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Integrating Nature-Based Solutions into Flood Risk Management

An Explorative Study on Enhancing Flood Resilience in the Netherlands and Germany

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Colophon

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Abstract

Within the last decades, the awareness of the climate change and the need to adapt increased rapidly. Flood risk and the loss of Biodiversity are main challenges. One innovative concept to cope with those are nature-based solutions. As they combine ecological, economical, and social interests, they withhold the potential to contribute to flood resilience. Resilience can be built through its three aspects robustness, adaptability, and transformability. When implemented NBS can have a positive influence on all three and therefore contributes to resilience. Before they must be implemented. Within this process barriers and enabler as well as chances and challenges within are faced. These are highly contextual, but through the exploratory research in this thesis, they are elaborated upon by looking at two examples, 'Große Aue' in Germany and 'De Onlanden' in the Netherlands. Data was collected by conducting a policy analysis and semi-structured interviews. The results indicate that nature-based solutions as a fairly new concept still needs to be more acknowledged and promoted within policies. When implemented they show a high potential to positively influence the aspects of resilience. Therefore, it was concluded that if nature-based solutions are integrated into flood risk management they can contribute to flood resilience and are valuable within the process of climate adaption.

Key words: resilience, nature-based solutions, climate adaptation, robustness, adaptability, transformability, flood risk management

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List of Abbreviations

BBSR – Federal Institute for Research on Building, Urban Affairs and Spatial Development

BMI – Federal Ministry of the Interior and Community

BMUV – Bundesministerium für Umwelt, Naturschutz, Nukleare Sicherheit und Verbraucherschutz

BRPHV – Federal Spatial Planning Ordinance for Trans-State Flood Protection

CBD – Convention on Biological Diversity

ERDF – European Regional Development Fund

EU – European Union

EZK – Ministry of Economic Affairs and Climate

FRM – Flood Risk Management

GER – Germany

GI – Green Infrastructure

ICZM – Integrated coastal zone Management

IFRM – Integrated Flood risk Management

IRBM – Integrated River Basin Management

IUCN – International Union for Conservation of Nature

NBS – Nature-based Solutions

NDC – National Determined Contributions

NGO – Non-Governmental Organization

NL – Netherlands

NLWKN – Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz

NWP – National Water Program

RUG – Rijksuniversiteit Groningen

SDG – Sustainable Development Goals

TNC – The Nature Conservancy

UN – United Nations

WFD – Water Framework Directive

1 Introduction

The increasing frequency and intensity of the consequences of the climate change becomes progressively present. More severe weather events, such as droughts, storms, and floods, occur increasingly around the world. Climate scenarios show that this will by no means remain an exception but will become more frequent and even more extensive in the future (IPCC Work Group I. 2013). Only recently in July 2021, heavy rainfall caused severe damage in Belgium, Luxembourg, Germany, and the Netherlands. Small streams became raging ones and the floods caused widespread inundations. In addition to the record financial damage (Trenczek et al 2020) caused by the destruction of buildings, infrastructure and land, the social aspect of the loss of lives as well as (social-)existences and community structures is enormous.

Within the context of expected rising water levels and increasing precipitation (Restemeyer et al 2015), floods and their potential impact form a serious risk for existing traditional flood protection measurements. In addition, the pressure increases due to global population growth and the increase in socio-economic activities in flood prone areas (van Herk et al 2015). The impacts of recent floods show that traditional technical measures as they currently exist are no longer sufficient to adapt to the situation. Consequently, strategies and management must change to be able to adapt to the changing circumstances. Background to this discussion is the limitation of resistance structures. Within flood risk management a shift was emphasized from hard structural solutions to an integrated approach that consists of both structural and non-structural responses (van Herk et al 2015). This rethinking of and change in the traditional approach is included in integrated flood risk management (IFRM) policies such as the EU Flood Directive 2007/60/EC. In 2006 the European Commission published this Directive. All Member States of the European Union must demonstrate flood protection measures and plans for its waters, whether seas, lakes, or rivers and flood prone areas. The goal of the directive is to reduce and manage the risks that floods pose to human wellbeing, the environment, cultural heritage, and economic activity. One aspect of the directive is to improve preparedness and resilience.

Resilience is an integrated concept within flood risk management and goes beyond the traditional measures such as engineering solutions. The endless raising and improving of resistance structure limited the flexibility of the system and caused a ‘lock-in’ (Vis et al 2003, Restemeyer et al 2017). Restemeyer et al (2017) discusses the commonly made differentiation between

resistance and resilience: “A resistance strategy is to reduce the probability of a flood hazard, whereas resilience aims at minimizing the consequences of flooding” (2015, 46). Correspondingly, resilience is often associated with the shift from ‘fighting the water’ to ‘living with the water’ (e.g. Vis et al 2003, Lu and Stead 2013, van Herk et al 2015, Restemeyer et al 2017). A social-ecological system is resilient when it can maintain its function and services and is able to adapt and transform to accommodate change in response of stresses (Vis et al 2003, Folke et al 2010, Brown et al 2020).

Flood resilience appears therefore as promising strategy for water management. The potential is discussed by numerous scientist (e.g. Vis et al 2003, Schelfaut et al 2011, Singh et al 2021). Discussed are here different resilience-relevant measures which bring resilience into practice. The added value to flood risk management through resilience adaption is particularly emphasised. Taking this into account the incorporation of resilience into flood risk management is a promising strategy in climate impact assessment.

In the light of the changing conditions due to climate change, the idea of flood protection is increasingly becoming a part of public interest. But in addition to the threat of increasing probability and potential impact of floods, the loss of biodiversity is a major challenge of our time. According to the 2020 global Living Planet Index, the destruction of ecosystems has led to an average decrease in population of 68% between 1970 and 2016 (WWF 2020). Most named causes for biodiversity loss are overexploitation, habitat change, pollution, climate change, agriculture/deforestation, urban sprawl, and infrastructure development. All of these are in direct causality with human activities. Especially the areas surrounding inland and coastal waters experience pressure on several levels. Their biodiversity is directly affected by the enormous pollution of the waters and by the spatial pressure caused by the infrastructure that has grown especially during the period of industrialisation. Indirectly, the consequences of climate change can be observed as a cause of biodiversity decline (Slingenberg et al 2009). To counter further biodiversity loss the EU adopted its Biodiversity Strategy for 2030. This is a comprehensive, ambitious, and long-term plan to protect nature and reverse ecosystem degradation. Aim is a recovery of the local biodiversity. To do this, it sets out a series of concrete actions and commitments. One of these measures are nature-based-solutions (NBS) (Naumann and Davis 2020).

1.1 Potential of Nature-Based Solutions

Hard or grey infrastructure, which describes human engineered measures such as dams, sea-walls, roads, pipes, or water retention basins, forms the basis of traditional flood protection. With the increasing integration of resilience strategies into water management, the disadvantages of grey infrastructure standing alone are becoming more and more evident (Restemeyer et al 2017). NBS are an alternative approach to mitigate with a changing climate. NBS involve working with and enhancing nature to help address societal challenges including climate change mitigation and adaptation. Simultaneously they are capable to address economic benefits and natural interests, such as biodiversity loss (Miles et al 2021). The European Commission emphasize that "NBS have the potential to improve the condition and resilience of ecosystems in urban, rural and wilderness areas and as such" (European Commission 2020). NBS can positively influence the vulnerability of socio-economic systems by reducing exposure, reducing sensitivity, and supporting adaptive capacity (Seddon et al 2020). These dimensions seem to align with the key principles of a resilient system and show potential to enhance such. The link between NBS and flood risk management, and thus the ability of NBS to contribute to flood resilience, is the subject of this study and will be discussed further in this thesis.

1.2 Research aim and question

This assessment of the potential of NBS to enhance climate change mitigation through protection from climate change impacts, supporting biodiversity and securing ecosystem services has been subject to discussions in the context of urban areas (e.g. Kabisch et al 2017, Huang et al 2020). However, this reveals a knowledge gap in science and practice how NBS can provide intended benefits to build resilience in flood-prone areas away from the urban context.

The aim of this study is to understand the potential of NBS to contribute to flood resilience through integrating them into the flood risk management. By identifying the potential, the research can contribute to a better understanding of the implementation process of NBS as well as the link between NBS and flood resilience. Additionally, this study is supposed to give insights on how NBS are embedded in current policies, the enablers and barriers in the implementation process will be considered, and NBS as an instrument in the process of 'building resilience' will be explored. The results can help planners and policy makers assess the

potential of NBS to make a system flood resilient when integrated into flood risk management strategies. This leads to the following research question and sub-questions:

- *How can the implementation of nature-based solutions enhance local flood resilience in the Netherlands and Germany?*
  - *SQI: How are nature-based solutions embedded in relevant policies?*
  - *SQII: What are barriers and enablers within the implementation of nature-based solutions?*
  - *SQIII: How can nature-based solutions contribute to 'build resilience'?*
  - *SQIV: What are the lessons learned in the implementation of nature-based solutions?*

1.3 Relevance of this study

Nature-based solutions is named as promising concept and is adopted in several governance strategies to 'build resilience' regarding inter alia flood risk management. Especially climate change and its consequences are a driver for a transition towards resilience through ecosystem-based solutions. In existing literature, this concept is equally described as promising as well as challenging (e.g. Vis et al 2003, Schelfaut et al 2011, Singh et al 2021, European Union 2021). In particular, the amount of needed participation of various actors and stakeholders is named as challenge, but also as opportunity to reach consensus and therefore broad acceptance. The EU adapted nature-based solutions into its programmes, where those support major EU policy priorities such as the 'European Green Deal', its biodiversity strategy and climate adaptation strategy (European Union 2021).

The idea of resilience has several goals in changing the traditional way of flood protection. One is to create adaptive measures which are capable to deal with uncertainties and changing circumstances. When nature-based solutions are embedded in this, they in turn have the potential to be not just maintaining or increasing nature and biodiversity but also contributing to flood protection. In this regard, it would be positive to pick up on the above-mentioned and to consider the increasing collaboration between disciplines, sectors, and societal actors. As this concept is embedded in the integrative approach of flood protection, collaboration, and participation of societal actors (citizens, NGO's, civic initiatives) experience an increased value.

Such an integrative approach, that includes a participative process could help increase the participation in and social acceptance of water management.

Within this thesis, different projects in which nature-based solutions have been successfully integrated and are implemented are considered. The intention is to explore their opportunities, challenges, and conditions to gain an overview of the chances and barriers of the implementation and adaption of nature-based solutions in practice. This can contribute as a projection for further projects.

1.4 Reading guide

This research is carried out in three parts. Within the first part, a literature review is conducted and describes the theoretical context of nature-based solutions, flood risk management and resilience. The second part describes the methodology and includes a description of the selected cases in which nature-based solutions have been integrated. The third part focuses on the results and shows the chances and challenges of NBS to contribute to resilience.

2 Theoretical framework

Flood prone areas are adapting to the changing circumstances for as long as those are exploited. Since the beginning, the focus in flood risk prevention and later in management has been on technical and engineering solutions. This slowly started to change since the 1970s when there became more environmental awareness. Governments and scientist stress on the need to adapt to climate change. Climate adaptation thus sets the scope of this study. The intention of the following sections is to give an overview of the main developments discussed in the literature regarding the changes within planning. This development is closely linked to the paradigm shift in water management to which in turn, the resilience concept is linked. A literature review on the current developments in this matter will be presented in this chapter and is supposed to give first insights to answer the research questions.

2.1 Setting the Scene: Climate adaption and the transition in water management

As already mentioned above, flood prone areas are adapting to the changing circumstances for as long as those are exploited. Since the beginning, the focus in flood risk prevention and later in management has been on technical and engineering solutions. This slowly started to change since the 1970s when there became more environmental awareness. Governments and scientist stress on the need to adapt to climate change.

Climate adaption is necessary to ease the consequences of the impacts and the exacerbating damages associated with climate change. The need to adapt is recognized to be one of the biggest challenges for governance. Consequences are to be observed within ecological, social, or economic systems. In response to actual or expected effects or impacts adjustments must be made within "processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change" (UNFCCC n.d.). Adaption governance can be found at different scale as countries and communities need to develop adaptation solutions which fit their needs and circumstances (Wilby and Keenan 2012). Those adjustments and solutions are supposed to deal with impacts of climate change that are already happening, as well as prepare for future impacts. The latter is a challenge in its own right, because of the uncertainties of future developments.

Uncertainties are present in planning and always pose new challenges. The goal is to understand and minimise them as much as possible. In terms of water management, climate change is probably the most uncertain issue currently. What is known, is that changes in this matter mainly affect sea levels, precipitation patterns and storm frequency (Fankhauser 2017). Scientists have been trying to predict these changes for some time using climate scenarios. This does give the opportunity to make large-scale predictions about how individual climate zones will potentially change. But "nonetheless, predictions are still uncertain, in particular for the regional and the local level" (Restemeyer et al 2017, 920). It becomes even more complex when uncertainties are not viewed isolated but within their interdependencies. Uncertainties associated with climate projections are always related to developments in natural systems and sectors that are affected by other uncertainties (Refsgaard et al 2013). This makes decision-making even more difficult.

With the rising awareness and increasing attention on the circumstances brought about by climate change and the need to adapt to them, the effects of science based technical solutions and the command-and-control approach were questioned. This led to a transition in water management and a paradigm change.

First aspect which led to the transition was that traditional water management primarily comprises a resistance strategy. This mainly describes the technical constructions such as dikes with the purpose of holding back the flood. These measures often date back to the first half of the twentieth century including raising the height of the dike after each flood. Even with predicted scenarios, simply maintaining these measures would lead to a constant increase in the height of the dikes. The constant need for heightening of the embankments created a path dependency (Restemeyer et al 2017). But there are more disadvantages of a resistance strategy within the flood risk management. According to Vis et al (2003), those are the lack of a multi-layer safety approach, economic growth in flood prone areas due to overestimations of the safety factor provided by the resistance strategy, and the endless raising and improving of the water defence structures. Accordingly, traditional flood control, can be described as a centralised predict-and control approach with an emphasis on technical and engineering solutions.

Secondly, in most planning scenarios a command-and-control governance was used. Within this paradigm the goal of water management is to maximize resource exploitation by reducing natural variability. “This approach is typified by centralized, sectoral institutions, limited stakeholder involvement and expert-led problem solving focused on technical engineering solutions” (Schoeman et al 2014, 378). With the need to adapt to climate change impacts and effects scientist and policy-makers evaluated current governance practices. Various authors suggested a shift towards a more adaptive planning and management approach (Restemeyer et al 2017). This led to a change of the paradigm which “emphasizes broader stakeholder involvement; integration of sectors, issues and disciplines; attention to the human dimensions of management; and wider recognition of the economic, ecological and cultural values of water” (Schoeman et al 2014, 379).

[Box 1] Example: Transition within the Dutch water management (after Vis et al. 2003, van der Brugge et al. 2005, van Herk et al. 2015)

Until the 20th century, water management in the Netherlands was characterised by a technocratic-scientific regime. The floods of 1993 and 1995 led the government to question the problematic nature of the previous water management. A report by the supplementary committee was commissioned, which stated that 'Dutch water management is not sufficiently prepared to meet the challenges of climate change effects in the next century' (*CW21 2000 in van der Brugge et al. 2005*). In 2003, a dike on the river Meuse broke almost unexpectedly. This clearly indicated the weakness of human intervention and underlined the spatial pressure of water. It has become clear that the cause of the catastrophic effects of previous floods are often caused by the rigid infrastructure of flood protection. The water-related problems in the Netherlands are therefore the result of the whole of human interventions in the water system. A transition was introduced by first an ongoing process of integration between water management and nature development driven by the growing ecological concern, empirical knowledge, learning experiences and cross-fertilization. Within the transition it was crucial to create space for innovation, inside and outside the regime, to break the dominant perspective and practice. Through ongoing processes, the Netherlands implemented new river widening measures, new collaboration between authorities, new methods and practical guidelines, new policies and regulations, new governance arrangements and project management processes which led to an which led to an increasingly integrated management approach.

