Master Thesis

Flood Risk Governance and the Implementation of Nature-based Solutions

M.Sc. Construction Management and Engineering

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Delft University of Technology

TU Delft

Rijkswaterstaat
Ministerie van Infrastructuur en Waterstaat

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Master Thesis

Flood Risk Governance and the Implementation of Nature-based Solutions

by

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Student Number: 5632331

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Cover: Islands in the Marker Wadden in the Netherlands (Aerovista Luchtfotografie, 2024)

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"[...] You must take time, time is the factor also in this, that people trust you, [...] that you will do it carefully, that you will do it in a way that the nature will improve and not just for your own goal, but for the wider perspective. So trust in each other. And [...] again, that's not only projects, but that's in life. You must be able to trust each other and therefore you must also give and not only take. It's easy, Finn, it's easy."

Project manager regional water authority

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Preface

Doing this master's degree, and particularly conducting this final research, has been an incredible experience for me, which I would have never expected.

After much effort, I came to this topic. It is exciting to see that during the time of my research *NL2120* has begun, a knowledge programme aiming to upscale and mainstream nature-based solutions in the future, emphasizing the relevance of the topic on which I hope to have contributed just a little bit.

First, I would like to thank my whole committee for their support in shaping my research and guiding me in this incredible learning process. Thanks also to Rijkswaterstaat and Alexander for accommodating me in this very interesting organisation. Special thanks to Yara for her patience during every step of my process.

Furthermore, special thanks to all interviewees who were willing to share their knowledge and experience with me. Without you, this research would not have been possible.

Lastly, I would like to thank my family for their incredible support over the past years. I thank Tatiana for her unconditional love and support during this exhausting period. I am looking forward to finally moving on together with you. Ultimately, thanks to Milo for keeping me calm whenever I needed it the most.

And now, I hope you enjoy reading!

Finn Frederik Bartels
Delft, November 2024

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Abstract

Extreme sea level events are more likely to occur more frequently in the future due to climate change. Therefore, new approaches to flood risk management must be explored. Instead of following a solely defence-dominated engineering approach, improving resilience has become increasingly popular and more desirable. Nature-based solutions (NBS) are actions inspired by, supported by or copied from nature that simultaneously help societies address environmental, social and economic challenges. Therefore, they have the potential to contribute to a more resilient Flood Risk Governance (FRG). However, implementing new perspectives will inevitably widen the scope and increase the number of stakeholders involved in the decision-making process. The idea of more collaborative and participatory governance has gained increased interest among researchers. Nevertheless, influential stakeholders often prefer solutions that cost less and hold fewer management complications and risks, even if other, more multi-functional solutions might be more beneficial for the other stakeholders and society. To further contribute to the knowledge of FRG and the implementation of NBS, this thesis aims to explore how the current FRG can be enhanced for the implementation of nature-based flood defence systems.

The chosen approach is a qualitative study. In addition to reviewing related literature, a first round of interviews explores the current FRG. Furthermore, a multiple-case study was selected as a research method. Data was gathered through interviews and document review in a thematic analysis. Both barriers and enablers for the design and implementation of NBS were identified. Ultimately, the research discovered that barriers and enablers are deeply interconnected, which was depicted in a framework. Moreover, the framework was categorised into three levels of governance. From there, recommendations are given to relevant stakeholders.

The Netherlands can reflect on a long history of living with water, leading to a well-defined FRG with clearly divided responsibilities. Nevertheless, this historical and cultural background also made the system somewhat rigid, making the integration of novel approaches, such as NBS, rather difficult. Several barriers and enablers for wider NBS implementation have been identified within the case studies. Moreover, potential solutions were extracted.

Based on the framework, the study provides a set of policy recommendations targeted at Rijkswaterstaat and other stakeholders of the Dutch FRG. These recommendations focus on enhancing governance flexibility, fostering interdependencies, and creating incentives to overcome risk aversion and promote nature-based approaches. Additionally, the study suggests revising existing legislation to accommodate adaptive management practices better and integrating long-term monitoring and evaluation to support continuous learning and improvement.

The study concludes that better integration of NBS in FRG requires addressing distinct areas of responsibilities, encouraging adaptive and flexible governance arrangements, and promoting collaborative approaches to policymaking. By enhancing stakeholder engagement and providing adequate financial and regulatory support, the Netherlands can improve the resilience of its flood protection system while harnessing the multiple benefits offered by NBS.

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Executive summary

Introduction
Climate change, rising sea levels, and extreme weather events increase the risk of flooding in many regions worldwide, particularly in low-lying areas such as the Netherlands. The country has faced significant flood risks for centuries, necessitating extensive measures to protect its land and citizens. Traditional engineering solutions, like storm surge barriers, have proven effective but come with high costs and limited adaptability to future climate scenarios. In response, there is growing interest in Nature-Based Solutions (NBS) as a complementary approach to conventional flood defences. This research investigates how Flood Risk Governance (FRG) can facilitate the implementation of NBS to create a more resilient and holistic flood risk management system in the Netherlands.

Research Objective
This research aims to provide recommendations for public organisations to establish governance measures that support the routine implementation of NBS. Specifically, the study aims to identify the challenges, success factors, and necessary improvements in the current governance framework to enhance NBS adoption. The research also aims to bridge the gap between existing literature and practical experiences, providing actionable insights into the governance of NBS.

Research Method
The research method involves a multi-method qualitative study, using semi-structured interviews with experts in flood risk management, including senior advisors and researchers, and case studies of specific flood protection projects. In a first round of interviews, the current governance in regard to NBS implementation has been investigated. Conducting this highlighted the existing system's strengths and limitations, such as its rigidity and the historical emphasis on traditional engineering solutions. In the next step, the case studies focused on two cases that involved NBS implementation by different organisations, such as Rijkswaterstaat and regional water authorities. A thematic analysis was done to identify challenges, success factors and potential solutions.

Results
The examination of the current FRG framework revealed that while the Dutch system is efficient and has a long history of successful flood management, it also tends to be somewhat rigid, making integrating novel approaches like NBS challenging. The case study analysis identified key challenges in FRG, including *Institutional Inflexibility*, *Uncertainties* related to the effectiveness of NBS, *Risk Aversion*, *Financing Complexity*, *Spatial issues* and *Local opposition*. These challenges limit the routine implementation of NBS, creating barriers to adopting innovative solutions. However, success factors such as *Multi-functional thinking*, *Creation of Co-benefits*, *Shared Risk and Collaborative Financing*, *Creating interdependencies and Trust*, *Positive Framing and Promotion* and *(Local) Stakeholder Involvement* can mitigate these challenges. The results are summarised in a framework that links identified challenges, success factors, and resulting policy recommendations.

Framework
The framework developed in this research depicts the interconnection of the identified challenges and success factors from the two case studies investigated. Furthermore, it presents recommendations for the Dutch FRG to support the uptake of NBS. The framework shows that challenges and success factors are interconnected and assigns these elements to macro, meso, and micro governance levels. The goal is to illustrate how the success factors or suggested policy measures can mitigate the challenges and enhance NBS implementation.

The findings suggest that successful NBS implementation requires addressing institutional barriers and promoting a more flexible governance structure. Effective collaboration among stakeholders and financial arrangements that distribute risk more evenly are crucial. Incentives for stakeholders to expand their roles beyond traditional responsibilities are also essential for fostering innovation in flood management.

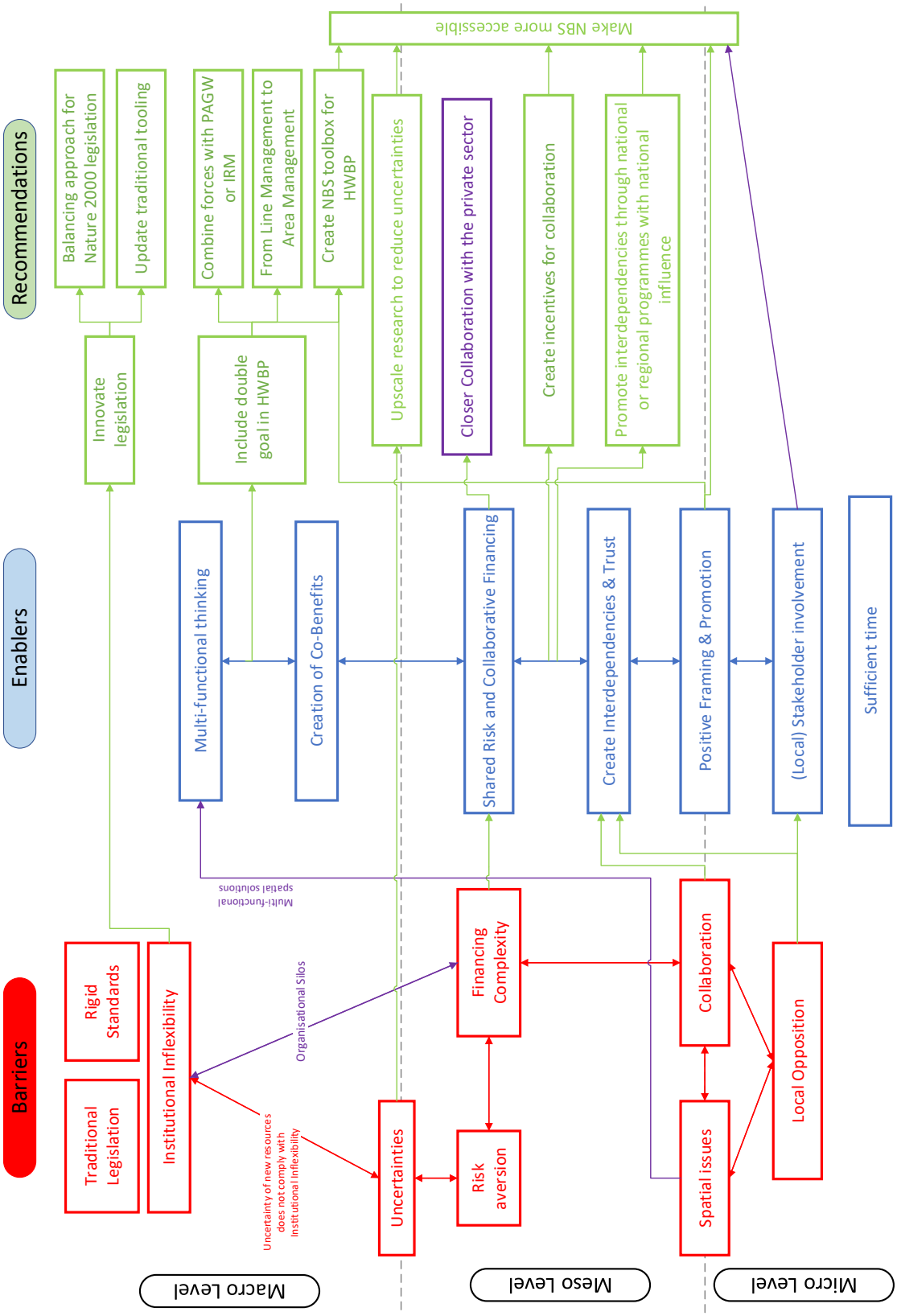

Figure 1: Framework demonstrating challenges, success factors, and recommendations in NBS implementation

Discussion
This research contributes to existing literature by identifying enablers and barriers to NBS implementation similar to those found in previous studies, such as those by Van Eekelen and Bouw (2020) and Sarabi et al. (2019). The research findings align with enablers like institutional embedding, multi-stakeholder approaches, and capacity building, and it identifies challenges such as institutional inflexibility, uncertainties, and spatial issues. The framework presented in this research adds value by interconnecting these factors and providing practical recommendations categorised into macro, meso, and micro governance levels. These insights underline the importance of an integrated approach, Risk Sharing and Collaborative Financing, and a supportive policy environment for mainstreaming NBS in FRG.

Limitations
The main limitation of this study is its qualitative nature, which may restrict the generalisation of the findings. Additionally, the number of experts interviewed may not fully represent all stakeholders or viewpoints in FRG or NBS. Moreover, the findings may be context-specific to the Netherlands, limiting applicability to other countries or governance systems.

Conclusion
To facilitate the design and implementation of NBS, FRG must evolve towards a more flexible and integrative approach. Legislative innovation is essential to create space for sustainable solutions like NBS. Moreover, the Flood Protection Programme (HWBP) should incorporate multi-functional goals beyond safety, including ecological and spatial quality improvements. Developing a toolbox of NBS measures, shifting from line management to area management, and creating incentives for regional authorities to collaborate beyond traditional mandates are critical. These measures will enable Dutch FRG to effectively integrate NBS, enhancing resilience to future climate-related challenges.

Recommendations

For the European Commission

- Innovate the Nature 2000 legislation to a more balancing approach, allowing positive changes

For the Ministry of Infrastructure and Water Management

- Foster further interdisciplinary programmes
- Combine the goals of PAGW with the HWBP
- Promote interdependencies through national or regional programmes with national influence
- Create more incentives for collaborative approaches in flood risk implementation.
- Innovate national legislation.
- Allow innovative tools if they prove to be working.
- Make NBS more accessible.

