)

Green infrastructure can entail protected areas, field margins on intensively used agricultural land, as well as parks and green roofs in cities. Blue, water-related infrastructure can comprise rivers, coastal areas and wetlands as well as artificial elements like channels, retention basis and wastewater networks. Green / blue infrastructure aims to provide ecological, economic, and social benefits. The concept helps to understand these benefits and to mobilize investments. Attention to green / blue infrastructure also helps to avoid relying on expensive built infrastructure when nature can provide cheaper, more durable options (European Commission, 2013).

The concepts of green / blue infrastructure and NBS are closely related and can sometimes be used synonymously. However, there is a difference between the focus on physical infrastructure and the broader term solutions that covers a variety of actions (Nesshöver et al., 2017).

Building with nature

Building with Nature is a design approach to realize water-related NBS for societal challenges. It harnesses the forces of nature to benefit economy, society and the environment (Eekelen & Bouw, 2020). A systemic perspective and the inclusion of natural processes lies at the core of Building with Nature.

Building with Nature can be used for water-related infrastructure such as flood defenses, sustainable port development and for the restoration of ecosystems. Recent projects include the restoration of mangroves, artificial dune landscapes, and salt-marshes that protect coasts in the Netherlands and worldwide (Eekelen & Bouw, 2020). In addition to forming sustainable coastal defenses, Building with Nature projects can form biodiverse and valuable landscapes. The concept forms a sub-set of NBS and can be helpful for developing water-related NBS that entail intense human interventions.