Box 1: Example: Transition within the Dutch water management (van der Brugge et al 2005; van Herk et al 2015; Vis et al 2003)

The transitioning within flood risk management lead to a development from traditional flood control, towards flood resilience, an adaptive, ecosystem-based and integrated water management approach with an emphasis on social learning and adaptive capacity (Restemeyer et al 2015).

2.2 Flood resilience

Resisting measures as they currently exist can no longer withstand the expected consequences of climate change. The previously common command-and-control approach is increasingly proving to be no longer adequate. To deal with the coming events, adaptation is necessary. The main prospect of climate adaption is the potential to adjust to the upcoming changes. But as those changes are inevitably accompanied by uncertainties, being adaptive is not enough

(Restemeyer et al 2017). To be able to cope with exacerbating circumstances in the context of climate change it is necessary to do more. Flood risk management needs to become resilient, to not only reduce the risk from climate change, but also improve living conditions (Dodman et al 2009). As above described, flood risk management is already changing and focuses more on spatial and ecological approaches. As eco-centric approach, resilience is one of these.

2.2.1 What is flood resilience?

Within flood risk management, resilience is an alternative approach with its focus on the interaction with social systems and nature (Restemeyer et al 2017). Resilience is rather new to flood risk management (Liao 2012) but it is now established within this field (Lu and Stead 2013). The European Commission (European Union 2021) identifies the concept of resilience as promising framework to prevent and adapt to the impacts of flooding. In vulnerable system even small disturbances may cause dramatic consequences. Increasing vulnerability makes adaption and resilience necessary. It shows the degree to which a human or natural system is unable to cope with adverse effects, including changing variability and extremes. The impacts of climate change are influencing the social and natural system on all levels and show the high co-dependence. To adapt it is necessary to consider the economic, social, psychological, physical, and environmental factors as well as institutional transformations at a variety of scales (Dodman et al 2009). The ability of social-ecological systems to change, adapt, and crucially, transform in response to those changing circumstances defines Davoudi et al (2012) as resilience. Within the literature, it is often described that the adaptations are based on a bounce-forward principle rather than a bounce-back (Davoudi et al 2012, Restemeyer et al 2015, Spaans and Waterhout 2017). Accordingly, Restemeyer et al (2015) describes resilience as concept of living with the water and not against it. Still, resilience remains somewhat a fuzzy concept (Davoudi et al 2012). Nevertheless, “it appears that resilience is replacing sustainability in everyday discourses in much the same way as the environment has been subsumed in the hegemonic imperatives of climate change” (Davoudi et al 2012, 299). To further understand this approach, a closer look into it is helpful.

2.2.2 Equilibria and resilience

Resilience gained increasing attention and interest over recent years. It has its basis in the applied sciences where it is used to describe the stability of materials and their resistance to external shocks (Davoudi et al 2012). In the 1960's it entered the field of ecology and since then, resilience is indicated as a multi-interpretable concept and several definitions were developed which, however, agree of its ability to persist and adapt (Davoudi et al 2012, Restemeyer et al 2015, Spaans and Waterhout 2017). This consensus is mainly based on Holling (1973) assumption of an equilibrium in a system which describe a state to which an existing system can return to or a new state to which it could evolve to. Holling (1973) distinguishes those states, which are later commonly referred to as engineering and ecological resilience (Holling 1996, Davoudi et al 2012) Engineering resilience "concentrates on stability near an equilibrium steady state, where resistance to disturbance and speed of return to the equilibrium are used to measure the property" (Holling 1996, 53). This reflects the traditional notion of resilience and shows that the faster a system bounces back to its original function, the greater the resilience (Liao 2012). Ecological resilience is described as not only a system which can resist and return but also can absorb change and disturbance "before the system changes its structure by changing the variables and processes that control behaviour" (Holling 1996, 53). Unlike within engineering resilience where the focus is on maintaining efficiency of function, within the ecological resilience the focus is on existence of function. These definitions reflect on two different aspects of stability and this difference is fundamental. Where engineering resilience describes the existence of a single, stable equilibrium, ecological resilience describes the existence of multiple equilibria with the possibility of systems to change into different stable domains. Therefore, they can become alternative paradigms Davoudi et al (2012). Davoudi et al (2012) analyses of climate change adaptation plans have also shown that their interpretation of resilience is at best ecological and at worst engineering.

2.2.3 Beyond Equilibrium and the Adaptive Cycle

Even though the differentiation of stability makes the distinction between engineering and ecological resilience, both define a state of it. More recently, in the context of climate change, the

focus has shifted more to the vulnerability of our systems and thus their stability. With former definitions of resilience, the common understanding includes the return to a steady state, whether this is the state a system was in before (engineering resilience) or an adapted state (ecological engineering). This emphasis on the return to 'normal' or the 'new normal' leads to the questioning of the normative. Davoudi et al (2012) criticises that resilience is, therefore, often reduced to emergency responses in combination with the return to stability and discusses the necessity of long-term adaptive capacity building. This leads to an evolutionary perspective on resilience as "resilience is not conceived of as a return to normality, but rather as the ability of complex socio-ecological systems to change, adapt, and, crucially, transform in response to stresses and strains" (Davoudi et al 2012, 302). With the evolutionary resilience, the beyond equilibrium, a third understanding of resilience was established.

Evolutionary resilience advocates the notion of change through external influences and argues that disruption can also come from within. It challenges the whole idea of equilibrium and encourages the paradigm shift towards a view of a world which is rather chaotic, complex, uncertain, and unpredictable. In a resilient social–ecological system, disturbance has the potential to create opportunity for renewal, re-organization, and development. Various scientists consider instead of a stable or equilibrium condition the adaptive cycle which focuses on the dynamics of systems (Lu and Stead 2013, Davoudi et al 2012, Folke 2006, Walker and Salt 2006). Within the adaptive cycle structure and functions of systems undergo four distinct phases of change, visualized in the form of infinity curves. The four phases include: growth(r), conservation(K), creative destruction(Ω), and reorganization(a) (Figure 1).

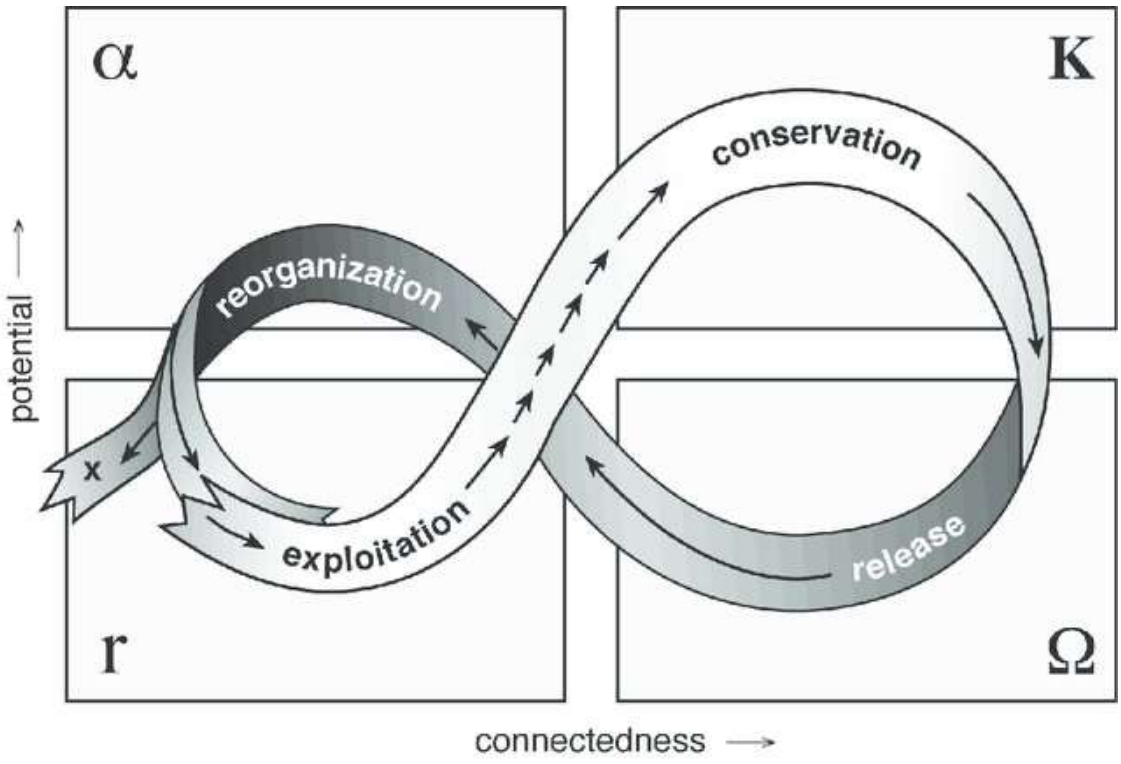

Figure 1: The adaptive cycle. Source: Gunderson and Holling (2002, 34)

The growth phase describes a period of exponential change. It shows rapid growth of resources, more competition, and opportunities and a high but decreasing level of resilience. In the conservation phase, growth slows down. It shows stability, certainty, reduced flexibility and low resilience. Within the creative destruction phase, chaos appears, and resources and capital are released. This leads to high uncertainty with low but increasing resilience. The reorganization phase is characterized by innovation, restructuring. During this phase the greatest uncertainty appears but with high resilience (Folke 2006, Davoudi et al 2012). "The phases are not necessarily sequential or fixed, and secondly, systems function not in a single cycle, but rather in a series of nested adaptive cycles that operate and interact" (Davoudi et al 2012).

Figure 2: The panarchy model of adaptive cycle. Source: Davoudi et al (2012) adapted from Gunderson and Holling (2002, 34–41) and Pendall et al (2010, 76)

This "panarchy" is illustrated in Figure 2 and was developed by Gunderson and Holling (2002) is described to oppose hierarchy. They move in cycles at multiple scales from small to large, at different speeds from slow to fast, and in various timeframes from short to long. This means that complex systems constantly interact with each other and thereby maintain resilience. However, there is always a threat that a system gets 'locked in' in the conservation phase. When that happens, the system is more vulnerable for new disruption. With this understanding, the adaptive cycle model underpins the evolutionary meaning of resilience (Davoudi et al 2012).

The adaptive cycle does not in itself offer a framework for 'measuring' resilience. Evolutionary resilience helps to understand how a system responds to a disruption within a system and the consequently dynamics of functions and structures in a complex adaptive system. To build resilience we need to be able to measure it and therefore translate the adaptive cycle model into practice.

2.2.4 Building resilience

To be able to evaluate flood resilience, the theory must be converted into an operational framework through a conceptualization. Walker et al (2004), Folke et al (2010) and Restemeyer et al (2015) identify robustness, adaptability, and transformability as the three key dimensions of resilience. As robustness includes technical measures and spatial measures it represents the traditional aspect of flood protection and is declared as no longer sufficient to stand alone within flood risk management. Various authors suggest that as a nevertheless important part, it should be complemented by adaptability and transformability. Robustness describes the ability to persist, absorb disturbance or withstand shock (Holling 1973, Davoudi et al 2012). It also refers to the withstanding of floods and contains mostly technical measures such as the

strengthening of dikes (Restemeyer et al 2015) Through technical and spatial measures it contributes to reduce the probability of flooding. Brown et al (2020) identifies this characteristic as 'persistence', the capability of a system to keep functioning as usual in response to changing conditions and without changing its identity. The second dimension is adaptability, where a system can maintain coherent function by modifying its physical and social environment to accommodate change (Restemeyer et al 2015, Brown et al 2020). Walker et al (2004)refer to it as the capacity of actors in a system to influence or manage resilience and to adjust within the system to make it less vulnerable (Folke 2006). Adaptability contributes to reducing consequences of flooding. The third dimension is Transformability which refers to a transition to a new system when ecological, economic, or social structures make the existing system untenable (Brown et al 2020). It describes the ability within a system to change based on new knowledge to find the most appropriate way to manage flood risk (Restemeyer et al 2015). Transformability promotes societal change.

2.3 Nature-based solutions

Somarakis et al (2019) identify a lack of evidence of NBS effectiveness and the quantification of their environmental, economic, and social benefits. It is explained by the fact that up to now there has been insufficient or no analysis of the effectiveness of implemented NBS. This study addresses this matter and aims to identify the challenges and chances of NBS and its potential to enhance flood resilience when implemented. The following section defines the term NBS and clarifies its function as an umbrella concept that covers a range of different approaches, aiming to operationalise the concept of sustainable development. This sub-chapter also introduces an approach for classifying NBS and explains its typology.

2.3.1 Nature-based solutions and the climate change mitigation challenge

The term 'nature-based solutions' (NBS) was introduced by MacKinnon et al (2008) and Mittermeier et al (2008). Both focused on the solutions to mitigate and adapt to climate change

effects while simultaneously protecting biodiversity, building capacity, and fostering resilience (Mandić 2019). This can therefore be regarded as a relatively new concept with a focus on ecosystem-based initiatives, aiming at biodiversity conservation and environmental management (Eggermont et al 2015). So far, there has been a uniform basic understanding of what NBS entail, but no fixed definition. In 2016 the International Union for Conservation of Nature (IUCN 2020) presented at its 2016 World Conservation Congress a definition to be used as global standard for NBS. According to this definition, NBS are:

"*actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*" (*IUCN Resolution WCC-2016-Res-069-EN*)

The IUCN definition refers primarily to the aspect of nature conservation. Other definitions, however, cover a broader spectrum. Therefore, it still appears to be a fuzzy concept with multiple meanings. Sarabi et al (2019) undertook an extensive literature review in this regard and found that "NBS are more often considered as solutions that provide benefits to the environment and humans simultaneously rather than focusing on nature conservation and restoration" (Sarabi et al 2019, 4). The definition by the European Union (n.d.) emphasises on all three pillars of sustainability and define NBS as:

"Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience"

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. Further on, NBS aim at multi-functionality, i.e. at producing several benefits simultaneously and the benefits being often interrelated (Somarakis et al 2019).

2.3.2 Conceptualizing NBS

NBS is often described as multidisciplinary 'umbrella concept' which combines other established approaches such as ecosystem-based adaptation and ecosystem-based mitigation,

ecosystem-services, building with nature and green-blue infrastructure (e.g., Mandić 2019, Sarabi et al 2019, Somarakis et al 2019, Seddon et al 2020). Nesshöver et al (2017) emphasize that those approaches might seem to complement each other but are also diverse in terms of starting points, goals pursued, and perspectives. These concepts share a common "objective to use natural resources and/or natural processes for societal, economic and ecological benefits" (Scheres and Schüttrumpf 2020). The differences and similarities of NBS with other concepts can be briefly summarised.