For Rijkswaterstaat

- Use advisory role towards the Ministry of Infrastructure and Water Management to initiate policy changes
- Introduce a second goal or multiple goals in the Flood Protection Program (HWBP)
- Introduce toolboxes of NBS in the HWBP

For the regional water authorities

- Seek further collaboration with the private sector
- Consult stakeholders early in the decision-making process, including environmental NGOs and local citizens

For TU Delft

- Provide more information about NBS within the Master programme of Construction Management and Engineering (CME)

For further research

- Comparative analysis of the Dutch governance structure with other countries to generalize findings
- Research into the long-term cost-effectiveness of NBS, with regard to climate change and sea level rise
- Research regarding the effectiveness, reliability, and maintenance opportunities of NBS
- Gathering more qualitative data from NBS implemented in primary flood defence measures to support the findings
- Research on the holistic long-term benefits of NBS, considering a thorough overview of all stakeholders
- Research on how participatory aspects can contribute to the uptake of NBS

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Nomenclature

Abbreviations

Abbreviation	Definition
CME	Construction Management and Engineering
FRG	Flood Risk Governance
FRM	Flood Risk Management
GDP	Gross domestic product
HREC	Human Research Ethics Committee
HWBP	Hoogwaterbeschermingsprogramma [English: Flood Protection Programme]
MRQ	Main research question
NBS	Nature-based solutions
NFM	Natural Flood Management
NGO	non-governmental organisation
PAGW	Programmatische Aanpak Grote Wateren [English: Programmatic Approach to Great Waters]
RWS	Rijkswaterstaat
SRQ	Sub-research question

1

Introduction

This chapter introduces the topic of the research. Section 1.1 will define the problem in detail. Section 1.2 outlines the research objective. Section 1.3 introduces the research questions that this thesis aims to answer. Section 1.4 provides an overview of the topic's importance in terms of societal and practical relevance. Lastly, Section 1.5 will provide an outline of the report.

Aerial picture of the Houtribdijk, dividing the Ijsselmeer and the Markermeer, recently reinforced with nature-based features (Van Middelkoop, 2024)

Climate change is leading to the rise of the global mean sea level, causing an increase in flood events for many parts of the world (IPCC, 2023). According to the most recent IPCC report (2023), extreme sea level events that occurred every century in the recent past are projected to occur at least annually at all locations that are exposed to the turn of the tide. Moreover, extreme precipitation will be more likely to occur, leading to a higher risk of inland floods. Lastly, rapid urbanisation in flood-prone areas also contributes to a higher exposure to flood risk (Du et al., 2020).

Due to its geographical location and topography, the Netherlands has already been exposed to severe flood risk for several centuries and, consequently, has already taken complex and expensive measures to secure its land and the safety of its citizens (Bloemen et al., 2018; Driessen et al., 2018). Furthermore, since 65% of the Dutch GDP is earned in areas that could be affected by floods, the Netherlands has a particular interest in flood risk management (FRM) (OECD, 2014). Recent events, such as the big flood in the summer of 2021, have provided further evidence of the need for nations also to reinforce their inland flood protection measures. This includes not only the Netherlands but also neighbouring countries, such as Germany, Belgium and Luxembourg, which are also vulnerable to flooding in both their coastal regions and riverbeds (Tradowsky et al., 2023; WMO, 2021).

Following the disastrous flood event of 1953, the Netherlands established the so-called 'Delta Works', an initiative to construct a collection of essential flood protection infrastructure, including unique storm surge barriers (Bloemen et al., 2018; Van Den Brink, 2009), such as, among others, the Eastern Scheldt Barrier or the Maeslant Barrier (Rijkswaterstaat, 2024c). The latter closed automatically in December 2023 at the threshold of 300 cm above NAP (NOS, 2023), proving its effectiveness and relevance in practice for the first time.

Despite the benefits of a storm surge barrier, it is a highly complex engineering solution, resulting in significant construction and maintenance costs (Climate-ADAPT, 2023), whereas it potentially lacks room for adaptability for potential future climate scenarios (IPCC, 2023). Hence, the call to assess the potential of 'green' nature-based solutions (NBS) alongside traditional 'grey' infrastructure is becoming stronger (Penning et al., 2019). strategies have evolved beyond the traditional approach of using engineered 'hard' defences and have expanded to encompass a range of interventions focused on mitigation, preparedness, and recovery (Vreugdenhil et al., 2022). Those concepts contribute to the idea of resilience, which has been introduced as the most desirable outcome of (Driessen et al., 2018). Driessen et al. (2018) introduced six governance strategies to achieve more resilience against flooding, one of them being the diversification of approaches. While Du et al. (2020) outline that the implementation of hard protection strategies is necessary for a sufficient reduction of flood risk, their findings also state that a multi-scale approach which includes 'soft' solutions offers bigger benefits.

1.1. Problem definition

Table A.1 provides an overview of the literature studied to identify the knowledge gap. This research aims to build upon existing literature and new experiences from practice.

NBS inevitably widen the scope of , and therefore, more stakeholders will play a part in it (Waylen et al., 2017). Recent literature like Den Heijer et al. (2023) provide a good overview of the stakeholders involved in the Dutch flood defence system. The list includes governmental institutions (e.g., among others, the Ministry of Infrastructure and Water Management, represented by Rijkswaterstaat (RWS), Regional Water Authorities (RWAs)), private organisations, nature organisations and citizens (Den Heijer et al., 2023). Incorporating NBS in the process implies that those responsible for flood defence will need to act in a growing network of stakeholders with extensive interdependencies (Vreugdenhil et al., 2022).

Even if not always easy, involving stakeholders in the process of generating and evaluating information can help to ensure that decision-making is more transparent and accountable (De Bruijn & Leijten, 2007). Especially in flood management, public participation is essential since decisions often affect the citizens' properties directly (Challies et al., 2016). Values may be identified better, new knowledge can be gathered, and democratic values are acknowledged (Vreugdenhil et al., 2022), enhancing the legitimacy of measures taken to decrease flood risks (Driessen et al., 2018). Since local stakeholders know their area best, the final result will provide a better, more creative solution than without taking their knowledge into account (Koutsovili et al., 2023; Vreugdenhil et al., 2022).

Nevertheless, stakeholders responsible for flood resilience strategies in the Netherlands often prefer solutions that are mainly focused on flood protection, or as called by Gilissen et al. (2016), "defence-dominated" approach. As outlined by Vreugdenhil et al. (2022), the reasons for this are fewer management complications, costs and risks. According to Janssen et al. (2020), NBS have the potential to yield significant benefits for society as a whole but not necessarily for individual stakeholders alone. Also, Den Heijer et al. (2023) mention that there is a certain 'aversion to change' leading to a preference for traditional approaches in .

In their research that analysed the flood resilience of six countries of the European Union (EU), Driessen et al. (2018) emphasise that, in the Netherlands, the approach to is dominated by flood defence, acknowledging its relevance. However, they call for moving away from solely defence towards 'resilience' strategies. In terms of , this means that next to the capacity to resist floods, the capacity to absorb and recover from floods and the capacity to adapt and transform are equally essential values. Therefore, green infrastructure has been recognised as a method of contributing to the improvement of resilience as this diversifies flood risk measures (Driessen et al., 2018; Watson et al., 2016).

Rijkswaterstaat, as the policy-implementing arm of the Dutch Ministry of Transport, Public Works and Water Management, has traditionally been shaped by an engineering-focused approach (Van Den Brink, 2009). This makes it potentially prone to neglect a more holistic and interdisciplinary approach to FRM. Even if a transition has already taken place to a more integrated and "public-oriented national network manager", the organisation is still caught between its expert status on the one hand and the need to democratise its way of working on the other (Van Den Brink, 2009). More recently, Driessen et al. (2018) and Raadgever and Hegger (2018) recognised that flood awareness and citizen participation are lower than in the other countries that were part of their study.

Stakeholder participation is not only challenging in the Netherlands. Begg et al. (2018) outline that the actual possibility for stakeholders to participate and influence decision-making is limited in practice in Germany and the UK and that their current governance may even lead to conflict, frustration and inequality. Moreover, Waylen et al. (2017) outline that pre-existing ways of working may hinder the implementation of new approaches. They summarised three main factors that are barriers to implementing "Natural Flood Management (NFM)" in Scotland. Notable issues that were mentioned seemed to be similar to the ones that RWS is facing, such as "difficulties in allocating resources", "Challenges in using evidence and handling uncertainty", and "Complexities of co-ordination and

communication" (Waylen et al., 2017).

Sarabi et al. (2019) provide an in-depth discussion of NBS, identifying enablers and barriers for successful implementation. However, their study considers a broader definition of NBS than what is relevant to this thesis. While their research is centred on urban environments, this thesis focuses specifically on solutions in Flood Risk Governance (FRG). Moreover, their findings have not been validated through expert insights from real-world projects.

As mentioned above, implementing NBS may not be attractive for one stakeholder alone; however, it does potentially benefit society as a whole (Janssen et al., 2020; Vreugdenhil et al., 2022). Janssen et al. (2020) describe this as the "nature-based flood defence dilemma". The water authorities that are powerful stakeholders in the realisation of flood defence projects in the Netherlands often favour mainly defence-oriented solutions that entail fewer risks rather than multi-functional solutions that involve more risks and lower benefits for the water authorities. These findings coincide with those of other researchers, such as Van Den Brink (2009).

Hence, the defined **problem statement** is:

Current Flood Risk Governance in the Netherlands does not support the routine implementation of nature-based solutions, limiting progress towards a more holistic and resilient flood risk management approach.

1.2. Research objective

This thesis aims to gain in-depth knowledge about NBS and FRG. Another goal is to gain a deep understanding of the current Dutch Flood Risk Governance. Lastly, current barriers and enablers will be explored by investigating two case studies. The ultimate research objective is to provide recommendations for public organisations to set up appropriate governance measures that enable routine implementation to drive the uptake of NBS.

1.3. Research question

The main research question (MRQ) that shall be addressed with this thesis is:

"How can Dutch flood risk governance facilitate the design and implementation of nature-based flood risk solutions?"

The following sub-research questions (SRQs) help to answer the main research question:

- **SRQ1:** What are the key principles of flood risk governance, and how do they integrate nature-based solutions?
- **SRQ2:** How is the current Dutch Flood Risk Governance organised?
- **SRQ3:** What are the current barriers and enablers in designing and implementing nature-based solutions?
- **SRQ4:** What needs to be improved in the current governance to enable routine implementation of nature-based solutions?

SRQ1 is addressed through a literature review to set a theoretical framework. First, a thorough understanding of the current governance will be established. SRQ2 will be addressed through expert interviews, documents and literature review. To answer SRQ3 and SRQ4, a multiple case study is

conducted, including interviews with experts who were part of the projects. After answering the four SRQs, the MRQ is answered.

1.4. Relevance of the research

1.4.1. Societal Relevance

As climate change increases the frequency and severity of flooding events, providing effective FRM is highly relevant to society. This research can provide valuable insights into how public organisations can tackle this issue through NBS. Furthermore, the research underscores the importance of involving stakeholders and communities in environmental decision-making. Demonstrating how the current FRG can be improved by mainstreaming NBS can create more benefits for more stakeholders, potentially leading to more democratic and accepted solutions. Moreover, the findings can have significant implications for public policy by providing recommendations for improving governance structures in sustainable . This can influence how governments and organisations allocate resources, engage with communities, and design resilience strategies.

In many areas of the world, flood risk is one of the most relevant topics in securing citizens' safety. As pointed out by Den Heijer et al. (2023), the relevance of cooperation in flood defence management is not limited to the Netherlands. Many other countries will face similar challenges in the future, for which findings in this field can also be relevant.

1.4.2. Practical Relevance

As part of the Dutch Ministry of Infrastructure and Water Management, RWS is responsible for the design, construction, management and maintenance of the Netherlands' primary infrastructure facilities (Rijkswaterstaat, 2024a). Apart from road infrastructure, one crucial part that falls into its responsibility is flood protection (Van Den Brink, 2009). Hence, RWS has to deal with a variety of stakeholders. Having a powerful position in the development of hydraulic structures in the Netherlands (Van Den Brink, 2009), RWS should be aware that it has the power to initiate change. However, it also has the power to preserve the current situation (Waylen et al., 2017).

The Interim Report for the Sea Level Rise Knowledge Programme highlights that the extent of future sea level rise remains uncertain, and that NBS possess the potential to adapt more effectively to these uncertainties (Ministry of Infrastructure et al., 2023). From a practical perspective, this research offers recommendations for enhancing the benefits of by including NBS. By identifying factors that facilitate or hinder the successful adoption of these solutions, practitioners can improve the design and management of flood mitigation projects.

The implementation of NBS can lead to more robust and community-supported initiatives. Investigating the role of participatory governance in implementing NBS aligns with sustainable development goals by promoting effective solutions in flood defence, contributing to biodiversity, enhancing ecosystem services, and providing social and economic benefits. This focus on both environmental and social outcomes underscores the practical relevance of the research in contributing to a more sustainable and resilient FRG.

RWS has also started transitioning from traditional 'hard' and 'grey' infrastructure to more sustainable options with projects such as the reinforcement of the Houtribdijk, a dam between the Ijsselmeer and the Markermeer or the Zandmotor. In these projects, RWS focused not only on the future viability of its flood protection but also on opportunities for nature and recreation. This already demonstrates a commitment to the practical aspects of flood protection and the broader societal benefits such projects can provide. This research aims to provide strategic recommendations for water infrastructure authorities, such as RWS, for future decision-making and to contribute to implementing NBS beyond pilot projects.

1.5. Thesis outline

This section will provide an outline of this master's thesis. The following Chapter 2 will describe the chosen research method. Next, Chapter 3 will provide a profound overview of the literature studied, providing the fundamentals for this study. Chapter 4 will elaborate on the current governance in regard to NBS implementation, offering first results from practice. Chapter 5 will elaborate on the results from the case studies in detail. Chapter 6 introduces a framework that depicts the interdependencies of barriers and enablers to arrive at recommendations to facilitate NBS implementation. Chapter 7 will provide a discussion of the results regarding literature and practice. Chapter 8 will finalise this report with conclusions and recommendations directed to specific stakeholders.

2

Research Method

This chapter presents the research method used. As stated by Easterby-Smith et al. (2015), awareness of philosophical assumptions can increase the quality of research. Saunders et al. (2023) aligns with this, outlining that the research philosophy and approach to theory development influence the methodological choice and research strategies. While the former authors illustrate this in the "four rings model", relating research philosophies with research methods in a tree, the latter depicted this relation in the "research onion", which will be used as a basis for this chapter (see Figure 2.1). Hence, section 2.1 will describe the chosen research philosophy, section 2.2 will explain the approach to theory development, before section 2.3 introduces the research design, section 2.4 the data collection and section 2.5 the type of analysis.

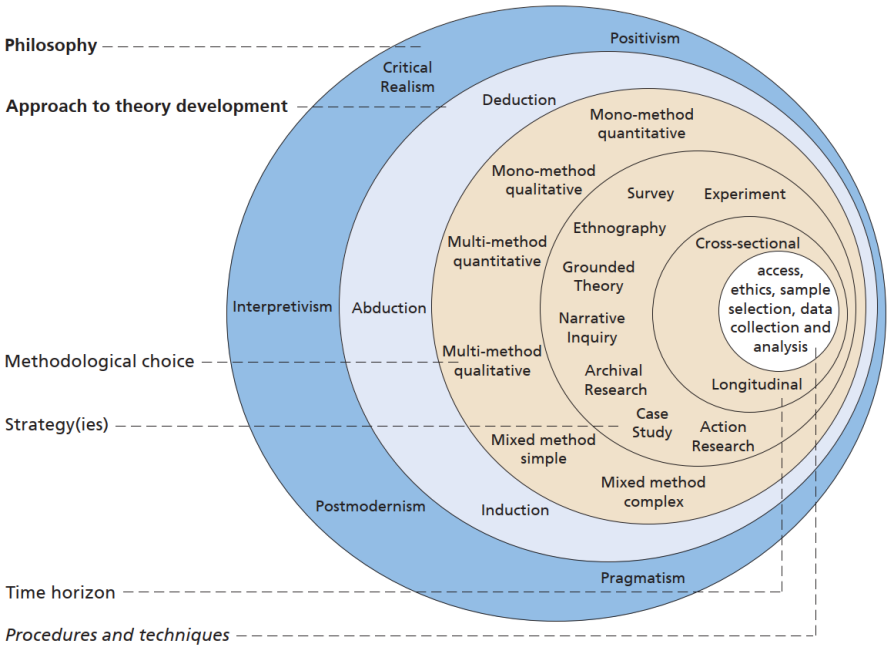

Figure 2.1: The research onion by Saunders et al. (2023)

2.1. Research philosophy

It is recommended to first address the larger philosophical ideas, also called world view, of a study to develop a profound research method (Creswell & Creswell, 2018; Saunders et al., 2023). Therefore, the outer layer of the research onion, the research philosophy, will be defined first. In the book of Saunders et al. (2023), the matrix by Burrell and Morgan (2017) is introduced, which categorises four different paradigms that represent four different ways of viewing the social and organisational world (see Figure 2.2). The matrix combines the two viewpoints of objectivism-subjectivism and regulation-radical change. Objectivism is a philosophy that implies that there is a single, objective reality that can be observed and measured. In contrast, subjectivism assumes that social reality is made from different perceptions and actions of people. The regulation perspective seeks to suggest how an organisation could be improved, while the radical change perspective aims to fundamentally change the way things are done in an organisation (Saunders et al., 2023).

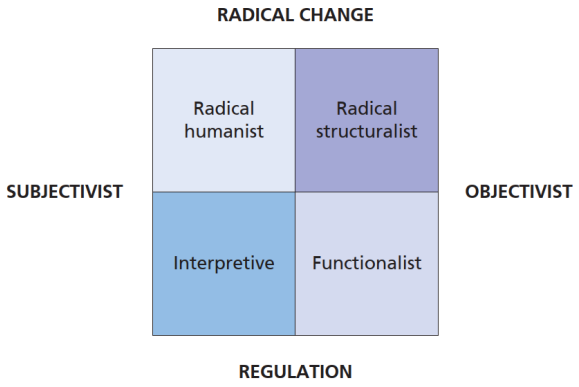

Figure 2.2: Matrix of research paradigms for organisational analysis (Saunders et al., 2023) developed from Burrell and Morgan (2017)

This research could be viewed as a hybrid approach of the Interpretive paradigm also incorporating elements of the Functionalist paradigm. The goal is to facilitate the design and implementation of NBS within the existing governance structures. Even if implementing NBS could lead to significant changes within the current governance, the goal is not to propose radical changes rather than indicating improvements of the current situation. First, given the practical and outcome-oriented nature of this research, combined with a focus on improving the existing governance, the research can be categorised within the Functionalist paradigm. The research seeks to identify key principles, organisational structures, challenges, and improvements in flood risk governance through empirical data and analysis. This indicates an objective approach to understanding and addressing existing issues. Secondly, a more subjective, Interpretive approach allows to capture the complexity and diversity of viewpoints essential for developing effective and contextually relevant flood risk governance strategies.

Ultimately, Saunders et al. (2023) introduced five major philosophies from business and management: positivism, critical realism, interpretivism, postmodernism and pragmatism, as also depicted in Figure 2.1. One philosophy that aligns with this research is the philosophy of interpretivism. Interpretivism takes a subjective perspective focusing on complexity, richness and diversity of perspective, arguing that interpretations can differ considering the historical or geographical context of people (Saunders et al., 2023). Compared to other viewpoints, such as positivist, that seek to discover universal laws, interpretivism acknowledges that different cultural backgrounds and circumstances at different times create different meanings, hence, create different social realities. Therefore, the interpretivist viewpoint seems to align with the complexity that researching governance structures entails.

Another philosophy that aligns with this research is Pragmatism, a research philosophy that em-

phasises practical application and problem-solving, striving to combine objectivism and subjectivism. Pragmatists acknowledge that the world can be interpreted in several different ways, with no single perspective providing a complete understanding, while, at the same time, they aim to contribute practical solutions (Saunders et al., 2023). Within pragmatism, it is common to use a mix of methods to gather and analyse data to arrive at practical recommendations (Creswell & Creswell, 2018). Hence, the classification to pragmatism corresponds with the mixed categorisation on the matrix from Burrell and Morgan (2017). Flood risk governance is a complex character that can facilitate different complex viewpoints. Therefore, the topic aligns well with a pragmatic research philosophy.

2.2. Approach to theory development

Saunders et al. (2023) argue that considering the approach to theory development enables the researcher to make more informed and deliberate decisions in the design of their research. Commonly, there are two contrasting approaches to reasoning that can be utilised in research: deduction or induction. Further, reasoning can be a combination of both, called abduction. If a research project is guided by theory, it follows a deductive approach. In contrast, this research aims to investigate a topic and create a theoretical explanation as data is gathered and analysed. This method is data-driven, meaning it utilises an inductive approach (Saunders et al., 2023). As implied by Saunders et al. (2023), research projects are often a mix of deduction and induction. An interpretivist approach is often predominately inductive, while a pragmatic approach is often abductive. In the previous section, this research has been identified as interpretivist or pragmatic. Therefore, this research will adopt an abductive approach with inductive dominance.

2.3. Research design

This research aims to explore the current governance approach and how to facilitate the implementation of NBS in FRM. Since the main research question is a "how" question, this research can be classified as an exploratory or also as an explanatory study (Saunders et al., 2023). An exploratory study aims to investigate and provide clarity on a particular issue, problem, or phenomenon while an explanatory study established causal relationships between variables. The sub-research questions also have an exploratory character, all of them being either "what" or "how" questions.

In order to find answers to the research questions, individual experiences must be gathered, and complex issues must be analysed. Hence, a qualitative study is chosen as it is considered a suitable approach (Waylen et al., 2017). As several qualitative approaches will be used, the method chosen is defined as **multi-method qualitative study** (Saunders et al., 2023). Figure 2.3 shows the research design, pointing out which method will be used to answer which research question.

Figure 2.3: Research design

SRQ1 creates the fundamentals for this research. It aims to identify key terms to provide a framework for the following research questions. To answer SRQ1, information is gathered through a literature study on flood risk governance (FRG) and its relation to NBS in flood management.

SRQ2 focuses on the current governance. For this question, a single categorised strategy as suggested by Saunders et al. (2023) does not seem to be completely suitable. However, Yin (2016) pointed out that a qualitative research does not always need to emulate one of the "specialized types". Hence, to answer SRQ2, first, a documentary research is carried out. Hereby, the focus will be on publicly available government documents, such as publications or strategy reports. This is also known as secondary data since it has originally been created for a different purpose. Furthermore, to complement the collection of secondary data and to gather more inside knowledge, primary data will be collected through conducting semi-structured expert interviews. The selection criteria for the interviewees selected are defined in Section 2.4.1.

To find answers to SRQ3 and SRQ4, a case study is selected as the research strategy. The main research question is a "how" question, and therefore, a case study is considered an appropriate re-

search method due to its exploratory character (Yin, 2018), while a minimum of two or three cases is recommended (Keusters et al., 2022) to establish whether findings can be replicated across cases (Saunders et al., 2023). The selection of cases is known to be crucial for this (Saunders et al., 2023) and will be done based on predefined criteria (see section 2.4.2).

In this research, a case study will be approached using an interpretivist methodology (Saunders et al., 2023). This involves conducting an inductive analysis of the data, identifying themes and patterns, and situating these findings within existing literature to refine, expand, or develop theory.

Saunders et al. (2023) points out two different time horizons for research: cross-sectional and longitudinal. While longitudinal research investigates developments and changes over time, cross-sectional research looks into a certain phenomenon at a particular time. As this research is time-constrained, the time horizon for this research is defined as cross-sectional.

2.4. Data collection

As highlighted by Saunders et al. (2023), data used in a study can be categorized as either primary or secondary. Secondary data was originally created for a different purpose, while primary data is generated explicitly for the current research. In this study, both secondary data will be utilized, and primary data will be collected. Table B.1 provides an overview of the secondary data collected to answer SRQ2.

2.4.1. Interviewee selection criteria to answer SRQ2

SRQ2 aims to understand the current governance and its relation to NBS implementation. Therefore, the following selection criteria were set up for the selection of the interviewees:

- Expertise in FRM
- Knowledge of NBS
- Experience in governance and policy-making
- Experience with stakeholder engagement
- Regulatory and legal expertise
- Varying positions within a public organisation to bring as many perspectives as possible:

The chosen criteria ensure that different perspectives of the current Flood Risk Governance are covered to create an overview that represents reality as well as possible. The chosen experts shall be knowledgeable about the current FRM principles in general but should also be able to talk about the current status of NBS implementation, to put the questions into the right light. As this research addresses Flood Risk Governance as a wider approach to FRM, the experts should also have knowledge about the policy-making level. As stakeholder engagement has been considered an important prerequisite for NBS implementation, this has been another criteria. Not all of the criteria mentioned above is likely to apply to the interviewees, which means that not all have to apply. Possible professional positions within organisations are:

- Process manager
- Project manager
- Flood risk manager or advisor
- Environmental engineer
- Policy analyst or advisor

This procedure is known as purposive sampling (Yin, 2016). In addition to this, based on the interviewees that were chosen purposively, snowball sampling has been done. This means that during some interviews, the interviewee suggested other potential interviewees who had then been contacted for an interview. Here, it may be emphasised that the selection of these interviewees was not based merely on convenience but was made with clear and purposive intent. Table 2.1 provides an

overview of the interviews conducted to answer SRQ2. Furthermore, Section B.1 provides the interview protocol followed in those interviews. Based on the first findings from literature, the questions were categorised into three different levels of governance, the macro, meso and micro level.