Ecosystem-based adaption as approach seeks to manage the natural environment in a way that balances benefits for nature and society. The approach uses the natural environment to adapt to climate change and maintain our life. Ecosystem-based adaption aims for adaption to the negative effects of climate change on all levels (Munang et al 2014). Ecosystem-based adaptation measures are part of the NBS and should be. This is essential as the solutions themselves are adapted to climate change, and to promote societal adaptation (Nesshöver et al 2017).

Ecosystem services describes how society depends on nature, multi-functionality and multiple benefits are at core, "Ecosystem services can provide a wide range of benefits for human well-being, including provisioning, regulating and cultural services and benefitting both private and public interests in different sectors of society" (Howe et al 2014, 263). The concept of ecosystem services is closely intertwined with the concept of NBS, as they are considered to provide or enhance ecosystem services. These can be seen as a good way to design and evaluate NBS (Somarakis et al 2019).

The concept of *building with nature* evolved from the discourse of humans being part of the natural system, this innovation programme is based on the interconnectedness of the subsystems nature, society, and engineering (van Slobbe et al 2013). It delivers several benefits varying from protection against flooding and coastal erosion to providing opportunities for nature, recreation, and other function (European Union n.d.). The inclusion and combination of the natural, social and engineering perspective is the core of Building with Nature. Due to its fundamental similarities with NBS it can be helpful in developing water related NBS that are associated with intensive human interventions (van Slobbe et al 2013, Kabisch et al 2017).

Green-blue Infrastructure is a targeted approach for solving specific activity or land-use problems. Green-blue infrastructure is "defined by the use of natural and designed blue and green

components to mimic and/or enhance natural hydrological cycle processes of infiltration, evapotranspiration, and reuse" (O'Donnell et al 2021). 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, which encompasses a variety of measures (Nesshöver et al 2017).

2.3.3 Types of NBS

NBS encompass a wide range of measures, from the preservation of ecosystems to the creation of new ones. Based upon the work of Howe et al (2014), Eggermont et al (2015) hypothesize that "most often, the higher the number of services and stakeholder groups is targeted, the lower the capacity to maximize the delivery of each service and simultaneously fulfil the specific needs of all stakeholder groups will be" (Eggermont et al 2015, 244). Therefore, they can be distinguished by their degree of intervention and the type of engineering into three categories of NBS. The categorisation was carried out according to a gradient, which is determined by the following two components:

- "How much engineering of biodiversity and ecosystems is involved in NBS?",
- "How many ecosystem services and stakeholder groups are targeted by a given NBS?".

Type 1 NBS- no or minimal intervention in ecosystems. Solutions of this type are intended to help maintain or enhance the impacts of specific ecosystem services in existing natural or under-managed ecosystems with no or minimal intervention. This type of NBS promotes better use of natural/protected ecosystems, implying the delivery of multiple ecosystem services to multiple stakeholder groups.

Type 2 NBS- NBS for sustainability and multi-functionality of managed ecosystems. With a higher degree of intensive or extensive management, type 2 NBS improve the sustainability and multifunctionality of ecosystems to enhance ecosystem-services. This type of NBS implies an increased provision of fewer ecosystem-services to fewer stakeholders. Type 2 NBS include for example within coastal landscape management the enhancement or facilitation of habitat expansion.

Type 3 NBS- Design and management of new ecosystems. Through the establishment of such solutions, ecosystems are heavily managed or even created as new ones. Therefore, those NBS present an intrusive approach. Goal of Type 3 NBS is to maximize the delivery of key ecosystem-services for key stakeholder. For example, type 3 NBS refers to green-blue infrastructure or the restoration of degraded ecosystems.

These types can be put into a Schematic representation (Figure 3) of the range of NBS approaches. The level of engineering or management applied to biodiversity and ecosystems is shown in the x-axis and the number of services to be delivered, the number of stakeholder groups targeted, and the likely level of maximization of the delivery of targeted services is shown on the y-axis (Eggermont et al 2015). The graph thus shows a gradient that refers to the input and not to the efficiency of the NBS. Accordingly, it should be noted that the three types of NBS are not interdependent but complement each other. There is no performance classification and thus type 3 is not better than type 1, they merely have different characteristics (Eggermont et al 2015). The case studies in this thesis focus on the restoration and re-meandering of rivers, the creation of floodplains, and sustainable coastal protection. All these projects represent types 3 NBS.

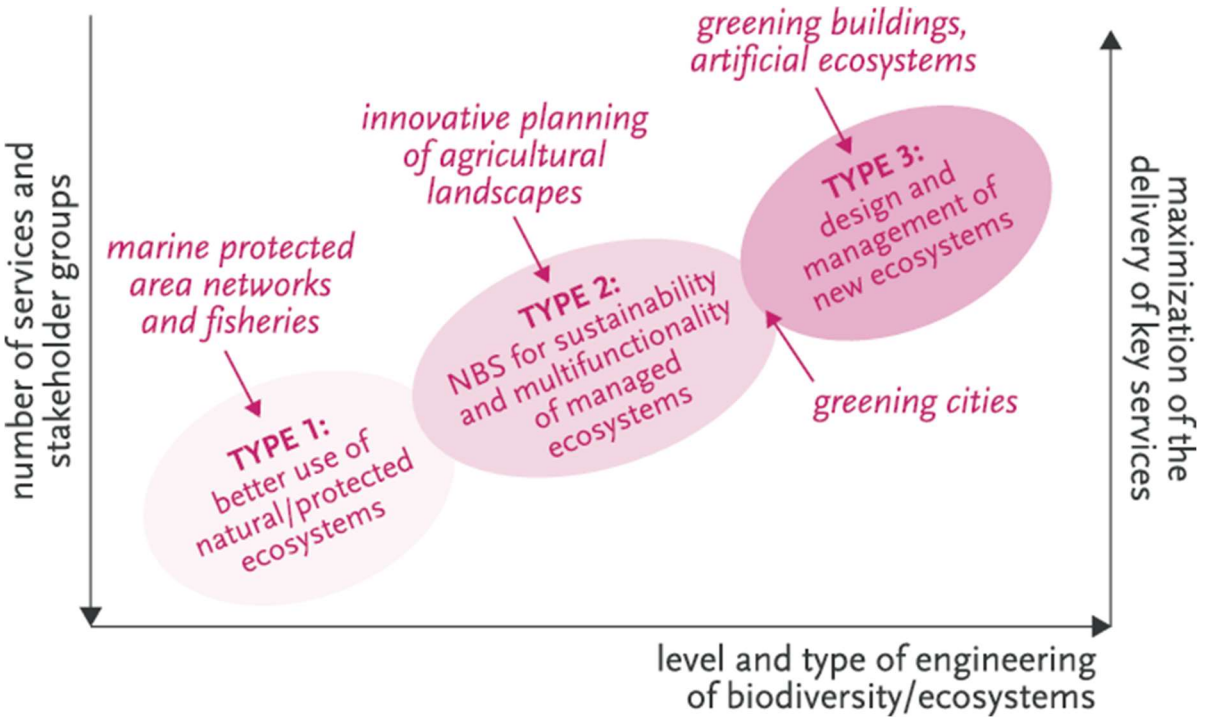

Figure 3: Schematic representation of the range of nature-based solutions (Eggermont et al 2015)

2.4 Policy Context and Flood Risk Governance

The enormous damage caused by floods that occurs time and again makes it clear how important it is to deal with preventive and long-term flood protection measures at an early stage. Since complete protection against floods is neither technically feasible nor economically viable, comprehensive management is required. With the objective to establish a framework for the assessment and management of flood risks within the Floods Directive (2007/60/EC) the European Union formulated a regulation for all member states. The member states then translated this directive into their national law. Two of these states are the Netherlands and Germany. Both countries have experienced several devastating floods in the past and will face further challenges in the future. They form the geographical scope of this study.
Another aspect besides flood risk management within the EU legal framework is climate adaptation. Climate adaptation and related nature-based solutions are not only integrated in national and EU directives but into several policy levels. By looking at these, a top-down structure can be identified.

2.4.1 International

Ecosystem-based approaches are becoming increasingly important in international policy. Behind this is the view of many experts and decision-makers that ecosystems have an important role to play in climate change mitigation and adaptation, and that there are numerous synergies with biodiversity conservation and human well-being associated with these approaches (Slingenberg et al 2009, Miles et al 2021). Organisations such as The International Union for Conservation of Nature (IUCN) and The Nature Conservancy (TNC) have exerted a decisive influence here and have advocated for ecosystem-based or nature-based solutions to be given greater consideration also in international processes (e.g. the UN climate negotiations); especially against the background that such approaches can also contribute to climate protection and adaptation in addition to their important contribution to the UN Sustainable Development Goals (SDGs) (Gómez Martín et al 2020). NbS can help generate multiple benefits for society, such as food and water security, climate mitigation and adaptation, while addressing

biodiversity loss. This is their unique selling point. NbS can therefore contribute towards the achievement of many of the UN Sustainable Development Goals (SDGs) simultaneously, including in particular, climate action (SDG 13), life on land (SDG 15), zero hunger (SDG2) and clean water and sanitation (SDG6), alongside many others.

2.4.2 EU-Level

Both countries considered, are members of the EU and therefore follow its Flood Directive, 2007/60/EC. Different to the previous EU Water Framework Directive [2000/60/EC], which mainly focused on the environment and water quality, the new Directive 2007/60/EC provides a common framework for flood risk management in Europe (Adamson 2018). Through this directive, the EU adopts the transition in flood risk management and changed its strategy from the traditional technical engineering approach to water management as integrated approach (van J. Ruiten and Hartmann 2016). It is less aiming to avoid floods and more rather seeks to reduce the negative consequences, "especially for human health and life, the environment, cultural heritage, economic activity and infrastructure associated with floods" (2007/60/EC:L 288/27).

The Flood Directive moreover requires flood risk management to systematically plan with shocks, to improve local stakeholder participation (Tsakiris et al 2009) and to focus on giving rivers more space through non-structural measures (2007/60/EC). The Floods Directive contains three main objectives that EU Member States must meet within certain deadlines. Members must undertake a Preliminary Flood Risk Assessment by 22 December 2011, Prepare flood hazard maps by 22 December 2013, and Prepare, Flood Risk Management Plans by 22 December 2015. Those steps need to be reviewed every six years in a cycle.

The EU has adopted the concept of NBS into major EU policy priorities, in particular the European Green Deal, biodiversity strategy and climate adaptation strategy, as a way to foster biodiversity and make Europe more climate-resilient (Naumann and Davis 2020). At the EU level, ecosystem-based approaches or nature-based solutions were discussed early on, but initially only indirectly integrated into the corresponding strategies and policies. The previous EU Biodiversity Strategy 2020 included the overarching goal of halting the loss of biodiversity and the

degradation of ecosystem services by 2020, while restoring them as much as possible. As a follow-up plan to this, these goals are concretised within the current EU Biodiversity Strategy 2030. The great importance of intact ecosystems for the achievement of climate goals is particularly emphasised here. Nature-based solutions are also now explicitly mentioned in the new biodiversity strategy. These are to be systematically promoted and integrated. Thus, the EU Climate Change Adaptation Strategy explicitly lists ecosystem-based approaches as cost-effective and easy-to-implement adaptation measures that can deliver various benefits. "As nature restoration will make a major contribution to climate objectives, a significant proportion of the 25% of the EU budget dedicated to climate action will be invested on biodiversity and nature-based solutions" (COM(2020) 380 final). The European Commission funds research and innovation projects that propose NBS through Horizon 2020, Horizon Europe, and the European Regional Development Fund (ERDF).

2.4.3 The Netherlands and Germany

The Netherlands has 29% of its land area below sea level and 59% of the country is flood prone. Besides the potential of coastal flooding, there is also a high potential of fluvial flooding from the rivers, the largest of which are the Rhine, Meuse, Scheldt, and Ems. The history of the fight against the water includes the construction of dikes, which began as early as around 1000 AD (Ward et al 2013). By 1400 AD an almost completely closed dike system existed along the rivers. Regularly dike bursts occurred and the system had to be maintained and improved over the ages (Vis et al 2003). The most devastating floods in modern times hit the Netherlands in 1953, whereafter the national project Delta Works was implemented and the floods in 1993 and 1995 mainly led to the transition towards a more integrated water management, which ultimately set its goal to become resilient. Today, the Dutch Ministry of Infrastructure and Water Management is responsible for policy, implementation and control in the sectors of transport, aviation, housing policy, public works, spatial planning, land management and water management. The responsibilities for water management are further divided within Rijkswaterstaat (the executive branch of the Ministry of Infrastructure and Water Management) and the district water boards (waterschapen, also: heemraad or hoogheemraad). Rijkswaterstaat is responsible for the management of the major waters, such as the sea and the rivers. They are in charge for the design,

construction, management, and maintenance of the main infrastructure facilities in the Netherlands such as dykes, dams, weirs, and storm surge barriers. Whereas the water boards or authorities in the Netherlands are a public authority responsible for water management in a specific geographical area. Their borders do not follow municipal or provincial boundaries, but river basins or watersheds. The water authorities manage natural water systems and protect residents from flooding and ensure the supply of clean water. The National Water Plan 2016-2021 sets out the Dutch flood risk management and freshwater supply policies.

Germany is as well increasingly experiencing the consequences of climate change. Above all, there is more heavy rainfall and more drought. Soils are unable to absorb large amounts of water in a short time due to building development, compaction or drying out. The risk of flooding increases where large masses of water run off or accumulate in a short time i.e., on slopes or at coastal locations. The Rhine catchment area was as well affected by the two major floods of 1993 and 1995. Similar to the Netherlands, a more integrated flood risk management has since developed in Germany (Surminski et al 2020). Even though roles and responsibilities remain somewhat fragmented due to the federal system. The federal (Bund), state (Länder) and municipal governments each have few specific flood management duties. Yet floods do not stop at federal state borders, which is why protective measures must cover the river basins as a whole. In 2018, it was decided to develop a transnational spatial plan for flood protection. On 1 September 2021, the Federal Spatial Planning Ordinance for Trans-State Flood Protection (BRPHV) came into force. With the help of the cross-state spatial development plan, uniform nationwide spatial development standards in flood prevention are being implemented for the first time. The plan serves to improve flood protection by better and, above all, more uniformly protecting flood-prone areas through forward-looking spatial planning (Surminski et al 2020). The plan was developed by the Federal Ministry of the Interior and Community (BMI) in cooperation with the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), but is still to be implemented by the federal states who thus continue to be responsible for flood risk management.

2.5 Barriers and Enablers

Identifying potential barriers and opportunities provides a good insight into the implementation of nature-based solutions and the challenges involved. Many factors can support or hinder the success of nature-based project implementation. As projects can vary greatly in their design, management, funding, and stakeholder participation, it is not possible to establish a universal template for success of a nature-based project. NBS can be applied in many ways and are not tailored to a specific case. However, since NBS is an approach that is applied within a specific field, commonalities can be identified. This makes it possible to identify the basic framework and create a guideline for new projects to follow. This can help overcome certain obstacles and increase the likelihood of implementing the project through known success factors. Comparing multiple studies (Naumann et al 2015, Sarabi et al 2019, Kumar et al 2020) that have investigated this, the most prominently inhibiting and facilitating factors were elaborated. Those Barriers hindering the process of implementation are listed in Table 1.