No.	Date	Occupation	Interview Duration	In-Person/ Online
G1	13-06-2024	Advisor for flood protection	1 h 8 min	Online
G2	14-06-2024	Programme Director	57 min	Online
G3.1	24-06-2024	Flood safety advisor	26 min	Online
G3.2	27-06-2024	Flood safety advisor	1 h 20 min	Online
G4	01-07-2024	Senior Advisor Deltaprogramme	52 min	In-Person
G5	15-07-2024	Coordinator NL of an environmental NGO	50 min	Online
G6	24-07-2024	Advisor coast protection	54 min	Online
G7	16-09-2024	Senior Consultant Water and Energy	53 min	Online
Total			7 h 20 min	

Table 2.1: List of Interviews conducted to answer SRQ2

2.4.2. Selection of case studies to answer SRQ3 and SRQ4

To answer SRQ3 and SRQ4, a multiple case study analysis was conducted. Most flood defence measures in the Netherlands are the responsibility of the regional water authorities. As discussed by Janssen et al. (2020), in particular, the water authorities have a certain aversion to implementing solutions that might benefit society as a whole but are not the best solution for the water board individually. Therefore, the chosen case studies should also include the water boards to investigate this issue further.

The case studies were selected based on the following criteria:

Criteria	**Reasoning**
Have implemented a nature-based solution according to the common definitions.	To fulfil the requirements of the main research question.
Have not been discussed widely in literature.	To create an added value.
Cover different areas of implementation	To identify similarities and differences
Were implemented by different organisations (RWS, RWAs, Alliance)	To identify similarities and differences
Are part of the primary flood defence system of the Netherlands	Refine the focus of research on a specific area where NBS implementation does not go beyond pilot projects.

Table 2.2: Criteria for the selection of case studies

The two case studies chosen are *Room for the River Waal in Nijmegen* (Case Study 1) and the *Clay Ripening Pilot and Wide Green Dike* (Case Study 2). The selection was made during the first phase of interviews, in which several cases were discussed. Both case studies fulfil the above-defined criteria and will be further introduced in Chapter 5.

2.4.3. Data collection for multiple case study

To gain inside knowledge of the case studies, further semi-structured interviews were conducted. The participants for those interviews were mainly chosen through the snowballing principle. Nonetheless, it was ensured that all interviewees were involved in the respective case study. Table 2.3 presents a summary of the conducted interviews, while section B.2 outlines the interview protocol used. Also, for the case studies interviews, the questions were divided to address the three different levels of governance. Lastly, documents that give insights into the case studies to inform the public have been reviewed for every case to complement the interview data (see Table B.2).

No.	Date	Occupation	Interview Duration	In-Person/ Online
CS2.1	03-07-2024	Project manager in regional water board	1 h 11 min	Online
CS2.2	26-08-2024	Director	55 min	In-Person
CS2.3	06-09-2024	Project Manager (Province)	52 min	Online
CS1.1	28-08-2024	Project Manager (Consultancy)	50 min	Online
CS1.2	20-09-2024	Programme supervisor HWBP	55 min	Online
CS1.3	26-09-2024	Project Manager	1 h 2 min	In-Person
Total			5 h 45 min	

Table 2.3: List of Interviews conducted to answer SRQ3 & SRQ4

2.5. Data analysis

All interviews were recorded and automatically transcribed using Microsoft Teams. Next, every transcript underwent a data-cleaning process in which all transcription errors were corrected. Furthermore, all transcripts have been anonymised. After this, a copy of the transcript was sent to the participant for a final review. After sighting and organising the data ("winnowing"), a thematic analysis was conducted in six phases as described by Saunders et al. (2023):

- data familiarisation;
- data coding;
- initial theme generation;
- development and review;
- theme refining, defining, and naming;
- (writing up).

The analysis was conducted using CAQDAS (Computer-Aided Qualitative Data Analysis Software), which supports continuity and enhances both transparency and methodological precision (Saunders et al., 2023). Among the recommended software options, ATLAS.ti has been selected for this study due to its availability through the university.

First, the data was coded into different themes that are supported multiple times in the collected data (Creswell & Creswell, 2018). This process was an iterative process in which themes were be defined and refined. A thematic analysis is deemed appropriate for the selected research method as it offers a systematic and flexible framework for the analysis of qualitative data. The approach to theory development has been defined as abductive with inductive dominance (section 2.2). This implies that the themes will be derived from the data obtained. However, considering the abductive aspect of this research it also implies that some themes were derived from theory and then modified as the data is explored. In the specific case of this research, the overall themes that will be started with are

the different levels in which flood risk governance has an influence: the macro, meso and micro levels as described in section 3.2.2.

The aforementioned approach was applied twice: initially to address SRQ2 through the first round of interviews, and subsequently within the case studies to answer SRQ3 and SRQ4. In total, 134 codes were generated in Atlas.ti. While some codes contained up to 143 quotations from the interviews, others had only one. Ultimately, Excel was utilized to derive clear and meaningful themes to effectively address the research questions.

When analysing the interviews to answer SRQ3&4, a deep interconnectedness of the themes became apparent. Hence, in order to demonstrate the relations, the themes have been depicted in a framework, which has been ultimately used to arrive at recommendations.

2.6. Research Ethics

Access and research ethics play an important role in every study. Hence, the steps specified by the **H**uman **R**esearch **E**thics **C**ommittee (HREC) of TU Delft have been followed. This includes creating an informed consent form for each participant of the research, a checklist with a risk assessment and mitigation plan and lastly, a data management plan. The application, including all of these documents, has been approved by the HREC of the university.

3

Literature review

The following chapter aims to answer SRQ1: *"What are the key principles of flood risk governance, and how do they integrate nature-based solutions?"* . Section 3.1 introduces the term nature-based solutions, resulting in a definition regarding FRM. Section 3.2 follows up on the general term of governance and Flood Risk Governance (FRG). Section 3.4 summarises the literature review to answer SRQ1.

Aerial picture of the Sand Motor [Dutch: Zandmotor]; mega sand nourishment off the coast of Kijduin, The Hague (Rijkswaterstaat, 2024b)

3.1. Nature-based Solutions

NBS are a relatively young concept, and its definition still seems to have "a lack of consensus" (Sarabi et al., 2019). Nevertheless, many organisations have recognised it as an important topic that should be paid more attention to in the future. First, two in literature commonly used definitions (Brillinger et al., 2021; Nehren et al., 2023; Randrup et al., 2020; Sarabi et al., 2019; Verstand et al., 2024) shall be noted:

"Nature-based solutions aim to help societies address a variety of environmental, social and economic challenges in sustainable ways. They are actions which are inspired by, supported by or copied from nature. [...]." (European Commission, 2015)

"Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits." (Cohen-Shacham et al., 2016)

Another definition worth mentioning is the resolution of the United Nations Environment Assembly (2022):

"[...] nature-based solutions are actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits [...]".

All definitions show that NBS is a broad term that is not solely used in FRM. It is worth noting that the definition proposed by Cohen-Shacham et al. (2016) is primarily focused on the preservation and rehabilitation of natural habitats. In contrast, the perspective presented by the European Commission (2015) offers a broader perspective and takes into account the three dimensions of sustainability concurrently. The review by Sarabi et al. (2019) highlights the significance of this difference in approach. By means of a systematic literature review, Sarabi et al. (2019) outlined several more common definitions of NBS, concluding that NBS are often considered as "solutions that provide benefits to the environment and humans simultaneously rather than focusing on nature conservation and restoration."

Furthermore, much of the literature refers to NBS for urban environments. Hence, other keywords for NBS found in the literature are "blue-green infrastructure" or "ecological engineering" (Sarabi et al., 2019). Penning et al. (2019) describe NBS as the idea that "the natural ecosystem and ecosystem processes can provide a service in terms of solving water challenges". Coming back to FRM, NBS is a research field that has the potential to support flood defence efforts (Waylen et al., 2017).

The term NBS applies to a variety of defined goals that cannot all be covered in this research. Hence, more specific terms that this research aims to cover are "nature-based flood protection" (World Bank, 2017) or "natural and nature-based features for flood risk management" (Bridges et al., 2021).

NBS measures may be implemented in addition to existing structural measures, such as vegetated foreshores in front of a dike line, sand nourishments, oyster reefs, mussel beds, cyclic floodplain rejuvenation or managed realignment (Janssen et al., 2020; Vreugdenhil et al., 2022). In other cases, NBS could substitute conventional measures, e.g., with a dune (Vreugdenhil et al., 2022). As more examples for NBS, Pontee et al. (2016) mention beaches, dunes, saltmarshes, mangroves, sea grasses or coral and oyster reefs.

The following five principles were proven to be important during the development of the "NNBF [natural and nature-based features] Guidelines" (King et al., 2021):

- Use a systems approach to leverage existing components and projects and their interconnectivity
- Engage communities, stakeholders, partners, and multidisciplinary team members to develop innovative solutions
- Identify sustainable and resilient solutions that produce multiple benefits
- Anticipate, evaluate, and manage risk in project or system performance (see also section 3.2)
- Expect change and manage adaptively

Not all of the concepts mentioned seem to be tangible. They present a more holistic approach in which the whole system is looked at. In the case of a river, for example, the whole drainage basin of the river. For example, some of today's flood risk defences may lower the risk of floods for one part of a river effectively. However, this may come at the cost of increasing flood risk in another part of the river system.

As mentioned above and repeatedly in further literature (Challies et al., 2016; Driessen et al., 2018; King et al., 2021; Matczak & Hegger, 2021) stakeholder engagement seems to be particularly relevant for the implementation of NBS.

NBS are often considered as "multipurpose" and can consist of the following components (King et al., 2021):

- Nonstructural measures (e.g., communication and education that convey information about protecting life and property, enhanced building codes, and established evacuation routes)
- Structural engineering (e.g., breakwaters, seawalls, and levees)
- Natural features that are "created and evolved" over time through physical, biological, geological, and chemical processes operating in nature (e.g., existing wetlands, reef systems, or islands)
- Nature-based features that mimic characteristics of natural features but were created by human design, engineering, and construction to provide risk reduction (e.g., newly created wetlands or islands constructed for the purpose of minimizing storm impacts)

Verstand et al. (2024) describe ten categories of NBS in a Dutch context, namely "*Dynamic Nature Management*", "*Biobased Building*", "*Nature-positive Food Production*", "*Restoration of Estuaries*", "*Green-blue infrastructure*", "*Natural Coastal Defences*", "*Restoration of Streams and Rivers*", "*Rewetting*", "*Natural Water Purification*", and "*Freshwater Storage*". Several of the topics mentioned above are not within the scope of this research. However, the concepts of "*Restoration of Estuaries*", "*Green-blue Infrastructure*", "*Natural Coastal Defences*", and "*Restoration of Streams and Rivers*" are relevant topics that this research aims to address.

Natural Coastal Defences
Coastal areas face several challenges, including the risk of flooding and erosion. Natural and NBS offer a range of approaches to address these issues. These solutions can involve creating or restoring natural habitats such as salt marshes, mangrove forests, reefs, beaches, and dunes, enhancing existing habitats, using more organic materials for structures, and ecologically enhancing existing hard infrastructure. Combining NBS with hard structures like dikes in a multilayered approach to FRM can also be effective (Simm, 2021).

As outlined by Simm (2021) several benefits arise due to the incorporation of NBS:

- Attenuate the energy, and height, of incoming waves
- Attenuate storm surge water levels along the shoreline
- Provide storage of floodwater in the upper tidal reaches of estuaries

- Reduce erosion of sediments and soils
- Attract and stabilise sediments
- Attract and sustain flora and fauna, which can stabilise structures such as dikes

Examples of the first pilot projects in the Netherlands for NBS used for Coastal defences are the Sand Engine (Dutch: "Zandmotor") or the reinforcement of the Houtribdijk (**Rijkswaterstaat2024Houtribdijk**; Rijkswaterstaat, 2024c). For other parts of the world, mangrove restoration in Demak, Java, is another example (Janssen et al., 2020).

Restoration of Streams and Rivers
Rivers are a crucial natural resource for human civilisation, as they provide various essential services. The most significant contribution of rivers is their role as a primary source of fresh water, which is indispensable for sustaining life. In addition, rivers also serve as a source of energy, generate revenue through various economic activities, and facilitate recreational activities. To optimise their value for transportation, agriculture, flood risk reduction, and urban development, many of the world's major rivers have undergone significant re-engineering. However, this has resulted in a loss of their natural state, leading to a state of disequilibrium or sediment imbalance in many regions (Haring, Schielen, Guy, Burgess-Gamble, & Bledsoe, 2021).

Haring, Schielen, Guy, and Burgess-Gamble (2021) gathered the following primary objectives for NBS in a fluvial setting:

- capture, retain, slow, or disperse floodwaters throughout the upper and middle watershed, using native vegetation where possible to capture and retain water and sediment and to slow erosion
- improve the connectivity and interaction of the watercourse with the floodplain (creating space for water and room for the river)
- preserve or restore sediment balance (Wohl et al. 2015) to maintain not only stream channel geomorphology but also floodplains and deltas through appropriate sediment-building processes
- restore or maintain lowland and river delta functions in ways that replicate or mimic natural features or processes

Den Heijer et al. (2023) conducted research on the cooperation of five Water Authorities in the Netherlands, identifying the influence of dilemmas and bottlenecks in flood risk asset management. The study shows that effective cooperation between actors is vital to flood risk asset management and that asset management encompasses not only technical aspects but also organisational and inter-organisational dimensions (Den Heijer et al., 2023). The term situational cooperation is introduced. This describes an agile approach in shaping cooperation depending on different situations. Those findings may also be helpful for the implementation of NBS in FRM. In this area, many solutions need to be unique and fit-for-purpose for a particular area, too.

As highlighted by Janssen et al. (2020), despite the advancements in the field, routine implementation remains limited. Another perspective on the concept of NBS has been proposed by Randrup et al. (2020), who suggested broadening the scope from NBS to nature-based thinking (NBT).

3.2. Water Governance and Flood Risk Governance (FRG)

3.2.1. Water Governance

The term *governance* has undergone lively discussions and contrasted with the term *government*. Scholars have identified a shift from a centralised government towards governance (Alexander et al., 2016). This entails that there has been a shift of power and authority away from "big" government towards the market, civil society, independent bodies and other institutions (Havekes et al., 2016). As described earlier, this shift has also been identified by Van Den Brink (2009) regarding RWS.

Returning to water management, two frameworks create a solid base for evaluating water governance in general. The OECD (Organisation for Economic Co-operation and Development) published its "Principles on Water Governance", recognising that there is no "one-size-fits-all" solution to water challenges worldwide. However, the principles apply to a larger picture of water issues, such as floods ("too much"), water shortages ("too little") and water quality ("too polluted") (OECD, 2015). With this in mind, Havekes et al. (2016) introduces five elementary building blocks for good water governance. Moreover, the three-layer water governance model is introduced as a framework for assessing and analysing water governance (Figure 3.1).

Figure 3.1: Three-layer model of water governance by Havekes et al. (2016)

Ultimately, Alexander et al. (2016) introduce a framework that relates exclusively to FRG, validating it with empirical research from England. Three benchmarks have been created for the evaluation of FRG. The first set of criteria reflects how much FRG supports societal resilience. The second part deals with the governance's efficiency, and the third with its legitimacy.

3.2.2. Flood Risk Governance

The term Flood Risk Governance (FRG) is a term used broadly for every strategy that contributes to a better flood resilience of a country. Some initiatives (or rules) are decided on a national level (or even international), whereas others might come from more regional water authorities, municipalities or other organisations, e.g., organised groups from citizen's initiatives.

Literature on Flood Risk Governance (FRG) has grown substantially, along with Flood Risk Management (FRM). Through the analysis of 3059 articles, Dordi et al. (2022) mapped out the difference between those key terms: While FRM has an emphasis on risk assessment, FRG focuses on the policy perspective, including all actors. Furthermore, it has been concluded that research on FRG remains limited compared to FRM, emphasising the importance of social analyses on governance processes and solutions for the future.

FRG refers to "steering and decision making by actors from the domains of state, market, and civil society, often through partnerships [...]." (Matczak & Hegger, 2021), meaning that various groups and individuals participate and work together to develop and implement FRM policies, ensuring effective collaboration among stakeholders (Takin et al., 2023). In their research on flood risk management, green infrastructure, and resilience, Takin et al. (2023) concluded that "effective flood risk management requires collaborative processes, stakeholder's engagement, a mix of top-down and bottom-up approaches and decentralised approach, transparency, capacity building, inclusive governance and decision-making process, equity, and social legitimacy [...]." (Takin et al., 2023).

As previously alluded, Driessen et al. (2018) introduced six key governance strategies that have the potential to enhance flood resilience:

1. The diversification of flood risk management approaches;
2. The alignment of flood risk management approaches to overcome fragmentation;
3. The involvement, cooperation, and alignment of both public and private actors in flood risk management;
4. The presence of adequate formal rules that balance legal certainty and flexibility;
5. The assurance of sufficient financial and other types of resources;
6. The adoption of normative principles that adequately deal with distributional effects

Parallel to this, four different stakeholder levels shall be mentioned (Sarabi et al., 2019):

- Macro (regional, national, international): (e.g., European Parliament, Ministry of Infrastructure, Rijkswaterstaat)
- Meso: City level, municipal departments, water boards etc.
- Micro: Citizens, landowners, business owners, citizen groups, and non-governmental organisations (NGOs)
- Transboundary actors

International Governance Level
All four actors contribute to a country's specific FRG. Starting with the highest (macro) level, the Floods Directive (Directive 2007/60/EC) was introduced by the European Parliament. The directive states that the respective countries must implement a three-stage plan of, first, flood risk assessment, second, creating flood hazard and flood risk maps, and lastly, compile flood risk management plans that shall be reassessed every six years (Driessen et al., 2018). Directives from the EU are binding, however, every country is free in how the agreed goals of the directive are achieved (Priest et al., 2016). Hence, even if the directive has been widely seen as an important step towards a common minimum flood management framework, Driessen et al. (2018) also lines out its potential shortcomings: a lack of substantive requirements makes it uncertain if the directive alone has the ability to improve flood resilience.

National Governance Level(s)
According to Driessen et al.'s study (Driessen et al., 2018) on governance change, the Netherlands stands out in comparison to other European nations with regard to the implementation of legally binding safety regulations that explicitly define the extent of the government's responsibility for flood protection. The European Flood Directive has been nationally implemented through the Water Act (Kaufmann et al., 2015).

One example of national governance is the Delta programme of the Netherlands: It stimulates the exchange of ideas and experiences as well as strategic planning with the inclusion of governmental actors at the national level (RWS), the regional water authorities, municipalities, and knowledge institutions, among other actors.

Other programmes to ensure sufficient FRM in the future have been set in place, e.g., the Flood Protection Programme (HWBP) or Sea Level Rise Knowledge Programme. Nevertheless, the official documents seem to confirm that there is a strong emphasis on defence strategies rather than taking into account the concept of resilience and diversification.

This notwithstanding, the Delta Programme of 2024 (Ministry of Infrastructure and Water Management et al., 2023) recognises several new aspects, such as intensifying citizen's participation. Other suggestions, such as "multi-layer safety" are mentioned which are less focused on solely the prevention of floods but also on mitigation and resilience. Nonetheless, for now, the concept of concrete NBS only seems to be a niche solution which has only been reflected upon superficially.

In an elaborate report, Kaufmann et al. (2015) analyse and evaluate the FRG of the Netherlands. They conclude that the Netherlands has a "high level of path dependency of a defence approach with only incremental and gradual change." The flood defence approach provides a very good basic and adequate protection, however, the reduction of potential consequences in case of flooding is only "marginally established". Hence, it has a high capacity to resist, however, the buffer capacity is limited (Kaufmann et al., 2015). This corresponds with the analysis of Driessen et al. (2018) and of Raadgever and Hegger (2018) and supports the argument that NBS can contribute to a diversified FRG. Nonetheless, Raadgever and Hegger (2018) also note potential criticism and say that diversification does not (necessarily) guarantee resilience.

Meso Governance Level
Meso-level, together with micro-level are considered key actors for uptake and implementation of NBS (Sarabi et al., 2019). The system of regional water authorities has historically grown in the Netherlands. They raise their own taxes and are important stakeholders in FRM and integrated into the Dutch FRG (Raadgever & Hegger, 2018). For example, the Flood Protection Programme, is an alliance of RWS and all water authorities. Hence, they play an important role in FRM of the country. Also municipalities can play an important role for FRM and governance, since they are able to steer spatial planning.

Micro Governance Level
Micro-level actors are inevitably the most diverse group of actors (Sarabi et al., 2019). Participatory and collaborative governance for sustainable FRM is an emerging research agenda (Challies et al., 2016). There is a rising trend in using participatory decision-making in sustainable flood management (Koutsovili et al., 2023; Matczak & Hegger, 2021). Even though decision-making in a multi-actor environment can be complex, it is essential to look at participatory approaches in the governance of flood defence measures. Driessen et al. (2018) outline six governance strategies that contribute to increasing 'flood resilience', one being the increased involvement of private actors, which includes businesses, NGOs and citizens. Also, Matczak and Hegger (2021) highlighted a significant rise in interest regarding the participation of private actors in recent years.

Transboundary Actors
In this categorisation, the role of transboundary actors is considered essential for the uptake of NBS as they can diffuse knowledge among different stakeholder groups (Sarabi et al., 2019). The role of a transboundary actor can be taken by several stakeholder, for example NGOs or the private sector.

Figure 3.2 underlines that flood risk is a shared responsibility that corresponds with the above findings that all stakeholders contribute to FRG.

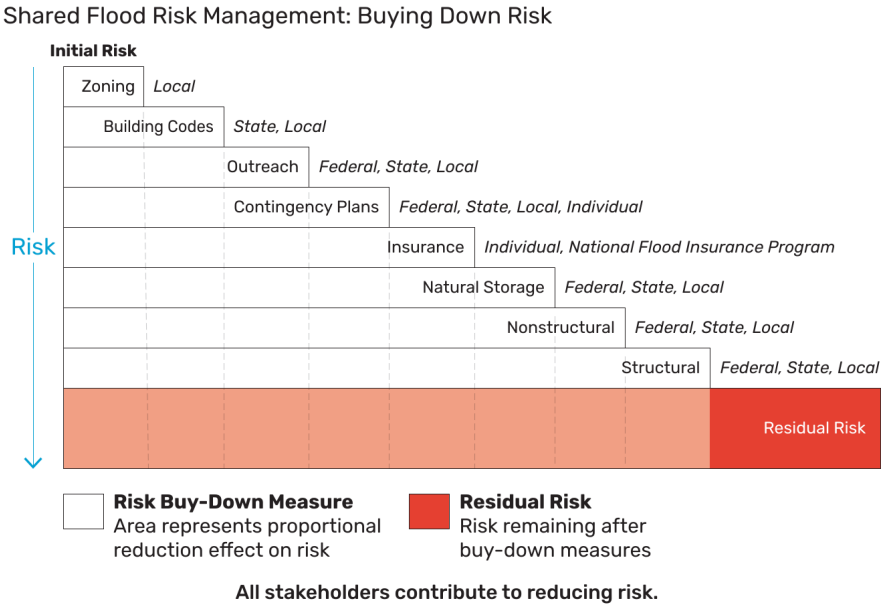

Figure 3.2: Shared Flood Risk Management by Haring, Schielen, Guy, Burgess-Gamble, and Bledsoe (2021)

3.3. Implementation of Nature-based solutions

To apply NBS in river systems to reduce flood risk, several principles can be followed that are not only focused on the reduction of flood risk but also include ecological, social, environmental and economic "co-benefits" (Haring, Schielen, Guy, & Burgess-Gamble, 2021).

Furthermore, about fluvial systems, Haring, Schielen, Guy, and Burgess-Gamble (2021) mention that there are still governance and institutional gaps that hinder the implementation of NBS.

Sarabi et al. (2019) discuss the term NBS in detail and identify enablers of and barriers to a successful implementation. One of the key enablers identified is partnership among stakeholders, which was mentioned in 27 papers that have been reviewed. On the other hand, one of the barriers identified was the uncertainty regarding the implementation process, which corresponds with the observation of Waylen et al. (2017). Nevertheless, the research of Sarabi et al. (2019) covers a much broader definition of NBS than what is intended with this thesis. Their research focuses on urban settings whereas this thesis aims to find solutions for FRG. Furthermore, the results have not been confirmed with experts from practice in real-life projects, which is one goal of this thesis.

It is recognised that both the meso and the macro level can act as an enabler but also as a barrier to the implementation of NBS (Sarabi et al., 2019).

Lastly, Van Eekelen and Bouw (2020) present a comprehensive collection of projects that have implemented the concept of *Building with Nature*. Building on several years of experience with projects in their pilot phase, they derive a list of enablers for implementing NBS, namely *Institutional embedding, Business case, Adaptive management, maintenance, and monitoring, Multi-stakeholder approach, Technology and system knowledge*, and *Capacity building*.