Table 1: Barrier

Barrier
Inadequate financial resources
Path dependency
Institutional fragmentation
Inadequate regulations
availability and adequacy of data
Limited land and time availability
Implementation of measures
Resistance/lack of acceptance in the population

The missing of sufficient information leads to uncertainty regarding the implementation process and the effectiveness of the solutions. Closely connected with this are the different interests/opinions often resulting in resistance by the public. The barrier of ‘path dependency’ refers to organizational decision making. This describes the behaviour of decision makers within the planning process. This often results in a restricted field of vision and the decision-maker exercising according to old habits. As this ‘path dependence’ requires changing individual and societal behaviour to be broken, it is categorized as cultural/behavioural barrier. Another barrier is ‘institutional fragmentation’. This obstacle becomes apparent when tasks within a project have been distributed in such a decentralised way that vision, legal frameworks and

procedures, and sectoral language do not align anymore. Based on the premise that NBS are still a fairly new concept, regulations supporting NBS implementation are scattered. This leads to 'inadequate regulations'.

From planning and conception to implementation and long-term assurance of a project, various factors are decisive for its success. The experience and insights of those responsible for the project, of actors involved in the project implementation, but also from other experts in this field, can provide information about the key essential factors for success. The most frequently mentioned factors that promote planning and implementation of nature-based projects in climate change mitigation/adaptation are the following:

Table 2: Enabler

Enabler
Partnership among stakeholders
Knowledge sharing mechanisms and techniques
Economic instruments
Plans, acts and legislations
Effective monitoring and evaluation systems for implementation process
Open innovation and Experimentation
Combining NBS with other urban elements and grey infrastructures
Appropriate planning and design

To facilitate the implementation process, these enablers (table 2) indicate to strive for an integrated planning process. Networking of actors links creation of partnership, adequate and target-group-oriented public relations work and sharing processes of knowledge and technologies. Important for success is also the integration of the project into political strategies and processes. Transparency and the willingness to compromise in the implementation of measures within the process is crucial for social and cultural acceptance. The availability and discoverability of NBS related data is named by Kumar et al (2020) to be key for facilitating the implementation process.

2.6 Conceptual Model

Figure 4 illustrates the conceptual model of this research. It shows the structure of the research, elaborated through the key findings of the literature review, and the direction of the following empirical research. It is supposed to visually present the aim and the relation of the theoretical concepts described as well as their interrelations.

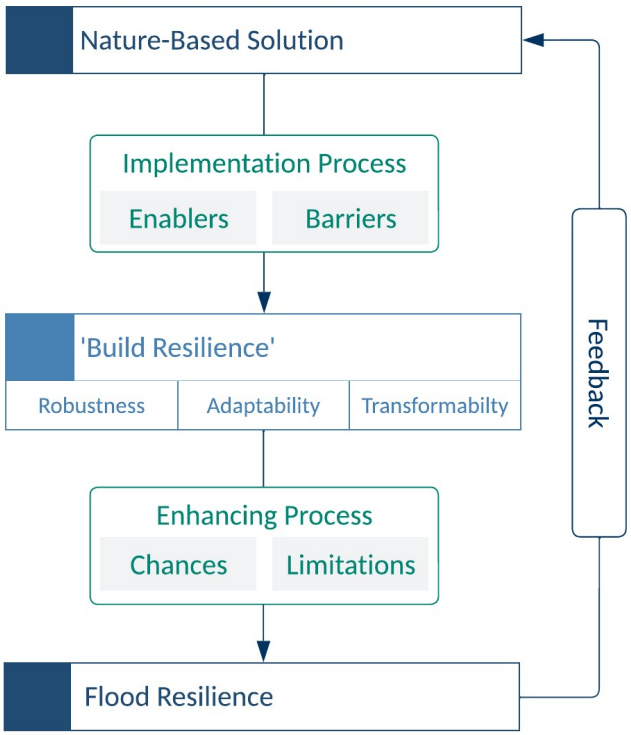

Figure 4: Conceptual Model

The figure shows a simplified representation of the path from NBS after being Integrated into flood risk management towards the normative goal of flood resilience. Illustrated is the full pathway investigated in this study. Within the Model a circular flow is presented. This is explained as resilience is not a fixed stage but an ongoing unfolding equilibrium through an ever-evolving feedback process (Chapter 2.2.2). The model starts at the top with NBS representing the independent variable and flood resilience is set as dependant variable on the bottom (dark blue). The path investigates the potential obstacles and inhibiting or facilitating factors that are encountered along the way. The factors that influence the implementation process are further investigated. Going on, the extent of the effect of the three pillars of building resilience is explored (light blue). Described in the literature, they have an impact on the enhancement process and eventually form and configurate the state of resilience. The processes and dependant factors are illustrated in green.

3 Research Methodology

This chapter contains the research methodology used for this Thesis. An overview of the research approach, the methodology, and data collection techniques used for this thesis is given. The choice to conduct a multiple case study is elaborated on, as well as a description of the decision-making process is given and the cases themselves are presented. The research is both explorative and qualitative. An overview of the ethics and limitations of the case study will be given in the end.

3.1 Research strategy and design

The research is based on three steps. In the first step, the selected cases in which NBS are integrated in the context of flood risk management are explained. Within the second step it is elaborated on their implementation process as well as their chances and limitations. The third step is to evaluate the lessons learned and how NBS can contribute to enhance flood resilience. The strategy of this study envisages that the methods will be carried out chronologically and sequentially.

To gain knowledge about those aspects and to be able to answer the research question 'How can the integration of nature-based solutions into water management projects in the Netherlands and Germany enhance flood resilience?' a qualitative research approach is used, and a multiple case study is conducted. The decision to pursue a qualitative research approach was made because of the specific outcome which focuses on the why questions and the underlying intensions. Unlike a quantitative approach, where the focus is on descriptive details such as the who, what and where questions, which are often conducted by numbers, the qualitative research seeks "a contextualized understanding of phenomena, explain behaviour, and beliefs, identify processes and understand the context of people's experiences" (Hennink et al 2020, 17). It helps to understand context dependant aspects within a study context, to grasp processes and interrelationships and to understand complex topics. This is important in this research, as the implementation process of NBS is possibly affected by barriers and enablers.

Qualitative studies are said to have the potential to provide insights into a topic that quantitative studies cannot (Azungah 2018).

3.2 Case Study Research

A case study is a suitable research method for this type of research. A common and comprehensive definition is provided by Yin (in Crowe et al 2011:4):

> "*an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*."

Conducting a research based on a case study gives the opportunity to analyse a specific context from several perspectives and to explore complex issues in-depth within their real-life context (Crowe et al 2011). The choice of a case study allows for sufficient insights in the connection between NBS projects and flood resilience. The decision to conduct a multiple case study was based on the premise that while NBSs must meet the same requirements and conditions, the projects in which they are integrated are highly context dependent.

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 risk management. All selected cases concern flood protection projects in which NBS are integrated. The definition for NBS must be fulfilled. The cases are located within the area of Lower Saxony, Germany and the Province of Groningen, the Netherlands which form the spatial boundary. The theoretical scope is set by the German regional water authority of NLWKN and the Dutch regional water authority of the Waterschaap Noorderzijlvest. All cases in this study are located in this agglomeration. These two regions are situated opposite of each other on the German-Dutch border, and both regions and authorities have a share on the North Sea coast and the Ems delta. In terms of timeframe, the research focuses on cases that are fully implemented.

Two cases have been selected in total, for each country two projects. These concern different spatial contexts as they are situated along the coast, river or in a low laying area. The cases are very suitable to construct NBS projects as they are prone to flood risk due to those specific

locations. As Projects in the urban context have already been the focus and discussed extensively within previous studies (e.g. Kabisch et al 2017), those are not considered in this research.

3.3 Research method and data collection techniques

For this research a mixed-methods approach is used. Research that combines multiple methods can produce more valid and reliable results.

This research combines techniques as literature review, policy analysis, and semi-structured interviews. The fundamental information is laid through literature research on the subject. The policy analysis provides the necessary policy context in which the cases are embedded. The semi-structured interviews provide detailed information about the cases and the process.

The research methods describe are used to answer the research question and gather knowledge about the potential of NBS to enhance flood resilience. In the process the sub questions are answered. The different methods used can be seen in Table 3.

Table 3: Applied research methods for sub-questions

#	Sub-Question	Main Method
SQI	How are nature-based solutions embedded in relevant policies?	Literature Review Policy Analysis
SQII	What are barriers and enablers within the implementation of nature-based solutions?	Literature Analysis Semi-Structured Interviews
SQIII	How can nature-based solutions contribute to 'build resilience'?	Literature Analysis Semi-Structures Interviews
SQIV	What are the lessons learned in the implementation of nature-based	Semi-Structured Interviews

3.3.1 Literature Review

The research started with an in-depth literature research. The majority of this can be found in the theoretical framework. Aiming to get insights into the key concepts of flood resilience and NBS, existing literature was examined. To collect relevant and significant data the available information had to be filtered. It was described earlier that the field of NBS is still relatively unknown and has many research gaps, nevertheless a qualitative selection of the available sources must still be carried out. In this manner, research on relevant scientific literature was conducted. Multiple portals and sources such as Google Scholar, SmartCat, relevant books, and various articles found in the process were used. The literature search was conducted through a focus on key words, such as 'climate adaption/mitigation', 'transition', 'integrated flood risk management', 'resilience', 'flood resilience', and 'Nature-based Solutions'.

3.3.2 Policy Analysis

For the policy or document analysis relevant policies within the geo-political context were examined. The policies viewed are currently valid and give an overview of the climate adaptation strategy, spatial planning, and flood policy in the study area. For this purpose, the various levels of administration were examined, and the relevant policy papers were reviewed. The international context, EU regulations, state policies, and regional water policies were analysed, including official texts of conventions, legislative decisions, and national guidelines.

3.3.3 Semi-structured interviews

Semi-structured Interviews were chosen to get the various perspectives of relevant parties. This form of qualitative research gives the interviewee the possibility to speak out in a representable manner of their respective organization. Interviews are a good option to answer direct questions and unclarities can be explained. They provide the opportunity to bring together the information from the various parties and gather insights from multiple methodological sides.

For the interviews an interview guide was set up to guide the conversation (Appendix A). The guide is divided into two Main parts. Within the first, questions regarding the barriers and enablers of the implementation process are included. The second part is about gaining insights on how robustness, adaptability and transition were present in the cases, leading to the questions on how NBS are limited or have the chance to enhance flood resilience in the area. The guide follows the lead of the conceptual model.

The semi-structured interviews are conducted with direct contact persons for the individual cases such as the project manager. Additionally, representatives of Dutch and German administrative levels, and an expert were interviewed. The relevant representatives have been identified through the document analysis. The interviewees are contacted via email in September 2022. In advance to the interviews, consent is obtained as well as extensive clarification on the anonymization of the data, recording of the conversation, information on the topic and the survey process. An overview of the held interviews can be seen in List 4.

Table 4: List of Interviews

#	Organization	Role	Case	Date	Location/ Medium	Abbreviation
1	Waterschap Noorderzijlvest	program strategist	De Onlanden	09.11.2022	Microsoft Teams	Resp. C
2	Maintenance Association 'Große Aue'	Managing Director; Association engineer	Große Aue	16.11.2022	In person, at ULV bureaus	Resp. A; Resp. B
3	Province of Groningen	Senior advisor water and safety	De Onlanden	24.11.2022	Microsoft Teams	Resp. D

3.4 Data analysis and interpretation

The evaluation of the interviews was conducted through a qualitative content analysis and interpreted through a SWOT-Analysis.

The data was analysed by coding the transcripts from the interviews. To carry out this step, it is needed to transcribe the interviews. This step is also important because of the open questions, to collect the information in written form and be able to reflect on the interviews. Parts

of the interviews which include sensitive or personal information or not being relevant for the thesis are led out completely within the transcription. Colloquial language and expletives were deleted.

For the interpretation of the results a SWOT-Analysis (Strengths, Weaknesses, Opportunities, Threats) was conducted. A SWOT-Analysis is used by organisations as a decision-making tool. It is a simple tool to systematically capture important trends and factors for achieving goals with the categories of internal strengths and weaknesses and external opportunities and threats "Spatial, urban and environmental planning uses the SWOT analysis to create a systematic basis for planning/political decisions" (Wollny and Paul 2015, 190). It is important to note that in a business SWOT-analysis the distinction made between internal (strengths/weaknesses) factors and external factors (opportunities/threats) may be relatively simple, but it can be more difficult to separate strengths from opportunities and weaknesses from threats in planning processes such as spatial, urban, and environmental planning (Wollny and Paul 2015). The SWOT analysis belongs to the verbal-argumentative methods. These evaluate exclusively through argumentation, not through arithmetic or logical aggregation (Wollny and Paul 2015). Such methods allow for a simple, quick, and generally understandable recording of specific factors. The SWOT analysis is designed as four-field matrix.

3.5 Ethics and Limitations

As NBS is a relatively new approach, which has so far been applied mainly in an urban context, it was not known at the beginning of the research how many prospective interviewees would be available to participate in an interview.

Difficulties in the research process, especially regarding the case selection, arose in the German context. The problems can mainly be traced back to different term and language use and difficulties concerning administrative matters. The former is due to translation issues as the English technical term 'nature-based solutions' has hardly been adopted in the original. Rather, it has been translated and even changed. In some cases, the term 'Ökosystembasierte Ansätze' (ecosystem-based approach) was used with the comment that it is used as synonym for NBS (Naumann et al 2015). Furthermore, this difficulty can be traced back to the alienation of the

word itself. The addition of the word 'nature' is viewed critically, as it can cause misleading associations and the aspect of multi-benefits is neglected (Schröter et al 2021). On the administrative part the difficulties arose due to transparency. Within the German higher governmental level, broad information's regarding NBS are provided and even articles and research can be found. But with having the focus set on one federal state (lower saxony), it seemed difficult to find clear information on cases and projects. Additional problems occurred due to a minimal number of implemented projects of NBS in Germany. They account for only nine percent of the proposed measures in flood risk management plans of the federal states, in lower saxony even only six percent (Brillinger et al 2020).

3.6 Case studies

The two case studies are presented in the following. Both are independent projects that will provide results on the implementation process and the impact on the resilience building process.

3.6.1 De Onlanden, Netherlands

De Onlanden area is a nature reserve of more than 2.500 hectares (Natuurmonumenten). It is located in the north of the Netherlands on the boarder of Groningen and Drenthe. Designated to nature and water storag, it functions as water retention area when heavy precipitation occurs and minimises the chances that the surrounding towns of Drenthe and Groningen are being flooded. Thus inconveniences to the locals are reduced. The area contains nature areas vulnerable to flooding. Through compartmentalisation those areas will be spared as long as possible when absorbing water. Before the project was initiated De Onlanden area was a low-lying agricultural area struggling with subsidence and excess water. The need for intervention became increasingly urgent after the city of Groningen and the province were partly flooded in 1998.

The project of De Onlanden is subdivided into two planning phases. The project was developed in the period 2007-2012. The construction combined water storage with nature and a robust

NBS was created. Shortly after the first phase was established it could prove its successfulness through effectively storing the water after prolonged rainfall and a storm caused a threating situation of high-water levels. The region was saved from a flood. At this point the area was able to store 7,5 million cubic metres of water. The second phase was established afterwards as part of the project 'Dry Feet 2050'. The three northern provinces and water boards investigated which measures were needed to take on the expected challenges of potential floods until 2050. De Onlanden are part of this strategic plan and are enforced into a second phase as 'Optimisation of De Onlanden'. The plans for additional water storage offers room for another 5,2 million cubic metres of water. The water is to be stored temporarily in extreme situations before it is drained to the sea.

Initiator of the project is the waterschap (regional water board) Noorderzijlvest. Administrative represented is the project by the Province of Drenthe, Province of Groningen and the municipality of Tyrnaarlo and Noordenveld. The land managers Statsbosbeheer, Natuurmonumenten, and the Drenthe Landscape Foundation are also involved. The planning process is designed in a participatory way. The water board and the parties involved included local residents, farmers, businesses, interest groups and user in the project at various moments.

3.6.2 Große Aue, Germany

The project Große Aue lays within the river basin of the Weser in Lower Saxony, Germany close to Sarninghausen in the district of Nienburg. The area is mainly characterized by agricultural land, forest, grassland, and moorland. In the course of the 20th century, the Große Aue was straightened to a large extent. As part of the implemented measure, it received a new side branch and thus a more natural design was restored.

On an area of about five hectares, a side branch was newly created to improve the watercourse and floodplain dynamics and a wetland berm (terraced grading of the terrain at the watercourse edge) was created to widen the flowing water cross-section. The new oxbow offers improved spawning and nursery habitats for fish and microorganisms. In addition, the near-natural development of the watercourse will create habitats typical of alluvial areas. Species dependent on flooding and pioneer species will benefit from these and the periodic flooding of

the area. The measure thus serves as a step towards "good ecological status" as defined by the Water Framework Directive and at the same time brings about a multifaceted nature conservation enhancement.

The project was launched around 30 years ago as a "blue-green" flagship project. Various stakeholders worked hand in hand on this measure: the maintenance and landscape conservation association Große Aue, the district of Nienburg, the Steyerberg municipality and the NLWKN.

4 Research Results

This chapter presents the results of the methodological research carried out. It is structured according to the first three sub-questions. First, the relevant policies are presented and analysed. Regarding the second and third sub-question, the results of the theoretical research and of the interviews were combined and are presented. The fourth sub-questions, as it concerns the lessons learned, are exploited within the discussion in the next chapter.

4.1 Concepts and Policies

This thesis focuses on the potential of NBS to enhance flood resilience in Germany and the Netherlands. For NBS to be able to do so, they must consequently be integrated and thus be implemented into flood protection. Initiated is this process through the inclusion of the approach into policies. Accordingly, the embedding of the NBS concept in policies is part of this thesis. Supporting a project by integrating it into policies is of particular importance. This can greatly facilitate the implementation process. As already mentioned before, NBS is a relatively new concept. It is relevant that the concept is embedded in policies, as these stimulate implementation. Therefore, the following section analyses the presence of this concept in existing policies.

The conceptualisation of flood resilience and NBS is described in chapter X, the theoretical Background. The results to this part of the first sub-question were gained throughout the literature review. Regarding the second part of the sub-question, Germany and the Netherlands

are required or obliged to follow certain frameworks at different levels. “The nature of the [policy document] could either be mandatory (including mandatory requirements or standards), voluntary (encouraging voluntary action), or a statement (relating to NBS thematically, but which does not encourage nor require action)” (Davis et al 2018, 16). Global policies which are issued through international conventions, councils, and summits and support the implementation of NBS are often voluntary guidelines. Those global guidelines have been signed by the participating countries which are further on responsible for its translation into national and local policies. Furthermore, both countries are members of the EU, where the directives are mandatory. An EU directive is a legislative act that sets out a goal which must be achieved. However, it is up to the individual countries to devise their own laws on how to reach these goals. Clear framework conditions for flood protection and nature conservation are given by the EU directives to implement the convention protocols into legal instruments through strategies. Germany and the Netherlands have both adopted the EU policies and included them in their own water management plans. The following policy document review is giving an overview of the embeddedness of NBS into policies. This does not include a complete list of all existing documents, but rather a relevant selection.

Table 5: Selected policy documents to be included in review

#	Policy field	Policy document	Organisation
1	Adaption	Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction and supplementary information	Convention on Biological Diversity
2	Adaption	IUCN Global Standard for Nature-based Solutions	International Union for Conservation of Nature
3	Adaption	The Sendai Framework for Disaster Risk Reduction 2015–2030	Third United Nations World Conference on Disaster Risk Reduction
4	Adaption	Paris Agreement	United Nations
5	Water	Water Framework Directive (2000/60/EC)	European Union
6	Adaption	Adaption Strategy (COM/2021/82)	European Union
7	Biodiversity	Green Infrastructure Strategy (COM/2013/0249 final)	European Union
8	Biodiversity	Biodiversity Strategy (COM/2020/380)	European Union
9	Water	Federal Spatial Planning Ordinance for Trans-State Flood Protection (BRPHV)	Germany
10	Water	Action Programme Lower Saxony Water Landscapes	NLWKN, Germany
11	Adaption	Environment and Planning Act (Omgevingswet)	Rijksoverheid, Netherlands
12	Water	National Water Program 2022-2027	I&W, EZK; Netherlands
13	Water	Waterkeringbeheerplan	Noorderzijlvest, Netherlands

'*Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction and supplementary information*'

This guideline is published by the Convention on Biological Diversity (CBD). It "provides information on principles, safeguards, tools, and a flexible framework for planning and implementing ecosystem-based approaches [as NBS], to support countries in integrating ecosystem-based approaches into their national biodiversity strategies and action plans, but also into other sectoral policies" (IUCN 2020). It describes NBS as tool to climate change adaptation, mitigation and disaster risk reduction and their potential to increase the resilience of ecosystems and human livelihoods to the impacts of climate change. The CBD is a practical tool for translating the principles of Agenda 21 into reality. It was signed by 150 government leaders at the 1992 Rio Earth Summit and is dedicated to promoting sustainable development. Its main three goals are (1) the conservation of biological diversity, (2) the sustainable use of the components of biological diversity, and the (3) fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Germany and the Netherlands are two of the signing parties and therefore they are required to transpose this directive or translate it into national policies.

'*IUCN Global Standard for Nature-based Solutions*'.

This guideline is "designed to support users to apply, learn and continuously strengthen and improve the effectiveness, sustainability and adaptability of their NbS interventions" (IUCN 2020). The International Union for Conservation of Nature (IUCN) is the greatest and oldest international organisation for nature conservation and was founded in 1948. The IUCN is a membership Union and composed of public, private and non-governmental organisations. It provides those organisations with the knowledge and tools that enable human progress, economic development, and nature conservation. Due to the scale of the IUCN and its many members, this organisation has the possibility to develop and provide best practices, tools, and international standards. Through the IUCN World Conservation Congresses, they can amplify or influence international, national, and local policies. Public, private and non-governmental organisations of Germany and the Netherlands as members are working closely with the IUCN to implement its standards and goals. The benefits for the members are "scientific credibility, its

unsurpassed knowledge base and convening power, extensive networking opportunities and access to high-level political, economic and social decision making" (IUCN 2020).

'*The Sendai Framework for Disaster Risk Reduction 2015–2030*'

This framework was adopted in 2015 at the 'Third United Nations World Conference on Disaster Risk Reduction'. This conference is part of a series of United Nations conferences focusing on disaster and climate risk management in the context of sustainable development. Participants to this conference are states, inter- and non-governmental organisations as well as other relevant stakeholders (Sendai Framework for Disaster Risk Reduction 2015–2030). The document forms a basis for action for states and civil societies worldwide. By 2030, disaster risks are to be reduced, the emergence of new risks avoided and the resilience of populations and institutions to disasters increased. It is a 15-year, voluntary, non-binding agreement which puts the states into a leading role to implement it, but responsibilities should be shared with the various stakeholders and participating organisations. NBS are included under the related term ecosystem-based approach. To achieve the strengthening of disaster risk governance and to manage disaster risk, the document stresses on the promotion of "transboundary cooperation to enable policy and planning for the implementation of ecosystem-based approaches with regard to shared resources, such as within river basins and along coastlines, to build resilience and reduce disaster risk, including epidemic and displacement risk" (Sendai Framework 28 (d)). Additionally, investing in disaster risk reduction for resilience is part of this framework. For the national and local level, the document states that it is important to "strengthen the sustainable use and management of ecosystems and implement integrated environmental and natural resource management approaches that incorporate disaster risk reduction" (Sendai Framework 30 (n)).

'*Paris Agreement*' and '*submitted NDC by Germany and the EU on behalf of all EU countries*'

The Paris Agreement is a legally binding international treaty and was established in 2015 and put into force in 2016 (UNFCCC n.d.). The goal is to limit global warming to 1.5 degrees Celsius, compared to pre-industrial levels. To achieve this the implementation of economic and social transformation, based on the best available science is required. The Paris Agreement is circular in structure and a new phase begins every five years. By 2020, countries submit their plans for climate action known as nationally determined contributions (NDCs). Those NCD's are

programmes in which countries communicate their envisaged actions to reduce their Greenhouse Gas emissions and the actions they will take to build resilience to adapt to the impacts of the changing climate. In the representative NDC submitted by Germany and the EU on behalf of all EU countries, the important role of the NBS to solve global challenges is explicitly mentioned.

'EU Water Framework Directive (2000/60/EC)'

The EU Water Framework Directive (WFD) is the most important piece of European water legislation and came into force on 22 December 2000. This framework includes regulations to halt the deterioration of the status of water bodies in the European Union (EU) and to achieve "good status" of rivers, lakes and groundwater in Europe. Emphasis is placed on protecting all types of water (surface, ground, inland and transitional), restoring ecosystems in and around these waters, reducing pollution of water bodies, and ensuring sustainable water use by individuals and businesses. The WFD provides a uniform regulatory framework for water policy and thus a basis for joint water management action in Europe. Additionally it is considered as sustainability guideline. The social, environmental, and economic impacts on people as well as the geographical and climatic conditions must be taken into account. The requirements of the WFD must be translated into national law. It is not designed to specifically mention measures such as NBS. Rather, it serves as a basis on which further and thus more detailed plans are developed as instruments. These include, among others, the EU Strategy on Adaptation to Climate Change, which puts a strong emphasis on NBS as a cross cutting priority.

'Climate Adaption Strategy (COM/2021/82 final)'

Adopted in 2021, the EU Strategy on Adaptation to Climate Change outlines the long-term vision for the EU to become a climate-resilient society, fully adapted to the unavoidable impacts of climate change by 2050. The aim to reach this goal is set by improving knowledge of climate impacts and adaptation solutions; by stepping up adaptation planning and climate risk assessments; by accelerating adaptation action; and by helping to strengthen climate resilience globally. Three main objectives are being pursued: smarter, faster, and more systematic adaptation. Proposed are as well a range of actions to meet them. NBS are taking a leading role in this strategy and its promotion is named as one of three priorities within the systematic objective.

'Biodiversity Strategy (COM/2020/380 final)'

The EU Biodiversity Strategy is a programme of measures to halt and reverse biodiversity loss in the EU and is the central part of the European Green Deal. The strategy contains specific commitments and actions to be delivered by 2030. To have the ecosystems restored, resilient, and adequately protected, the strategy set the goal to "put Europe's biodiversity on the path to recovery by 2030 for the benefit of people, the planet, the climate and our economy" (EU 2021:8). This goal relies on four pillars, protect nature, restore nature, enable transformative change, and EU action to support biodiversity globally. NBS are explicitly mentioned in this strategy and illustrated as "essential for emission reduction and climate adaptation" (COM/2020/380).

'Green Infrastructure Strategy (COM/2013/0249 final)'

The EU Green Infrastructure Strategy (2013) promotes the protection, restoration, creation, and enhancement of green infrastructure. Green Infrastructure (GI) is a "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services". The development of such networks and areas is the key goal of this strategy and enhances thus the success of the Biodiversity Strategy. The Green Infrastructure strategy encourages the implementation of NBS. "GI can make a significant contribution to the effective implementation of all policies where some or all of the desired objectives can be achieved in whole or in part through nature-based solutions" (COM/2013/0249 final).

'Federal Spatial Planning Ordinance for Trans-State Flood Protection (BRPHV)'

The objective of the spatial planning concept is to minimize the risk of flooding in Germany and thus to limit damage potentials by applying effective spatial planning flood prevention, with the aspects of a nationwide harmonization of spatial planning standards for better coordination of flood protection as well as a spatial planning approach based on the entire river basin district, the introduction of a risk-based approach in spatial planning to take into account differentiated aspects, and the regulation of 'critical infrastructures' to improve the protection of facilities of national or European significance. It is still to be implemented by the federal states who thus continue to be responsible for flood risk management. This ordinance emphasizes the implementation of flood control measures that focus on nature compatibility. Accordingly,

NBS are not explicitly mentioned, but this approach shows that such measures should be increasingly taken into account and integrated into the local flood management strategy.

'Action Programme Lower Saxony Water Landscapes'

The "Action Program for Lower Saxony's Water Landscapes" is the federal states translation of the BRPHV for Lower Saxony. It is intended to significantly strengthen previous efforts to conserve and develop native stream and river courses with their floodplains, as well as lowlands and lakes with their water-dominated communities and habitats. This program, jointly supported by the state's water management and nature conservation authorities, is an implementation component of the Lower Saxony Landscape Program and of the Lower Saxony Nature Conservation Strategy. With this program, the various objectives of water management and nature conservation are more strongly emphasized than before.

'Environment and Planning Act (Omgevingswet)'

The Environment and Planning Act describes the rules on the protection and utilisation of the physical environment. It is supposed to simplify and to merge the rules for spatial development in the Netherlands. Goal of the government is through this Act to ease the start of building projects. Furthermore, the various projects and activities in the fields of spatial planning, environment and nature, sustainable development and the different regions should be better linked. The Act is not yet established but is already developed and under revision and will come into force on 1 July 2023. The Act will replace several existing laws, including the Water Act, the Crisis & Recovery Act, and the Spatial Planning Act. The new law ensures that climate adaptation, nature and biodiversity are comprehensively considered in new projects. The Act is more in line with European regulations and translates EU policies into Dutch law. The Environmental and Planning Act of the Netherlands promotes nature-based solutions for health. Local and regional authorities have given the opportunity within the scope to engage measure for health promotion and protection. Nature-based solutions play an important role in health promotion through improving recreation, social cohesion, mental wellbeing, and absorbing pollutants. Thus, the Act is implicitly promoting the implementation of NBS.

'National Water Program 2022-2027'

The National Water Program (NWP) This NWP describes the main lines of the national water policy and the management of the national waters and waterways. For water policy, the NWP is an elaboration of the National Environmental Vision. Important parts of the NWP are the river basin management plans, the flood risk management plan, and the North Sea Programme. It describes the consequences of climate change, protection against flooding and a robust freshwater supply against increasing drought as current and future main challenges the Netherlands must face. The NWP is designed as integrated approach to planning and does not stand alone in its disciplines. Thus, included are the physical living environment, such as energy transition, housing construction, nature restoration and agricultural transition. The soil and water system sets preconditions for spatial developments. Within the NWP tasks are described and it is explicitly mentioned that NBS are going to play an increasing role in the water domain.

'Noorderzijlvest Water Board's flood defence management plan (Waterkeringbeheerplan)'

This plan describes the policy and management of the core task of flood defences and ensuring water safety in Noorderzijlvest's management area which comprises the northwestern half of the province of Groningen, northwest Drenthe and the Lauwersmeer area. The plan indicates which goals the water board is pursuing regarding water safety. Additionally, tasks and activities for the coming years for Noorderzijlvest are worked out in the Flood Management Plan.