3.4. Conclusion

This chapter has explored the key principles of FRG and how they integrate NBS. By examining the definitions and applications of NBS in FRM, it has been established that NBS is a diverse and evolving concept. The different definitions highlight its broad applicability and its potential to provide benefits for the environment, flood safety and society. In the context of FRM, NBS can complement or replace traditional structural measures, thereby contributing to more resilient and adaptive systems.

The discussion on FRG emphasizes the shift from traditional, centralized government to more participatory governance involving multiple stakeholders from various levels. Effective FRG must incorporate a mix of actors, ranging from macro-level (national or international) to micro-level (local communities and individual citizens), each playing a crucial role in the implementation of NBS. The integration of NBS in FRG requires collaboration, stakeholder engagement, and adaptive management approaches that account for the interconnectivity of systems and the need for sustainable and resilient solutions.

Ultimately, the chapter demonstrates that the successful integration of NBS in FRG hinges on embracing diverse governance strategies, fostering partnerships among stakeholders, and promoting a holistic approach that looks beyond flood defence to consider ecological, social, and economic co-benefits. The insights gained here set the foundation for understanding the challenges and opportunities in implementing NBS, which will be further explored in subsequent chapters.

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4

Current Flood Risk Governance - Effective but somewhat rigid

The following chapter presents the results from the primary and secondary data collected to answer SRQ2: *"How is the current Dutch Flood Risk Governance organised?"* The aim is to answer SRQ2 in light of the main research question and, hence, to provide sufficient insights into the current governance concerning the implementation of NBS.

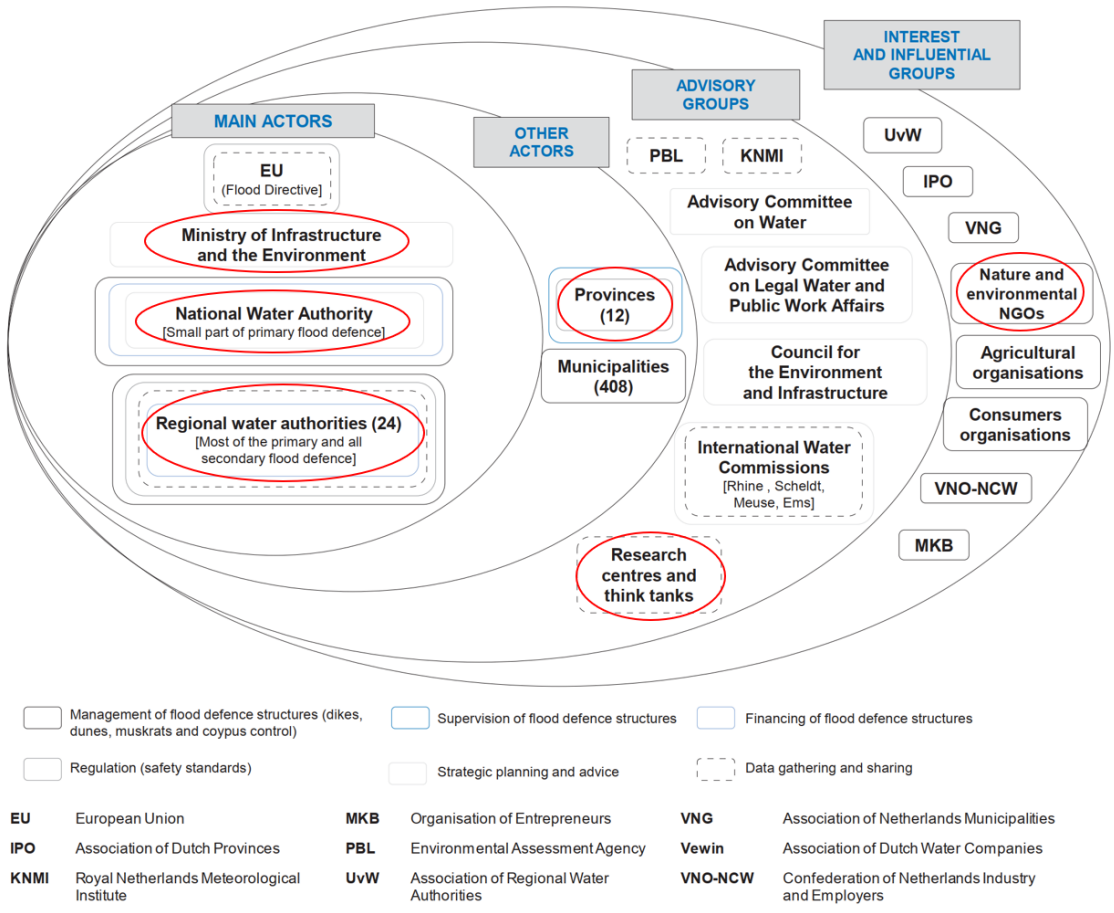

Figure 4.1: Institutional mapping of actors in Dutch FRG adapted from OECD (2014)

Using an analytical framework, the water governance of the Netherlands has been reviewed in an extensive report by the OECD (2014). This report depicts all main actors for flood defence in an institutional map (Figure 4.1). The figure has been adapted with red circles to show that the interviews conducted for this research were with stakeholders from all four groups, with an emphasis on the "main actors" (also see Table 2.1). In addition to the figure above, Figure 4.2 depicts a general overview of the most important influencing factors for FRG and the implementation of NBS in the Netherlands. The illustration shows timelines of the most important legislations, policy and knowledge programmes, implementation programmes and pilot projects for NBS.

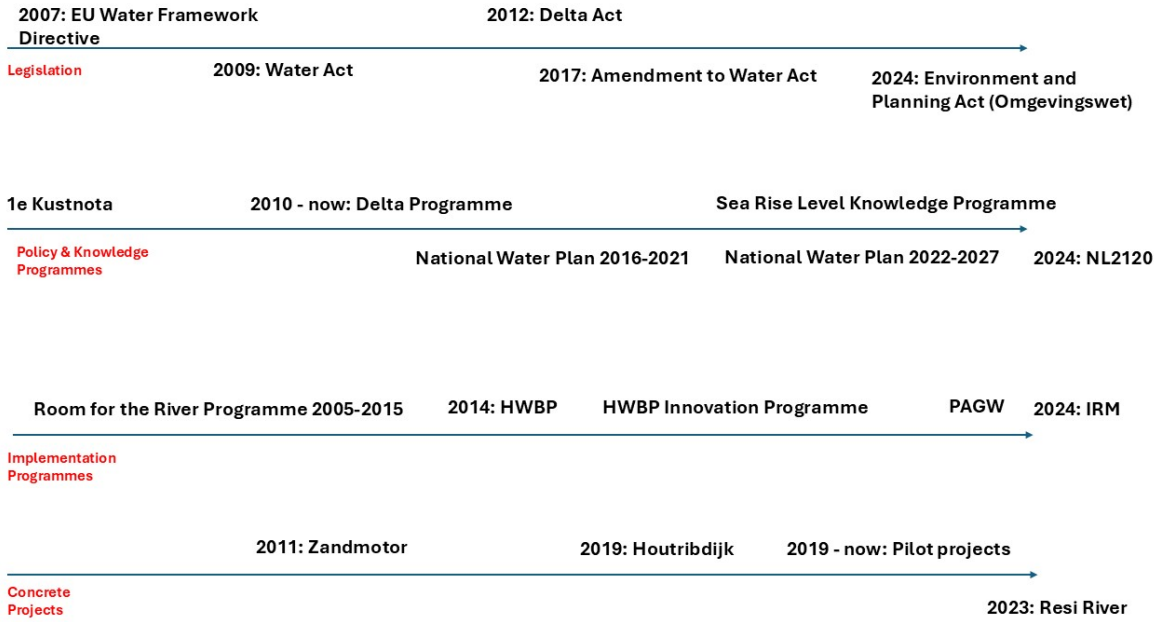

Figure 4.2: Timeline of the Dutch FRG regarding NBS implementation (created by the author)

Flood risk governance (FRG) in the Netherlands has evolved significantly over the past decades, transitioning from a traditional focus on structural measures, such as dike reinforcements, to more integrated approaches considering spatial and ecological quality. This chapter examines how FRG can create the necessary conditions to facilitate the implementation of NBS within FRM strategies. While the *Room for the River* programme successfully pioneered the integration of NBS by combining flood protection with spatial enhancements, subsequent programs, such as the Flood Protection Programme (HWBP), have reverted to a narrower scope focused mainly on dike reinforcement. This has resulted in stagnation and a missed opportunity to fully harness the potential of NBS. However, recent policy developments, including the *PAGW* and *NL2120*, show promise in revitalising the adoption of NBS. This chapter analyses these shifts and identifies the first challenges to NBS implementation.

By examining these dynamics, the chapter aims to highlight the role of governance in enabling sustainable and resilient flood risk strategies that extend beyond conventional measures.

4.1. Dutch Water Management: Historical and Cultural Roots

The following subchapter describes the Dutch FRG's historical and cultural roots, which are essential to understanding the current situation. Improving overall resilience alongside maintaining strong protection measures faces several obstacles. Some obstacles result from the Netherlands' historical and cultural view on addressing flood-related issues.

The Netherlands' flood defence system has historically grown. Floods have been recorded back

until the 13th century (Jensen, 2024) and ever since contributed to the country's effort to defend and reclaim its land. Also, the first water authorities date back to that time (Havekes et al., 2017). This indicates that Dutch FRM is enshrined in the history and culture of the country, and this has contributed to the fact that Dutch FRG can be seen as particularly unique. Several interviewees have emphasised the Netherlands' unique relationship with living with water. For example, a national law on flood defence only exists in the Netherlands. Moreover, its flood safety norms are the highest in the world (OECD, 2014).

"I think we're the only country in the world I think that have already have quite a set policy and it's also enshrined in law." (Interviewee G1)

"[...] what is really remarkable is that we are the only country that has a national law on flood defence. […] it started with the Wet op de Waterkeringen, it became the Waterwet and is now laid down in the Omgevingswet. [...] at national level [...] is stated that every inhabitant protected by dikes has a guaranteed safety level, which is expressed in flood risks and probability of flooding." (Interviewee G3)

The Dutch uniqueness is also grounded in the fact that a significant proportion of the economy is generated in flood-prone areas. Hence, the high flood safety standards are founded and can be justified by the necessity to safeguard the country's entire value chain. Or, to put it more simply, investments in flood protection measures continue to be worth their money.

"Because when things go wrong well, then we are lost. So we should always try to have that situation from not happening. [...] if you look with the eyes of a risk specialist [...], then still it is worthwhile to put every Euro in the prevention." (Interviewee G3)

Literature suggests that the Netherlands should focus on a more holistic approach to enhance resilience. Furthermore, several policy documents have addressed this already. However, during the interviews, it became clear that focusing on this issue may not be straightforward for certain regions. In some areas of the country, the land is so low-lying that any breach of the primary flood defence system would result in catastrophic consequences.

"But maybe most people don't realise that the situation in the Netherlands is maybe very specific. [...] we're a very low-lying country and also with low lying polders. And if a flood occurs - when we talk about flood risk we mainly talk about really serious floods and then we talk about floods [...] several metres of water will be flowing into the polder, so there's no way you can be resilient to that." (Interviewee G1)

"Depends a bit where you are. In some cases, it doesn't matter too much whether you have 3 metres water above your head or 3.2 or 3.3 metres above your head. It's still too much." (Interviewee G2)

The interviewees imply that for the very low-lying areas of the Netherlands, e.g. polders, the only possible way of ensuring flood safety is by protection through embankments, rather than other measures as suggested by Driessen et al. (2018). Interviewee G4 recognises that the Netherlands is in a situation where defence measures are necessary to safeguard the country. Nevertheless, they suggest moving forward in a direction that enables more resilient and sustainable solutions.

"So we are funnelled into a technical log-in situation. We have this system of embankments and, within that system, you can do limited things but you cannot say, OK let's get rid of the embankments and then just try to see how the Netherlands would survive that situation because we wouldn't. [...] So we need our system of embankments. Everybody agrees on that. But nevertheless, within that system you try to make the river as natural or as resilient or as sustainable [...] as possible." (Interviewee G4)

Interviewee G4 describes the current FRG as being "funnelled into a technical lock-in situation", which aptly characterises the current prevailing tendency to overlook NBS. Moreover, Van Den Brink (2009) notes that RWS's flood risk management approach has traditionally been rooted in a "technocratic" mindset, driven largely by civil engineers who favour technical solutions. However, this

approach has faced increasing scrutiny over the past decade. The construction of projects like the Eastern Scheldt Storm Surge Barrier marked a shift toward a more integrated and multifunctional strategy in FRM (OECD, 2014).

4.2. Increasing Resilience and Relations to the EU Flood Directive

The EU Flood Directive (Directive 2007/60/EC) drew the Dutch policymakers' attention in 2009 to limit the consequences of flooding besides preventing it (Algemene Rekenkamer, 2023). By looking at flood risk as the combination of the probability of a flood event with the potential consequences (risk = probability x consequence), the risk can also be decreased by minimising potential consequences. This is called multi-layer safety. The interviews revealed that attention to all safety layers is gradually increasing but not sufficiently followed up.