4.2 Level of Support

The policy documents were screened for the explicit or implicit mentioning of NBS or related terms. However, given the relative newness of the term NBS and predicted infrequency with which it will be explicitly mentioned in policy instruments, a range of related concepts were also included in the review process. These are 'green-blue infrastructure', 'ecosystem-based approach', 'ecosystem services', and 'building with nature'. Those related concepts and terms are part of the aforementioned findings of the literature review and are illustrated in the theoretical framework (Chapter 2.3.2)

The extent to which a policy instrument supports the deployment of NBS was assessed by Davis et al (2018) and four levels of support were identified (Table 6). The policies assessed were evaluated on the basis of this distinction.

Table 6: Level of support for NBS in respective policy documents (Davis et al 2018, 16)

Level of Support	Description
Strong explicit support	NBS or related terms are explicitly mentioned and strongly embedded throughout the framework, including in objectives, policy measure design and/or supported actions.
Strong implicit support	Strong framing of nature as a means to address (select) societal challenges, with multiple references to/support for elements of NBS or NBS intervention types; no explicit mentioning of NBS or related terms.
Medium support	NBS and related concepts are not a prominent feature, but deployment is supported through references to/support for individual NBS elements and interventions.
Low support	NBS are neither a prominent feature nor relevant for/mirrored in policy measure design and supported actions.

The level of support for NBS can be defined when scanning for mentions of NBS, NBS-related terms or references towards NBS in the policy documents reviewed. Based on this analysis, the following table can be summarised (Table 7).

At this point, a remark must be made about the selection procedure. The selection of policy documents for review was based on the principle that the policy relates to an issue-specific category. Those are climate adaption (adaption), flood risk management (water), and Biodiversity. This categorization of the policy fields is shown in Table 7. Accordingly, all documents analysed are at least in medium support of NBS.

Table 7: Allocation of the level of support to the policies

Policy document	Level of support
Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction and supplementary information	Strong explicit support
IUCN Global Standard for Nature-based Solutions	Strong explicit support
The Sendai Framework for Disaster Risk Reduction 2015–2030	Strong explicit support
Paris Agreement	Medium support
NDC by EU representing NL/GER	Strong explicit support
Water Framework Directive (2000/60/EC)	Strong implicit support
Adaption Strategy (COM/2021/82)	Strong implicit support
Green Infrastructure Strategy (COM/2013/0249 final)	Strong explicit support
Biodiversity Strategy (COM/2020/380)	Strong explicit support
Federal Spatial Planning Ordinance for Trans-State Flood Protection (BRPHV)	Medium support
Action Programme Lower Saxony Water Landscapes	Medium support
Environment and Planning Act (Omgevingswet)	Strong implicit support
National Water Program 2022-2027	Strong explicit support
Waterkeringbeheerplan	Medium support

4.2.1 Answer Sub-Question I

Top-down motivation for embedding the Innovation

The analysis of the above policies has shown that NBS are becoming more and more present. This is increasingly developing according to a hierarchical top-down structure. International conventions in particular initiate change and the translation of innovations such as NBS into regional policies. As the data basis and financial support for studies are often provided by regional authorities or members, these conventions can often be seen as a motivation for these institutions to incorporate the results into their policies. This in mind, an answer to the first sub-question '*How are nature-based solutions embedded in relevant policies?*' can be given. Germany has implemented the requirements of the Sendai Framework and translated them into the 'German Strategy for Disaster Resilience'. Within the 'Adaptation communication' guide, the Netherlands' submission to the United Nations Framework Convention on Climate Change, they have taken up the subjects of the Sendai Framework as well as the Paris Agreement and other international frameworks and/or conventions. Both countries explicitly

mention NBS in these publications and emphasise on its crucial role in climate adaptation. But besides the translation of the voluntary frameworks, Germany has so far rarely or not explicitly mentioned or integrated the term NBS or related terms in its internal guidelines. In some cases, they are implicitly mentioned but not sufficiently. To change this, the government envisages the development of an Action Plan on Nature-based Solutions for Climate and Biodiversity. The BMUV wrote a paper on the key issues which lays the foundations for this Action Plan. When looking at the level of support, it becomes noticeable that it decreases the smaller the scale becomes. This is an indication of the theory that innovations such as NBS are making their way top-down, from the international to the local level. The currency of the policies also plays an important role in this analysis. The currency of the policies also plays an important role in this analysis. In contrast to the other policies at the same level, the relatively newly implemented directive 'National Water Program 2022-2027' (NL) already describes strong explicit support for NBS.

4.3 Influencing the Implementation

The research within this thesis focuses on resilience and how NBS can contribute towards improving resilience. Integrated into the flood risk management strategy, NBS are highly promised to provide an increased flood safety while simultaneously facilitating ecological, economical, and social interests. Given this theoretical premise, and the political ambition to increase the implementation of such measures, the purpose of this research is to find out how these measures can be realised more easily.

The planning process and subsequent the implementation can be influenced positively or negatively. Those barriers and enablers that are often encountered in the implementation of NBS were analysed and identified in this study. This was done by means of a literature review and by interviewing representatives of the case studies. The following results will give an answer to the sub-question 2, '*What are barriers and enablers within the implementation of nature-based solutions?*'

4.3.1 Barriers

Inadequate financial resources

As NBS are embedded in different international as well as national conventions, regulations, and policies, as elaborated upon in the previous chapter, the financial resources can be a barrier. This issue revolves around funding schemes, budget allocation, and the general financing approach.

All interviewees mentioned insufficient funding as a barrier during the planning phase. However, the interviewee from the water board Noorderzijlvest differentiated this again, as the project 'De Onlanden' was carried out in two phases. He confirmed the thesis for the first phase, but not for the second phase. This can be attributed to the fact, that the first phase was declared successful and thus best practice. This made it easier to obtain adequate funding in the second phase. “In the past, it was of course [a barrier], there was a lot of discussion who was paying this and this measure. But in the case of the Optimalisation, it's not anymore a discussion about finance” (Resp. C).

Among other things, the problem can be traced back to insufficient funding or unreasonable bureaucratic difficulties. The latter in particular can be linked to inadequate regulations. A respondent from the maintenance association ‘Große Aue’ names this connection as a barrier. “Insufficient [funding] in the sense that, of course, too little money is being allocated by the state. That is true, but it was actually the modalities of procurement that were an obstacle here.” (Resp. A)

Path dependency

A barrier due to path dependency was not identified in the implementation of any of the measures in the case studies. But the reasons against this are different. A representative of the UGA said in this regard, that they cannot really give an adequate answer. “Since we didn't approach this project from a flood perspective anyway, that wasn't really the issue”. The 'De Onlanden' project, on the other hand, is dedicated to flood protection. “We are in a kind of transitional situation. When you test your system for climate change and climate scenarios and you find that you have to do something to raise the standards for water security, in the past it was always, "Okay, we as a regional water authority will take the technical measures, we can solve it". But nowadays the discussions go in a different direction: "Do we have to take these physical

measures?" We want to look more and more for natural solutions, like nature-based solutions." (Resp. C). The representative of the Province of Groningen answers the question whether the measure finds itself within a path dependency with the words: "It's breaking out".

Institutional fragmentation

The next associated barrier 'institutional fragmentation' showed divers results. Within the German case the interviewees emphasized on the good cooperation between the stakeholders. As this led to a decrease in distance the collaborative work "was an effort, but an acceptable effort. It worked well here" (Resp. B). Thus, institutional fragmentation was in this case not a barrier. Within the Dutch case, it well was. "*Now it becomes a barrier because people are more concerned with space and spatial planning. In the past, it was clear that the regional water authority is the organisation that takes care of the measures. But we took the measures only within our water system. But today, and also in the future, we are dealing more and more with spatial planning. And then you must deal with the municipalities. And that is becoming more and more difficult."* (Resp. C). The respondent from the province of Groningen defined the fragmentation even further as "*the most difficult thing about De Onlanden. It is located mostly in Drenthe, but Groningen has a high stake in it. This is the biggest fragmentation. It's a problem. That makes it a more challenging project, especially from a political standpoint*."

Inadequate regulations

Regulations help with planning at various stages. These can, for example, initialise a project, support its implementation or ensure its completion. Accordingly, adequate regulations can be of immense importance in the implementation of measures. As noted above, NBS are a fairly new concept in flood protection. It is therefore important to see whether the regulations in place supported the implementation of the case studies or, as asked here, were inadequate and therefore a barrier.

In its statements, the maintenance association 'Große Aue' mainly refers to regulations that have made financing more difficult. However, regarding the project as a flood protection measure or even as a NBS, a conscious differentiation was made. In the case of the 'Große Aue' measure, the focus was on nature conservation, the green aspect. It was not planned, or was neglected, from the point of view of flood protection. The fact that the blue side of this measure played a rather subordinate role helped to simplify the regulations for the project.

When asked whether this would also have been the case if the project had been a NBS from the outset, the answer was vaguely negative. NBS are so far underrepresented, especially in local regulations, and still need to be translated from EU regulations.

The answer was much more specific in the interview with the representative of Noorderzijlvest. "*There are no definite regulations to look for nature-based solutions and there are already regulations that interfere. But there is a new law, which is still under construction [Omgevingswet]. The idea behind this new law is that we must work more and more together. The municipalities with regional water authority and the provinces will work more together, so it is easier for the inhabitants to talk with the governmental organisations"* (Resp. C) This problem of transition to a new regulation was also emphasised by the representative of the province of Groningen. "*the transition of legislation, that is now a huge barrier. It makes it a bit more uncertain that you have to choose it. Back then it wasn't*" (Resp. D).

All interviewees confirmed what the methodological analysis had previously revealed. Insufficient regulations can be, and have been, an inhibiting factor in the planning process of the measures. It should be noted here that regulations are in most cases formulated for a specific purpose and a specific timeframe. Innovative concepts, such as NBS, therefore require specific policies and regulations that allow to implement them.

Availability and adequacy of data

Within the planning process the availability and adequacy of data is essential. This has a great influence and can determine the success of a project. The actors involved seem to be aware that this is a prerequisite. "*The water board always has to maintain the data. Every project starts with a data analysis and fieldwork and calculating how high the levels are. And that's always the time that it can always be better. The system doesn't work that well, yet. Did it stop the project? No it didn't!*" (Resp. D). Accordingly, none of the interviewees mentioned it as a direct obstacle.

Limited land and time availability

The obstacle of limited land and time availability was described by the interviewees as no hindrance. It should be noted, however, that both were able to remove these factors from their calculations under special circumstances. Therefore, those involved in both projects are well aware that this can be an obstacle. "*In the past it was maybe a barrier because we had to look*

for new lands and we had to create this retention area like it is now in combination with nature. Before the measure could be realised the land use had to be translated from agricultural land towards nature conservation area. But nowadays all the land we need, is already transferred to nature. If we decided to store water more upstream, we would be facing this barrier that we have to transform various agriculture [areas] to nature".

The project of the 'Große Aue' was implemented after the State had already purchased the land and the motivation to implement the project quickly was that high, it can't be named as issue. "*This project could be implemented explicitly because the space was already there. When you do new projects, it often fails because of the availability of space*" (Resp. A).

Implementation of measures

When it comes to the implementation of measures, this barrier is probably the vaguest described. To have a common understanding, it was further defined. Thus, what is meant here is the implementation itself, the phases, stages, and steps could be carried out continuously. Within the project of the 'Große Aue', this barrier has not been an issue. Concerning the Dutch case, the respondents were not able to give an explicit answer, but could imagine that an obstacle in this direction might occur. "*Probably the seasons, the working periods are the most time constrained. Seasonal restrictions are the most time constraining, compared to other works or public works You are not allowed to work on the dykes in storm season, from October till March*" (Resp. D).

Resistance/lack of acceptance in the population

When measures are implemented, especially if they are visible, there is often resistance or a lack of acceptance among the population. Within both cases this has been experienced. But, "*It becomes less. It's more due to the growing awareness among the population. Through constant communication, also on our part, with those affected, but also through the general transition in the population*" (Resp. A). Within the implementation of 'De Onlanden' the reactions from the population where even divers, as the representative from Noorderzijlvest explained. "*The nature related NGOs now are critical. Because we are more or less changing the IDs of the retention area. And because we now want to steer when to resolve water after events. The NGOs are really critical at least. But on the other hand there are also people who will speak positive about the regional water authority because water safety is really, really important. So*

you have all kind of reactions" (Resp. C). The respondent from the province of Groningen simply explained this with the words "*It's water safety, people tend to accept it*." (Resp. D). This is probably especially true for this area, as devastating floods have occurred here.

4.3.2 Enablers

Partnership among stakeholders

A good partnership and cooperation between the stakeholders was especially emphasised by the maintenance association 'Große Aue'. The interviewees had already mentioned the good cooperation while speaking beforehand about institutional fragmentation. They named it as an immense push factor for the project but also as unusual on this scale. The representative of Noorderzijlvest could also speak of a facilitating factor here. "*For sure. That's really important to have something like that*" (Resp. C).

Knowledge sharing mechanisms and techniques

Knowledge management is the process of capturing, sharing, developing, and using the knowledge efficiently. Knowledge sharing means that an individual, team, and the organization share the knowledge with other members in the form of inter alia grid and cloud computing or peer-to-peer reviews (*Navimipour & Charband 2016*). Knowledge sharing mechanisms and techniques are in today's competitive age a requirement to improve and a good way to find solutions to obstacles. Within the interview the representative of Noorderzijlvest confirms this and says, "*we have to be transparent about the data you use and also evaluate the high-water events, the periods when you want to use this retention area*" (Resp. C). The representatives of the maintenance association 'Große Aue' could not particularly emphasise this as a supporting factor in their project.

Economic instruments

Economic instruments serve to provide certain incentives to create awareness for the use of water resources. The goal is as well to ensure an efficient use of the resources. These can include tariffs and charges, resource use fees, pollution charges, purchase of rights (in this case water use), and subsidies. In the case of the 'Große Aue' the interviewees named this not as an enabler, even rather a barrier for the project implementation. A different view on economic

instruments were explained by the representative of Noorderzijlvest. "*If we are the only one who has to pay, it's too expensive. Maybe in the future it's possible, but in that case we need more organisations who will put money towards it. If you can organise some kind of economic mechanism that would help*".

Plans, acts and legislations

This aspect does present itself as somewhat a counterpart towards inadequate regulations. Specific supporting plans, acts and legislations can facilitate the implementation of measures such as the NBS. In favour of this, the maintenance association 'Große Aue' said, "*without the Water Framework Directive, [this measure] probably would not have been done*" (Resp. A). despite agreement, the answer in the interview with Noorderzijvest is a bit more theoretical "*they [plans, acts, regulations] would help us. But still, there is a lot of uncertainty about what is nature based solutions*" (Resp. C).

Effective monitoring and evaluation systems for implementation process

The interviewees from the maintenance association of 'Große Aue' could not find effective monitoring and evaluation systems for the implementation process as enabler within their planning process. In the case of the project 'De Onlanden', the answer was more differentiated. Noorderzijlvest's statement referred to the evaluation, which was rather negated in terms of an enabling factor. "*If you want to take steps forward, you'll also have to look backwards. You must learn from the past. Evaluations, for example, are really important. And that step is for us very difficult. We say evaluation is important. But it's not something we always do*" (Resp. C). The response of the representative of the province of Groningen referred to an effective monitoring process and mentioned the positive cooperation with the universities in this respect. "*There is quite a lot of cooperation between the RUG and other universities and higher educations*" (Resp. D).