The first layer, prevention, focuses on keeping the water out with flood defence measures. This is considered well-developed. It has been the centre of attention in past policies and is still considered an essential pillar for the future (Driessen et al., 2018; Kaufmann et al., 2015).

The second layer, consequence mitigation, aims to minimise the consequences with new spatial planning strategies, for example, providing flood plains or building new buildings on a mound.

The third layer, crisis management, focuses on preparation, including emergency evacuation plans and equipment.

This strategy aligns partly with the recommendation of Driessen et al. (2018), who also consider diversification of flood risk as one key governance strategy to enhance resilience. Nevertheless, the Court of Audit of the Netherlands recently argued that the current multi-layer safety approach from 2009 had not been followed sufficiently (Algemene Rekenkamer, 2023). In most of the investigated projects, the flood risk has been improved through measures concerning layer 1, prevention, rather than considering layer 2 or 3.

One critical interviewee agrees with this:

"[...] but I think there's more and more attention for it, for all layers. But mostly just on paper. [...] if you look where goes to money? Follow the money. You don't see so much changes. So, Most of the money still goes to layer one." (Interviewee G5)

The other interviewees revealed that, in their opinion, the Flood Directive has not led to any substantial governmental changes. On the contrary, several interviewees emphasised that the Netherlands has been a pioneer in FRM more than any other member state.

"According to the regulations, and on a project level, on a technical level, on a financing level, it hasn't changed the way we're dealing with flood management very much." (Interviewee G2)

"The other thing is that we didn't want to retrace our steps. And therefore, we welcome the idea of a framework directive and kept the impact as low as possible." (Interviewee G2)

"Now let me take it how it really went somewhere in the early 2000s. From our policy department, it was thought, well, let's help Brussels to formulate the European Flood Directive. And so it was actually built on the Dutch expertise, and we did to do the work on those days. And that was needed because we are the downstream country. So, for our things, the law should help us and not work against us." (Interviewee G3)

"I would say there was no connection between that. Actually, it was just a European directive. We already did a lot of things, so for us it was quite easy to comply with that directly." (Interviewee G4)

Ultimately, the current Delta Programme (2024) points out certain improvement measures for the future. One suggestion is to follow the outcomes of the Pluvial and River Flood Policy Platform.

In their report “Prevention isn’t possible, preparation is” [Dutch: “Voorkomen kann niet, voorbereiden well”], one of the recommendations is to extend the multi-layer safety by adding a fourth layer, namely the climate-robust restoration of damage. Moreover, a base layer of flood awareness is suggested. Also, those recommendations align well with the findings of Driessen et al. (2018).

4.3. Responsibilities

The following subchapter describes the responsibilities of key stakeholders in FRG and how it may affect the implementation of NBS. This is essential to later address recommendations to them considering their specific role.

FRM in the Netherlands is a shared responsibility between the central government and regional water authorities. The central government, through the Ministry of Infrastructure and Water Management and RWS, oversees national water policy, coastal defence, and large infrastructure, while regional water authorities manage the primary dike line. RWS also maintains the coastline and advises the Ministry. Although these efforts are largely effective, challenges arise in aligning timelines and approaches, limiting opportunities for innovative, nature-based solutions in favour of conventional dike reinforcement.

The responsibility of FRM is described as a joint effort of the central government and regional water authorities. While the national government is responsible for the coastal defence line and large hydraulic infrastructure, such as storm surge barriers, the regional water authorities are responsible for 3.400 km of primary and 14.000 km of other dikes. The central government is the supervising authority of all primary flood defence structures (Havekes et al., 2017; OECD, 2014).

The Ministry of Infrastructure and Water Management (formerly the Ministry of Infrastructure and the Environment) is responsible for national water policy and its alignment with other policy areas. RWS is responsible for designing, constructing, operating, and maintaining the Netherlands’ main infrastructure. The OECD (2014) points out that RWS also act as an advisor to the Ministry and, hence, plays a crucial role in Dutch FRG.

RWS is also responsible for maintaining the country’s sandy coastline through sand nourishments. This is done within the *Programma Kustlijnzorg* and contains nourishments along the Dutch coasts that are scheduled up to 2027. Several interviewees point out that this is a nature-based approach which has been followed already for longer. Since the introduction of the *First Coastal Policy Note* [Dutch: 1e kustnota] in 1990, the decision has been taken that the existing sandy coastline shall be maintained to ensure future safety with sand nourishments sustainably. Several documents later underlined this strategy, and it is still used today with the current National Water Plan 2022-2027. Apart from regular sand nourishment projects along the coastline, the Sand Motor [Dutch: Zandmotor] has been the first mega-nourishment project along the coast of The Hague, widely considered a successful implementation of an NBS pilot project. Compared to the rest of the coastline, this part has been untouched since one large nourishment and therefore, was able to develop in a more natural way than other parts.

The regional water authorities are essential stakeholders in the Dutch FRG. Over several centuries, the regional water authorities have consolidated to currently 21. Their area of responsibility is often divided over more than one province, as their borders were determined mainly hydrographically. The provinces, on the other hand, are in charge of integrated spatial and environmental planning within their administrative boundaries (OECD, 2014).

One interviewee pointed out that the interaction between requirements provided from a higher level, e.g. RWS, and complying with them can occasionally cause difficulties. The regional water authorities need to comply with a given safety level and, therefore, need to reinforce their primary flood defence line, e.g. the dike line, which they are responsible for. Interviewee G4 describes the difficulties within the interplay between RWS and the water authorities.

"We [RWS] say OK, just take this line and then design your dike such that this water level can be resisted [...]. And meanwhile, within Rijkswaterstaat we are thinking about measures. Measures to decrease that water level. So we say to the water boards, OK, well it's this level, but perhaps it's also this level. And then the water boards say OK, but we have to comply with tenders within the next year, so what do we have to choose? Well, we don't know. We [RWS] have to think about that. It's a long process. And of course, at a certain moment, they think, OK, well, we're not going to do this 'cause I'm not sure that you really are going to achieve that. So we take this upper level and that means that if you then want to consider a measure then that is, from protection point of view, no longer necessary because you already solved it with a stronger embankment. And I think that is going to be quite a nature dilemma. So in the cooperation between Rijkswaterstaat and the water boards. [...] and that is a kind of threat for the more nature-based solutions that we would like to apply in the river area." (Interviewee G4)

Interviewee G4 points out that the regional water authorities are under constraints regarding compliance with safety regulations within a specific time frame. This setting may hinder the implementation of solutions other than solely dike reinforcement.

4.4. Programmes and their support regarding NBS

The present Dutch FRG is characterised by several programmes that show the way forward. The Delta Programme and National Water Programme are mainly seen as a policy instrument published by the responsible Ministry of Infrastructure and Water Management. On the other hand, the Flood Protection Programme (HWBP; Dutch: Hoogwaterbeschermingsprogramma) is an implementation programme that guides the way forward regarding reinforcing the primary flood defence system.

"I think it's important [...] to realise that the Delta Programma, it's more a kind of policy instrument. [...] it gives guidelines how to develop strategies in protection. But the concrete interventions, they have to be part of the Hoogwaterbeschermingsprogramma." (Interviewee G6)

The HWBP is the Netherlands' most extensive implementation programme for dike reinforcement projects. Firstly, in 2009, new safety levels for primary flood defence infrastructure were specified in the Water Act. However, most recent safety levels have been in force since 2017 through an amendment which also determined that those standards need to be fulfilled by 2050 (Ministerie van Infrastructuur en Milieu, 2016). Since 2024, the Water Act has been implemented in the Environment and Planning Act, which aims to simplify and combine laws regarding land use, residential areas, infrastructure, the environment, nature and water into one (Informatiepunt Leefomgeving, 2024).

Every two years, the Dutch Association of Regional Water Authorities [Dutch: Unie van Waterschappen] publishes the water authorities' performance in several disciplines with two reports, namely the *Waterschapsspeil* and the *Waterschapsspiegel*. Even if the standards were set high, the assessment from 2012 showed that only 63% of all flood defences had met the standard, which was in force at that moment (OECD, 2014). It is noteworthy that the task of dike reinforcement has become more challenging, as the newest round of reporting revealed that, at the end of 2023, only 39% complied with the newest safety level from 2017.

Ultimately, to comply with the safety standards, in 2014, RWS and the regional water authorities joined forces in the HWBP. RWS manages 10% of the primary flood defence infrastructure, which is entirely paid by the state. The remaining 90% are managed by the regional water authorities, and their associated dike reinforcement projects receive a subsidy through the HWBP. The costs for every project are subsidised by 90% from money from the HWBP while the responsible water authority contributes 10%. The money from the HWBP is gathered from RWS, who pays 50% of the project costs and by 40% through a solidary contribution of all regional water authorities. Furthermore, if an innovative solution is implemented, 100% of the project costs may be eligible for HWBP subsidy.

The interviewees have indicated that the HWBP posed relatively strict guidelines regarding the

reinforcement of dikes. Due to its high influence, implementing innovative solutions within this framework, such as NBS, has been considered difficult. As a dike reinforcement is subsidised by 90% through this programme, it has a decisive power in its decision-making. Moreover, several interviewees pointed out that NBS are not a fundamental part of the programme.

"[...] but I agree with you that now in the Hoogwaterbeschermingsprogramma itself, the link with nature-based solution is quite vage, if it's even existing." (Interviewee G4)

"It's because the Hoogwaterbeschermingsprogramma, they have a very focused objective and, yeah, that excludes performing water management measures in combination with, for example, nature restoration, at least they may not spend money on it." (Interviewee G5)

As described above, complying with the determined safety level by 2050 is a challenging endeavour for RWS and the water boards. Therefore, the HWBP promoted to execute the work soberly and efficiently [Dutch: sober en doelmatig]. However, recent policy advice from the Board of Government Advisors [Dutch: College van Rijksadviseurs] towards the HWBP was to change this scope to *"smart and efficient"*. Their report entailed concrete advises towards the different stakeholders.

This notwithstanding, the HWBP did start to provide opportunities for innovative solutions regarding dike reinforcement. If NBS features have been considered, this has been made partly possible through the innovation programme within the HWBP. Also this has been pointed out positively in the interviews.

Before the HWBP was initiated, another important programme was the *Room for the River* Programme [Dutch: Ruimte voor de rivieren], mostly implemented until 2015. The maintenance of most of the primary dike lines is usually in the hands of the regional water authorities. However, since the programme entailed more than dike maintenance and reinforcement, the central government took the entire responsibility. Therefore, it has also been fully financed through national money. One of the selected case studies that was part of this programme was the Room for the River Waal Nijmegen.

Several interviewees pointed out the positive contribution and the international interest in the measures taken. Despite its big success, interviewees remarked that the programme was successful, especially because spatial quality was another factor included in the programme, along with safety. Several interviewees said that most *Room for the River* projects were mostly carried out because this second objective was in place as well. Moreover, it has been said that an ordinary dike reinforcement would have been more cost-effective in most areas.

Figure 4.3 depicts the toolkit of measures that could be taken for each project in order to achieve the defined goals. This gave project managers a clear range of possible solutions that can be taken.