Open innovation and Experimentation

Open innovation and experimentation as enabler was negated by all interviewees. "*There's actually no room for innovation in terms of the timeframe and 2027 is quite short term. Water safety is really important, so we have to meet this goal. Therefore, if you look at the room for innovation there is also a risk that you don't reach this goal*" (Resp. C).

Combining NBS with other elements and grey infrastructures

The combination of NBS with other elements and grey infrastructure as an enabling factor was frequently mentioned in the literature due to its simplistic nature. This can be explained by the circumstance that structures which already had a (here mostly) blue use are more predestined to be extended by green structures. The interview revealed that this was not the case with the "Große Aue" project, as there was no grey infrastructure beforehand, and the existing elements were removed. With the implementation of the 'De Onlanden' project it was different. Existing weirs and quays, as well as surrounding dykes were included or modified in the course of the implementation.

Appropriate planning and design

When it comes to appropriate planning and design the interviewees were all on the same page and named this as an enabler. The representative of Noorderzijlvest explained, "*it was in the situation after '98. The processing and planning, it was the success factor because you combined two goals together and also with a tight deadline of 10 years, it became a solution that was really the success in that time*" (Resp. C).

4.3.3 Sub-Question II

Everything that comes into existence does so in the context of countless causes and conditions

The results of the above conducted analysis gives insights to the sub-question '*What are barriers and enablers within the implementation process of nature-based solutions?*'. Several positive and negative influences on the implementation process could be identified. As emerged from the literature research, they are the most common barriers and enablers. However, they were perceived differently by the interviewees within the implementation process. Overall, most barriers have been experienced either way by both or by neither. Even if the results differ, the answers tend to overlap or even complement each other. A little different were the answers when it came to the enablers. Here more differentiations were made. But even though, important information was able to be drawn out of the interview answers. This can be seen as chance for future implementation and planning processes. Further results regarding the chances and challenges of implementation can be discussed based on a SWOT-analysis. These will be presented as part of the discussion.

4.4 Building Resilience

Flood resilience comprises the three elements robustness, adaptability, and transformability (Restemeyer et al 2015). All three components influence the status of resilience. Each is considered differently and has a different weighting in flood protection plans. Each of them also poses different challenges. In order to find out what contribution a NBS measure can make to resilience, the case studies were examined representatively, and the three components were analysed. The results will give insights for an answer to the third sub-question, '*How can nature-based solutions contribute to 'build resilience'?*.

4.4.1 Robustness

Robustness is one component of the building resilience concept. One perspective of this factor is the basis it constitutes for flood protection. It represents the physical structure to withstand a shock event. Robustness often serves as the foundation within the transition towards more integrated flood risk management. This can also contribute to the planning and implementation of NBS. New plannings and innovative solutions in integrative flood risk management are generally used in combination with the existing technical structures when it comes to the protection of flood prone areas. Through the establishment of NBS, multi-functional designs are being created. This often leads to a win-win situation, as the requirements for function, effort and cost efficiency are met.

Both measures in the case studies are designated as NBS and thus fulfil functions for flood protection. In the interviews, the respondents explained that the previous intentions of the measures were different. The German case of the Große Aue "*was planned proportionally more green than blue*" (Resp. B). When questioned about the initial goal of the project respondent A explained that the project "*was about designing a river landscape close to nature. It was about fulfilling the requirements of the area regarding the special needs of the local bat species. And ultimately it was about reactivating a floodplain landscape with structures of oxbow lakes that are as close to nature as possible*" (Resp. A). Whereas the Dutch case of 'De Onlanden' was from the first idea on a project designated to flood protection. "*The original goal was inspired by the flood events of the '98. So, an already low-lying area was used to be the water retention area. Flood protection was the main goal*" (Resp. C).

Despite the non-specific focus on flood protection, the structural features of the 'Große Aue' project are also useful in parts for flood protection. Considering that the area is located along a river, it can work as a buffer for highwater levels and thus prevent floods. Additionally, the area can hold back water masses when it comes to heavy precipitation rates. This was also perceived by the population. According to the maintenance association, this has even taken on too great a role in the public perception. "*It has always been perceived that way in public, more so than we intended. But it is not an explicit flood protection project. It is more related to nature conservation and species protection than to flood protection*" (Resp. A).

In the 'De Onlanden' case, the pressure of the previous floods brought the blue side of the project into focus, but the green side was not neglected. "*Flood protection was the main Goal from the water board, but it is also about the development of nature. Nature has also taken an increased importance for many other organisations*" (Resp. C). But, as it was already exploited in the previous subchapter (Chapter 4.3.1), this does not only have positive aspects. NGOs with a focused interest in preserving the function of nature have become a serious opposition in the 'optimalisation' project, the second phase. From the point of view of the province of Groningen, it must be emphasized that this is primarily a technical measure. "*It is a robust measure. There are some weirs so you can choose what water level you want in the area. It's all regulated. It can be actively put to use by figuratively pushing a button. Although in the minds of some national organisations they see it as natural system. But it's not a natural system, it's a natural area, but it's highly regulated regarding the water level*" (Resp. D).

The situation is different with the 'Große Aue' project. When asked about the performance of the project's technical design against flooding, this is described almost as a positive side effect. "*The riverbanks are not paved, they are purely natural ones. The growth that then develops on the embankments will hopefully be so strong at some point that it will be able to withstand [floodings]*" (Resp. A). And also for the future, the maintenance association is quite positive that the measure can show its worth with regard to smaller floods. "*We don't assume that anything has to be changed after a flood. The water sloshes in and out and then we look at what has happened. That's because the area is allowed to develop naturally*" (Resp. B).

At 'De Onlanden', the focus was on flood protection from the very beginning. Accordingly, the technical design was also developed with this in mind. Fixed weirs are replaced with movable ones and existing quays were raised at a number of locations. This specifically planned flood protection measure has already proven its technical design. "*In 2012, it was realised, finished.*

And in the same period, we already had to use this water retention area. So right from the start of its completion, it was a success as a retention area for water and for nature" (Resp. C)

4.4.2 Adaptability

The second aspect in building resilience is adaptability. It describes the ability of a system to adapt to a shock event and thereby minimising the vulnerability. This is achieved through the duality of physical and social change as well as adjustment. It thus describes the capacity of actors in a system to influence or manage resilience and to adapt within the system to make it less vulnerable. These capacities can be described by collaboration. Collaboration can influence the physical outcome as well as it stimulates societal change. By bringing stakeholders together and through consultation and information, participation and cooperation between sectors is ensured. To understand the degree of this multifunctionality of collaboration, the interviews included questions on the stakeholder participation.

The sequence of stakeholder consultation and cooperation plays an important role in the planning process. In order to plan and implement the measure effectively, hierarchy and timing are closely linked. The maintenance association of the 'Große Aue' has described this process. After forming a working group the affected municipality and great waterboards participated. In the next step all relevant stakeholders were invited. These included everyone known from watercourse development projects, all those who consider themselves affected, agriculture sector of the district, the lower water authority, and the lower nature conservation authority "*Then later the local stakeholders were also involved. We informed about the measure and the local impacts in a public event*" (Resp. B). Similar to this process, the relevant corresponding stakeholders were involved for the Dutch project.

In both projects, the motivation to implement them successfully was very high. Accordingly, all representatives described the collaboration as good to very good. However, it should be noted that the intentions behind the projects differed. This is important to mention in order to be able to take this into account in future planning. "*Within the first implementation of De Onlanden it was the common sense of urgency that was probably pretty high since the people had seen the high waters. Therefore, there was a lot of consensuses between the stakeholders and the collaboration went rather well. Now in the optimalisation phase, there is less pressure. So, there is more room for discussion and conflict*" (Resp. D).

Somewhat more difficulties were described with regard to the German case. "*No one was standing in the way or sitting it out, actually everyone was there and yet it was difficult for us. Because there were so many things that had to be considered at the same time or side by side or one after the other. And then to interlock the whole thing with financing guidelines that make high demands. But since all the actors were very flexible and really made an effort in the discussions that were held, the cooperation can actually be described as positive throughout*" (Resp. A).

4.4.3 Transformability

Transformability is the ability of a system to change from a previous situation into a new one. It can also be regarded as a system shift. These shifts can be described through physical changes (in the physical environment) and social changes (mind-set of citizens, mind-set of politicians). With the regard towards building resilience, the shift refers to social and political change, which is why the focuses within this thesis lays on these two.

All respondents confirmed that awareness and support among both citizens and politicians, for climate adaptation measures in general as well as specifically for NBS is increasing. This process was also initiated by the stakeholders of the measures. "*Through the information event and the citizens' meeting, we have taken all [civic groups and politicians] with us. The interest is certainly there. Not from everyone, but since the measure is basically meaningful and probably necessary nowadays, it was noticed and accompanied. And yes, we certainly had media attention*" (Resp. A). The latter is an important aspect within the process of transforming the awareness. The effects and dangers of climate change are more and more present within the media. The increased awareness and sensitivity towards impacts, puts pressure on climate adaption measures such as NBS are. But "*with public stakeholders, it's a matter of timing. You can't show [the plans] too early and say 'they don't know yet, or we can't say anything about it'. If you show them too late, they say, 'Man, it's all ready. They should have asked us before. Catching that moment, which is the right moment to go public, is not easy. We tried to work our way through with tact and sensitivity*." (Resp. B).

Somewhat more bureaucratically but still similar, the representative of the province of Groningen discusses this process in the Netherlands. "*Every project in the Netherlands has a participation officer or people organise that. It's a lot of communication and participation. And the*

Onlanden is a very visible project for a lot of people. That makes it also interesting for news organisations. So, there's a lot of involvement" (Resp. D).

The representative of Noorderzijlvest summarises this state within the transformation of participation. "*We are now in the situation that we are also transforming and that we in the past were really looking for technical solutions. But nowadays, looking towards the future, we also think about, that we have to accept an excess of water and you have to create awareness about that. And that's not only what we say, but also our members of the board, and other people from other organisations. You see that there is a change in mindsets. But still, of course, there are also people who don't mention this and are still on the classical way of thinking*" (Resp. C).

4.4.4 Sub-Question III

The compiled research through literature and interviews has given information which can be used to assemble an answer to the third sub-question of this thesis, '*How can nature-based solutions contribute to 'build resilience'?*'. The results are composed for each aspect of 'building resilience', robustness, adaptability, and transformability.

Even that both cases started with a different initialisation, both contribute to local flood protection. If the retention areas of the projects are not flooded, they serve with valuable nature functions for the preservation as well as for the protection of the environment. Before 'De Onlanden' was implemented, an alternative flood protection solution upstream was also discussed as a potential measure. This is still being discussed but was initially decided against mainly for financial reasons. The measure on the German side was initially planned for nature conservation. The additional flood protection function of this project is also an economically positive decision here. Including these aspects underlines the relevance that both projects are considered a NBS. Due to their technical design and their ability to withstand, they fulfil important aspects of robustness. They thus contribute to of building resilience. The Province of Groningen is confident about this project. "*It's a resilient measure. The development of 'De Onlanden' show a way to adapt to the future*" (Resp. D). Adaptability can be increased through collaborating with different stakeholders on different levels and between sectors. The elaborated examples regarding the adaptability show that collaboration between stakeholders is a sensitive aspect within the planning process. The concerned stakeholder, the amount, timing, communication, and other variables do affect the effectiveness of a project. However, it turns out that

when everyone pulls together, obstacles are easier to overcome. And this is exactly what could be observed in the two case studies, good collaboration and participation. However, the latter was characterised by informing the public rather than handing over decision-making power. Accordingly, even if limited, a positive contribution of an NBS intervention to the process of 'building resilience' can be identified. The respondents agreed that a transition towards more awareness and support for climate adaptation projects in general, both in the public and in politics, can be witnessed. This is due, inter alia, to increased information and the presence and perceptibility of the consequences of climate change that are already occurring. In summary, a change in mindset can be recognised. This indicates that a transition is taking place, which would be positive in terms of climate adaptation, but must be considered carefully. Bottom line, based on the segmentation in robustness, adaptability, and transformability a contribution from NBS to 'building resilience' can be identified.

5 Discussion

To gain a better understanding of the connection between NBS and resilience, the results are discussed in this chapter. In the beginning the findings for the fourth sub-questions are presented, which regards the lessons learned. Then the already gathered results of the previous chapter are put into a SWOT-analysis. The resulting findings on the chances and challenges of NBS in context of 'building resilience' are being discussed. Later within this chapter the results are brought together into perspective of the relevant variables of the conceptual model, to answer the main research question '*How can the implementation of nature-based solutions enhance local flood resilience in the Netherlands and Germany?*'

5.1 Lessons learned (Sub-Question IV)

In recognition of this thesis' focus on resilience within the theory of equilibrium and thus it being a constantly changing process without an ultimate goal, a generalization of the results is not feasible or would not be correct. Only the current situation can be evaluated. However, this is in no way a disadvantage or even a contradiction to the relevance of this study. Instead,

it makes an important contribution to the evaluation of the implementation process of NBS and thus to the improvement of the general conditions. As the consideration of the lessons learned is an important aspect in the evaluation of the results, it is nonetheless possible to use such as representative findings of the moment. Therefore, they can be generalized and used to improve future planning and implementations processes.

There are two main findings regarding the lessons learned. First is collaboration between stakeholders. The results from the literature review showed that poor collaboration is an obstacle and good cooperation can positively influence the process. This was confirmed and elaborated by the interviewees. "*It is indeed the good cooperation between the individual authorities. If you are open with each other, you can achieve something. Being open and involving all those concerned shows that it certainly works better*" (Resp. A). The second lesson learned concerns timing. A distinction must be made between the actual timeline of the process and the time factor for which the project is intended. "*You must start really, really, really in an early stage to be integrative, not start in the stages which in it's clear for you what kind of message you want to take, but before that. And the other lesson learned is we must look really, really ahead, not only for up to ten years ahead, but, for example, 2100s. And that way you can make a difference because these kind of types of measures take a lot of time to be implemented*" (Resp. C).

In addition to the lessons learned, the experience gained from previous implementations is as well important for the evaluation. Accordingly, in the interviews it was also asked what would have to change from their perspective for more NBS to be implemented. The responses closely matched the barriers identified, in the context that if these could be removed, further implementation of the NBS would be easier. Another aspect that had not been explicitly mentioned before was that "*We are not working with the necessary intensity on the projects or on the problems that we have to solve within the Water Framework Directive or flood risk management. There is simply a lack of staff to do this*" (Resp. A). To extend or elaborate on this question, it was also asked what specific changes policymakers could undertake to achieve this goal of facilitating the implementation process. One thing in particular was stressed here, and that is the aspect of awareness. "*There should be awareness that there is a maximum which can be reached with technical measures. Adaption is part of the solution and people should be aware of that, also towards the future. And maybe that's not really a nice message from the policy maker, towards the inhabitants. But, well, that is the current situation we are in now*" (Resp.

C). Another answer referred to the current situation regarding stiff regulations. "*Most systems, especially in the Netherlands, are developing systems or constantly adapting systems and they need to be dynamic, but dynamic doesn't work in current legislation*" (Resp. D). When asked about the outlook and how the NBS will develop in the future, one answer was unequivocal. "*If there are anywhere some examples with a positive impact and we are familiar with them, for sure we will implement them more. And even if there is a positive cost benefit analysis with it, then for sure they develop in a positive way*" (Resp. C).

This gives an answer to the fourth sub-question '*What are the lessons learned within the integration of nature-based solutions?*', which can be summarised as good collaboration being key for a successful implementation and the awareness of time for sustainable development.

5.2 Challenges and Chances (SWOT-Analysis)

The SWOT matrix presented in Figure 5 shows the main findings on the challenges and chances of NBS that could influence the decision-making process for their implementation. In this study, the SWOT analysis follows the findings from the methodological research and interviews. These findings are the basis for the interpretation of the research results. The interpretation is based on four questions that show the correlation and interdependencies within the SWOT-matrix.

internal	*Strength* • partnership among stakeholders • knowledge sharing mechanisms and technologies • effective monitoring and evaluation • appropriate planning and design	*Weakness* • fairly new concept • institutional fragmentation • implementation of measures
external	*Opportunity* • economic instruments • plans, acts, legislations • open innovation and experimentation • combination of NBS with other structures or grey infrastructure	*Threat* • resistance/lack of acceptance • inadequate financial ressources • path dependency • inadequate regulations • availability and adequacy of data • land and time availability

Figure 5: SWOT-Analysis

The first question concerns the weaknesses that lead to exposure to the threats. The first weakness describes the issue of NBS as a fairly new concept. This is described as weakness because it does not have its deserved acceptance and position. In the context of the first analysis question, it may therefore lead to a threat because it could provoke resistance or a lack of acceptance. Another weakness which can leave us at the mercy of a threat is the connection of institutional fragmentation and inadequate financial resources. As stated in the interviews, institutional fragmentation needs to be reduced to achieve an effective and positive outcome. However, if this is not the case and institutional fragmentation increases, it could lead to an inconsistent approach to applying for funds. The consequence of this would be that the realisation of the project would be threatened by insufficient funding. Implementation of measures means the division of the individual steps that must be processed successively. Accordingly, this weakness can become a threat if inadequate regulations make the process of conducting those sub-steps difficult, in terms of time, finances or inadequate bureaucracy. The weaknesses are also linked to the opportunities in such a way that they hinder the use of the opportunities. This describes the second analysis question for the SWOT-matrix. The first connection in this regard would be between the weakness of NBS being a fairly new concept and the opportunity of open innovation and experimentation. This combination is a perfect example for an interdependence of two aspects within the implementation. On the one hand, there is the negative influence. As a relatively new concept, NBS shows little experience, information, and best practices. This can have a negative influence on the design of space for the implementation of innovations and experiments, as the risk is very high. On the other hand, this can also be reversed. The strength of NBS as an innovation can compensate for the insecurity as weakness that comes from the fact that it is still a relatively new concept. Another important connection can be seen between institutional fragmentation and economic instruments. Institutional fragmentation can lead to a weakening of cooperation and collaboration, making it difficult for consensus to emerge in the planning process. Accordingly, the effective design of economic instruments to advance the implementation of NBS may be hindered. The first two analysis questions have highlighted the negative connotations and thus the challenges that can arise in the implementation of NBS. The third and fourth questions allows to draw conclusions about the chances. In terms of which strengths help to manage threats, the link between knowledge sharing mechanisms and availability and adequacy of data should be addressed. As internal positive variable within the SWOT-analysis, knowledge sharing mechanisms describes the chance for

stakeholder to develop information and data which might be missing. Within the interviews this issue was addressed as well. Therefore, this as strength can help manage the threat of availability and adequacy of data. Another matter that was discussed in the interviews and shows in the SWOT-analysis is the connection between the strength of effective monitoring and evaluation and the threat of path dependency. To escape from a lock-in resulting from a path dependency, a very important aspect is the monitoring and evaluation process of data from previous projects and processes. This link shows that managing a threat through a strength creates a chance for positive implementation of NBS. The final question for the analysis explores how strength can exploit opportunities. This reveals further chances. A good partnership between stakeholders is an enormous strength. This is not only one of the essential findings of the literature research but has also been emphasised in the interviews. Properly applied, it creates the opportunity to use, influence and shape plans, acts, and legislations as well as economic instruments. If good cooperation is used to seize these opportunities, a positive influence on a planning process and thus on a successful implementation can be seen. The connection between appropriate planning and design with the opportunity of combining NBS with other elements or with grey infrastructure shows a lot of potential for the exploitation of opportunities by a strength. It has several advantages, as the combination of these two variables can have a positive impact on different sectors. From a financial point of view, this concerns economic issues as well as the social sector through, for example, public participation. Great benefits for the environmental sector can also be observed in the use of existing structures, especially if grey infrastructure is included and not demolished or newly built to conserve resources.

The interpretation of the SWOT-analysis has given many insights on the chances and challenges for the implementation of NBS. This provides insights into which connections can influence the process positively but also negatively. By looking at the connections and interdependencies within the matrix, it is possible for the participating actors to theoretically prepare for potential chances and challenges.

5.3 Nature-based solutions and resilience (Main research question)

Several findings were gained during the research so far. The results led to the answers to the sub-questions. To proceed, the research findings are discussed. The information will then be

gathered for a final assessment which will lead to answer the main research question '*How can the implementation of nature-based solutions enhance local flood resilience in the Netherlands and Germany?*'.

A common challenge of modern time are the changing conditions due to the climate change. The implementation of adaptive measures gains increasing importance due to severe weather events from the near past and the severe issue of biodiversity loss. With this pressure in mind, international conventions developed policies and recommendations. As NBS shows a high potential to prove itself in flood protection and nature conversation issues, while providing economical, ecological and social benefits, they receive increasing attention and are emphasised especially at higher levels. The policy analysis showed that the presence of NBS in such is increasing. In comparison of the policies a top-down decline of the support for NBS is recognisable. This might be the case, because the stimulus for action on issues such as climate change comes from international conventions. It takes time for these to be translated into local policies. To what extent this time frame is appropriate cannot be concluded from the results of this work. However, in the Dutch translations NBS have already found more support through explicit mentioning than in the German translations. Despite this, the motivation to integrate NBS into local flood protection management can be seen from both countries.

The integration of such innovative concepts into policies is an important step for successful implementation. To put it simply, an NBS can only contribute to climate adaptation if it exists. Accordingly, the enablers and barriers for effective implementation were also examined within the scope of this thesis. For this purpose, the most prominent influencing factors were identified. Whether these variables generally occur during implementation is considered somewhat controversial. The question of whether these variables generally occur during implementation is considered somewhat controversial. Within the planning process, contextuality must be considered. A simple one-to-one transferability is therefore hardly possible. However, it is helpful to be aware of the different barriers and enablers. If these are considered, it can have a significant impact on the success of an implementation process.

It has been found that a good partnership among the stakeholders can be the biggest strength within the planning process. From all interviewees, this was named as key-factor for an effective implementation as such can be seen interdependent towards many other variables. Additionally, good cooperation and communication has shown up within the SWOT-analysis to be crucial. Here not only the individual factors that can influence the process but also the connections

between them were revealed. Other chances for a positive implementation of NBS were therefore obtained. But it is not only the positive aspects that are important to address. It is also essential to recognise the negative aspects, here weaknesses and threats. If these are ignored, they may be recognised too late or not at all and pose a real threat to successful implementation.

Robustness was in one of the researched cases a goal of the project in the other it was nature conservation. However, both have been developed in such a way that the missing aspects were present. Regarding the aspect of adaptability, both projects combined functions of nature and recreation. The latter contributes to the fact that there has been a change in the attitude of citizens and politicians. However, particularly emphasised by the interviewees of the Dutch example, is the awareness of rising water levels by the Dutch population. But awareness has also increased in Germany, especially after the floods in the summer of 2021. Accordingly, it can be assumed that a transition is taking place.

Considering the literature NBS are a measurement for flood safety. However, this is not the singular focus as it should according to its definition. The study has identified that NBS, when implemented, can contribute to all aspects of flood resilience, namely robustness, adaptability, and transformability. Therefore, NBS have a positive influence on resilience, as has been confirmed in this research.

6 Conclusion

The main objective of this research was to explore the role of NBS in the context of building resilience and to identify the chances and challenges for the implementation of NBS as a contribution to climate adaptation. General as well as project-specific knowledge can be gained from the results. The context dependency seems to be decisive for the enablers and barriers to the implementation. Nevertheless, awareness of these variables is an important aspect of successfully implementing NBS and thus incorporating it into local flood protection. It has been shown that besides flood protection, the ecological benefitting character of these measures has contributed significantly to the awareness and acceptance of such. Returning to the objectives of this work, flood resilience can be seen as a normative goal for climate adaption. It is

from its character not a fixed state but constantly evolving. Additionally, due to its divided aspects, it has a broad influence on not only the social but as well on the physical environment. It can be assumed that this development has a positive effect on climate adaptation. Concluding, it is important to rely on nature-based solutions wherever possible, as they offer great advantages, especially from a precautionary point of view, and at the same time ensure robust basic functions for health, supply and disposal in order to maintain the functionality of the entire system even if individual parts fail temporarily.
The research results contribute to both planning theory and planning practice. In times of uncertainties due to climate change the awareness of inhibiting or facilitating factors can help to understand the complex system and to improve resilience.

6.1 Reflection

When considering the conceptual model, the results can be assessed. The processes presented in the model were used as the basis for structuring the research. After the theoretical basis of NBS had been explored, the implementation process was examined. The results of this were subsequently used to conduct an analysis of the chances and challenges. The next up examination of the 'building resilience' process in a subordinate way, is that a successful implementation must have taken place to have an influence on this process. The extent to which this can be translated from theory into practice is questionable. Promoting NBS through its success as a contribution to resilience can be simplified if it is implemented. However, this shows a strength or chance of NBS, namely that it can be built with existing (grey) structures. Another important aspect identified is that of evaluation. This is also found in the conceptual model and is indispensable for the further successful implementation of this concept. Accordingly, the initial set-up of the conceptual model for this study design has proved itself suitable.

6.2 Final Thoughts

In retrospective finding an adequate answer to the sub-question which can be generalized for future NBS implementation might have been too ambitious. The investigation on the topic did gave interesting and relevant insights. The logical order from the theoretical background and

the motivation for climate adaption, over to the implementation process and its further influence on resilience still is understandable. Nevertheless, the topic was very broad, and the conclusion therefore only provide a partial answer to the questions.
Another obstacle faced, regarding the search for interviews. Initially 4 cases with each two representatives were aimed for. Due to a lack of time and responds it was reduced to the ones obtained. In addition, language barriers were faced. As a native German speaker, it was complicated to research inter alia governance arrangements and NBS in Dutch policies.
However, the willingness of the interviewees who participated in this study was gratefully acknowledged.

This thesis focused on NBS as integrative concept under the premiss to escape the path dependency of the command-and-control approach of current flood risk management. Unfortunately, this study was not able to paint a complete picture of how NBS stimulates a transition. Given that NBS have an enormous potential to make a positive contribution to resilience and thus to climate adaptation, further research should be done to expand their presence. This study has touched on several issues that should be explored further, and perhaps more detailed.

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8 Appendix

Appendix A: Interview Guide

Introduction

- Who am I: Personal background, topic of the thesis, explanation of key concepts, purpose of the interview
- Consent for recording and use of the interview: explaining the right to stop the interviewee whenever interviewee wants

Introduction interviewee:

- Could you please briefly introduce yourself including your professional status?
- How are you involved in flood risk management and what are your responsibilities?
- What is your role in the project and what are your tasks in relation to NBS?

Barriers and Enablers

Barriers for NBS implementation (inductive)

- What barriers or inhibiting factors did you experience, or do you expect for the implementation of nature-based solutions within the project (x)?

Barriers for NBS implementation (deductive)

Barrier	Y/N
Inadequate financial resources	
Path dependency	
Institutional fragmentation	
Inadequate regulations	
availability and adequacy of data	
Limited land and time availability	
Implementation of measures	
Resistance/lack of acceptance in the population	

Opportunities for NBS implementation (inductive)

- What opportunities did you experience, or can you expect for the implementation of nature-based solutions within the project (x)?

Opportunities for NBS implementation (deductive)

Enabler	Y/N
Partnership among stakeholders	

Knowledge sharing mechanisms and technologies	
Economic instruments	
Plans, acts and legislations	
Education and training, Effective monitoring and Valuation systems for implementation process and benefit	
Open innovation and Experimentation	
Combining NBS with other urban elements and grey infrastructures	
Appropriate planning and design	

Building resilience

Robustness

- What were the goals of this project?
- Was flood protection a goal of this project?
- To what extent does the technical design work against floods?

Adaptability

- Which stakeholders were involved in the planning process?
- How did you experience the collaboration between the different stakeholders?
- Was there anyone you didn't work with but should have been involved?

Transformability

- Were civic groups or politicians involved in the project?
- To what extent were they involved in the different phases of the project (from initial idea till implementation)?
- What was their influence or support on the project?

Closing – Lessons learned

- What did you learn from this project?
- What would have to change to implement more NBS?
    - What would you recommend policy makers to change/include?
- How do you think NBS is going to develop in the future?

To conclude

- Have I forgotten to ask anything or is there anything you would like to add?

Thanking

Appendix B: Poster Graduate Research Day

university of groningen / faculty of spatial sciences

Helena Marie Burhorn (Stud.-Nr. S4566424)
MSc Environmental and Infrastructure Planning | MSc Water and Coastal Management

Reducing the risk

Integrating nature-based solutions into flood risk management

BACKGROUND - CLIMATE CHANGE EFFECTS

Sea level rise
+35 to +85 cm

Biodiversity loss

change in annual precipitation
-5% to +6%

Average annual temperature
+1,8 to 5,1

PBL Netherlands Environmental Assessment Agency

In response to actual or expected effects or impacts adjustments must be made within "processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change" (UNFCCC 2022)

"There is a general consensus that using only traditional flood control measures is an inadequate response to dealing with growing risks" (Restemeyer et al. 2015)

PARADIGM SHIFT

shifting away from command-and-control, "typified by centralized, sectoral institutions, limited stakeholder involvement and expert-led problem solving focused on technical engineering solutions" (Schoeman et al 2014)

NATURE-BASED SOLUTIONS

Nature-based solutions (NBS) are actions which **enable the protection, sustainable management and restoration of natural and managed ecosystems**. They **provide solutions to societal challenges such as climate mitigation and adaptation**. The European Commission defines NBS as
"Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience"

INSPIRED AND SUPPORTED BY NATURE

NBS include the protection, restoration, or creation of ecosystems

COST-EFFECTIVE

in lifecycle usually cheaper than alternatives that deliver the same or similar services

ENVIRONMENTAL, SOCIAL AND ECONOMIC BENEFITS

delivery of multiple benefits

HELP BUILD RESILIENCE

can help withstand climate change impacts and can themselves be more resilient than other measures

INTEGRATED FLOOD RISK MANAGEMENT

"emphasizes broader stakeholder involvement; integration of sectors, issues and disciplines; attention to the human dimensions of management; and wider recognition of the economic, ecological and cultural values of water" (Schoeman et al 2014)

THE RESEARCH

How can the integration of NBS into water management projects in the Netherlands and Germany contribute to enhance flood resilience?

Flood resilience is an adaptive, ecosystem-based and integrated water management approach with an emphasis on social learning and adaptive capacity.
Robustness, adaptability, and transformability are the three key dimensions and help to evaluate the process of 'buliding flood resilience'

EXPECTED FINDINGS

I. Gaining insight of the concept of resilience and its relation towards flood risk management
II. Identifying functions and structures of nature-based solutions and their potential as instrument within the process of 'building resilience'
III. Providing insights on how nature-based solutions contribute to improving flood resilience by incorporating them into flood protection measures.

→ Relevant results for decision making in flood risk management projects to 'build resilience'

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