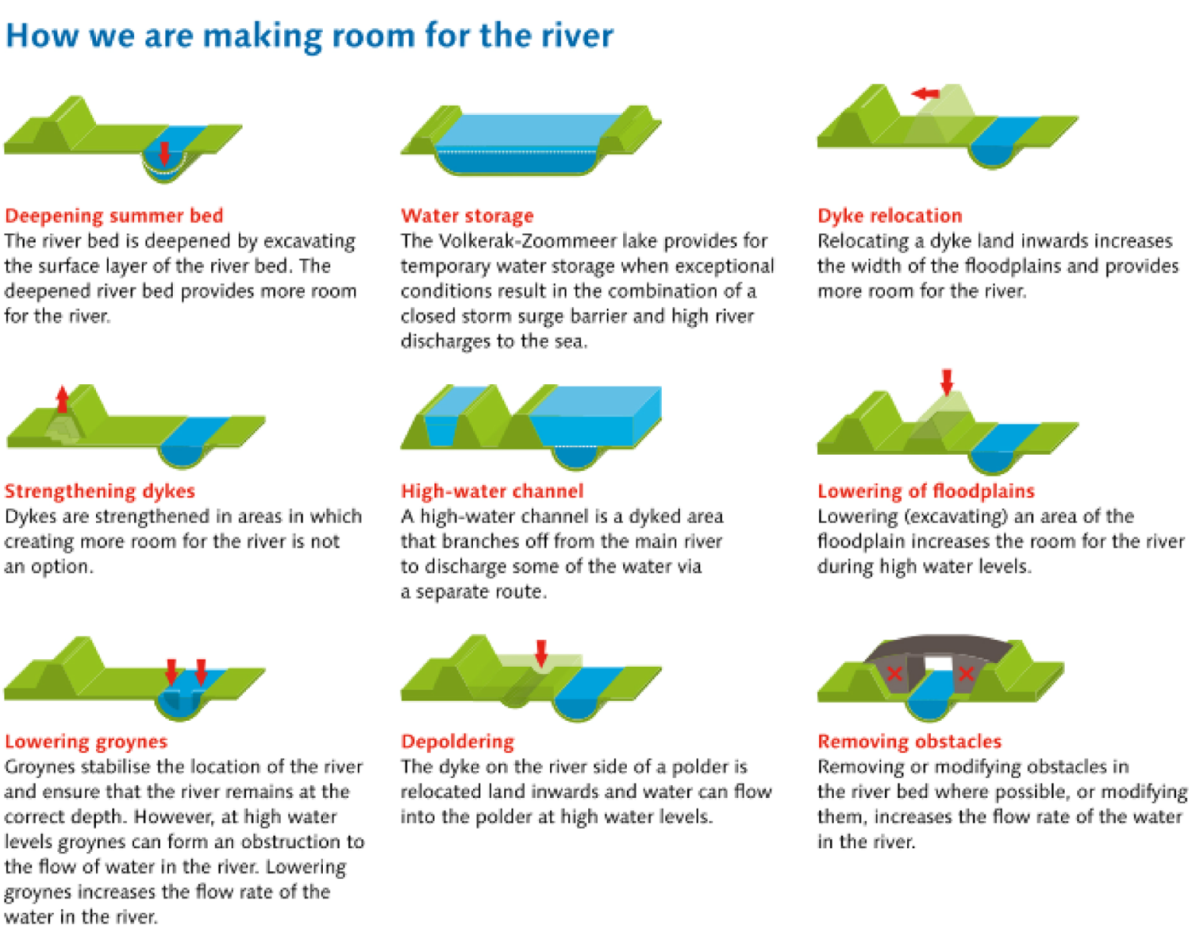

Figure 4.3: Toolkit of measures for *Room for the River* (Verweij et al., 2021)

After its completion, *Room for the River* has not been followed up by a new programme immediately. However, since 2024, the plans for a new program called the Integrated River Management (IRM) programme were published. This time, the programme is a collaboration between the national government, the provinces and the regional water authorities.

The official publications address several flood safety and environmental issues the Netherlands will face in the upcoming decades. However, several interviews have pointed out that most documents do not provide specific statements regarding NBS. For example, the National Water Programme (2022-2027) mentions "Nature-based solutions" explicitly only once.

"And that's where things go wrong, because in the national water plan [...] it states everywhere that for nature and environment [...] we need to change the way we do our water works and that nature-based solutions are very promising because they also deliver those benefits [...] but then nowhere in the national water plan anything is said, OK, we're gonna change the objective for the Hoogwaterbeschermingsprogramma or we are going to make sure that there's enough money for operational costs, which, of course, will increase if you have to combine a dike strengthening with a large nature restoration programme. So it's not practise what you preach, it's only preaching." (Interviewee G5)

It has been noted that most policy documents have formulated goals until the year 2050. While this seems a reasonable time frame for the implementation of a programme, several interviewees emphasised that the time frame of FRM has to cover a significantly longer period of time, strictly speaking, eternity. Only recently, some programmes started to look further ahead than 2050, such as the Sea Level Rise Knowledge Programme.

Another notable programme mentioned positively in the interviews regarding implementing NBS is the *Programmatic Approach to Great Waters* (PAGW; Dutch: Programmatische Aanpak Grote Wateren). Its goal is to improve the ecological functioning of the large waters in the Dutch delta. Interviewee 5 noted this as a supportive policy for NBS.

"That's called the 'Programmatische Aanpak Grote Wateren'. That's a new policy programme that has been started [...]. The objective of that programme is you have to indicate what big systemic changes are needed in the way we organise our water management, in our big waters, so our rivers, the coast, the big lakes […]. " (Interviewee G5)

Nonetheless, Interviewee 5 notes that the money spent on this programme is not yet enough for a wider implementation:

"But it's not enough to make the whole shift that is necessary." (Interviewee G5)

Another recently announced knowledge and innovation programme, financed by the National Growth Fund with 110 million euros, is *NL2120*, in which several public and private institutions, nature organisations, consultancies, and dredging companies are working together on gathering more knowledge to enable a wider implementation of NBS. *ResiRiver* is another project that focuses on the upscaling and mainstreaming of NBS for rivers in collaboration with several partners within the EU.

To conclude, several projects have already included NBS principles. In the past years, however, some initiatives, such as *Room for the River*, have not been immediately followed up. This notwithstanding, the recent development shows that NBS has been more widely accepted, and it will most likely be implemented further. Nevertheless, major programmes, such as the HWBP, should be aligned further with those initiatives.

4.5. Regional Water Authorities

The regional water authorities play an essential role in implementing flood defence solutions in the Netherlands. Dating back to the 12th century, the water boards started as a consolidation of farmers protecting their land from floods and reclaiming more land, they have grown into highly professional organisations (OECD, 2014). After the big flood of 1953, the water boards have consolidated from over 2,000 very local institutions to 21 entities nowadays. As government bodies, they hold an independent position in the Dutch democratic system and have the authority to establish regulations and make legally binding decisions for citizens (Havekes et al., 2017).

"But I think the water boards are most important. When it comes to implementing nature-based solutions, especially with the levees, they are the crucial factor. If they are not willing to do that then it becomes really difficult. So they are very crucial that they see the benefits and it should make things more easy for them. Because they are the ones that are keeping the levees and maintaining them." (Interviewee G1)

The structure of a regional water authority is comparable with those of municipalities and consists of a governing board, an executive committee and a chairperson. The governing board is structured on the principle of the "interest-pay-say" triad, which ensures that stakeholders impacted by the activities of regional water authorities contribute to costs in proportion to their interest and have a voice in decision-making through participation in the authorities' assemblies (Havekes et al., 2017). Three groups have guaranteed seats in the governing board. The largest group being represented are the residents of the respective water authorities, whose representatives are determined through elections in a four-year cycle. Moreover, representatives of open land owners (traditionally mostly farmers) and representatives of nature areas receive two guaranteed selected seats each.

"[...] and the idea is that we have the system of "interest-say-pay", and that means that the higher the

interest you have of the work of a waterboard, the more influence you have on the work of the water board. But also the more you have to pay to the waterboard. So a small farmer has less influence but also less costs than rich farmers. And that is the basic you can say of the Dutch flood risk management governance." (Interviewee G3)

The governing board is responsible, among others, for setting policies, adopting the budget, making water-level decisions, and levying taxes. The executive committee is selected from members of the governing boards and holds responsibility for the day-to-day business of the water authority and the execution of policies. Interestingly, one major responsibility also is the policy preparation for the final decision-making of the governing board. As pointed out by Havekes et al. (2017), this means that also the executive committee play a significant part in policymaking.

Lastly, the chairperson is appointed by the Crown. They are not a member of the governing board and, hence, have no voting rights within it. However, they are part of the executive committee and have a vote there (Ministerie van Algemene Zaken, 2024).

Interviewee G6 calls attention to the structure of the regional water authorities. When a dike reinforcement project is being initiated, the water board applies for a subsidy at the Flood Protection Programme (HWBP). This shows that first, the board of the water authority and then also the directors of the HWBP need to be convinced of the suggested solution.

"But we really need the 'dagelijks bestuur' to strengthen our case in a situation that we prefer to apply the nature-based solution option, that is more costly, and not applying the standard solution." (Interviewee G5)

Interviewee G5 criticises that the agricultural sector is being overrepresented in the water board:

"[...] for the governance to become right, we need political decisions. And the political decision-making is hampered by overrepresentation of the agricultural sector but also the neoliberal vision on how government should act." (Interviewee G5)

One of the water board's foremost responsibilities is complying with the determined safety levels. Hence, as it has also been described by Janssen et al. (2020), the regional water authorities alone are not incentivised to expand their scope beyond this responsibility.

"[...] the Regional Water authorities, which are responsible for the majority of the dike reinforcement projects, they're responsible for the dikes, and they are a bit shy to take responsibility for the foreshore because it's not within their regular scope. Because they want to keep their task as limited as possible." (Interviewee G2)

Ultimately, the shift of the regional water authorities from solely line management towards area management seems to be a promising approach which could facilitate the implementation of NBS.

"At this moment, the water board is taking care of this [dike] line. But if you would like to have this inside your calculations [pointing to the foreshore] then the water board should also be responsible for this entire stretch. In other words, you go from line management to an area management which is more complex. It's not impossible, but it's much more complex. (Interviewee G3)

The regional water authorities are key stakeholders in FRG in the Netherlands. However, there is currently no legislation that promotes the widespread implementation of NBS. As a result, any NBS initiative must be driven by the water authorities themselves. Given their existing obligations and budgetary constraints, they often prefer solutions that stay within their designated responsibilities. This suggests that the "human factor" still plays a crucial role in the adoption of NBS, and members of the governing boards need to be genuinely convinced that NBS are an appropriate solution for a given situation.

4.6. Participatory aspects

Based on the reviewed literature, participatory aspects appear significant in future FRG approaches that emphasise integrated solutions. However, questions about participation are often addressed only superficially. This may be partly due to the fact that most interviewees were associated with organisations at a higher level of governance.

Interviewee G4 highlighted that within *Room for the River*, public participation has been sought through community sessions.

"We had very extensive community communication sessions within Room for the River. So we went into those little community places and explained what we wanted to do and why we wanted to do it and what would be the impact." (Interviewee G4)

Interviewee G2 introduced one project that was part of *Room for the River*, which is a good example that the wishes of local inhabitants can enable more innovative solutions. The dikes of the Noordwaard polder in North Brabant were relocated, providing more room for the river for flood events. However, the initial plan to raise a dike in an affected neighbourhood led to protests. Ultimately, a wave-attenuating willow forest on the existing dike was found as an alternative solution for a traditional dike reinforcement. Through this, the dike did not have to be raised, which made the undertakings more acceptable on a local level (EcoShape, 2020).

"[...] another one was that the link to the spatial quality is that the pressure on lowering the crest level of the dike came from the development from [...] people who were going to live in a restored building at the other side of the dike and [...] one of the qualities of that building was that it would have a wide view on the polder system which can be flooded during high discharges. And if the dikes were too high, a large part of the people couldn't enjoy that view. So for a more aesthetical reason, it was chosen to lower the dike level. But that's also part of spatial quality." (Interviewee G2)

Moreover, Interviewee G5, who works for an NGO, introduced a community-based approach that has been tried to be implemented in the future.

"Naturkracht. And what we did is that we chose for a community-based approach to- You have to interact with local communities about the possibilities of nature-based solutions to prevent flooding. And what we see there is that we encountered a lot of support and enthusiasm. And now local authorities are also joining us in the partnership to promote the use of nature-based solutions. And now the water boards and the province, the national government, are that being addressed by them." (Interviewee G5)

The perspectives shared by the interviewees indicate that community engagement can foster public support and facilitate broader collaboration. However, the representation of higher-level governance actors in the interviews may have limited the exploration of participatory practices at the community level, highlighting the need for more diverse perspectives to fully understand and integrate public participation in FRG.

4.7. Current challenges in regard to NBS

One identified challenge concerning implementing innovative solutions in FRM is that the current standards and codes to design flood defences are based on traditional measures. One interviewee remarks that the tooling in hydraulic engineering is still very traditional. Hence, new solutions, e.g., implementing a dike with a more shallow slope or standards for plants that contribute to wave attenuation measures, are not part of a standard toolbox that can be used in a straightforward way.

One constraint of NBS, which has already been observed, is that NBS usually needs more space. However, space is precious in the Netherlands, and therefore, it is challenging to receive more space

for NBS projects. In the case of a dike line, for example, a dike that includes natural features is most likely to have a milder slope than a regular dike. Therefore, more space is needed. The dike can then be extended towards the inside of the country or the outside.

Using the inside is problematic since this land will be taken away from often privately owned (farm)land. Hence, the other option is to expand towards the sea. However, in most areas, this area falls under the regulations of Natura 2000.

It became evident that NBS projects alone as a flood risk solution are less cost-effective than ordinary dike reinforcement projects. Yet, more innovative NBS solutions which have been implemented have been considered successful and continue to draw much attention. However, their success is based on the fact that more co-benefits along safety were implemented in the scope management from the beginning.

Despite various challenges, projects with nature-based features have been successfully implemented. Nevertheless, in those cases, it became apparent that the projects' success was often grounded in that the project team consisted of the right people who were really convinced of an innovative idea which then has been pushed in the right direction.

4.8. Conclusion

This chapter addresses SRQ2 *"How is the current Dutch Flood Risk Governance organised?"* in light of the MRQ. While first elaborating on the historical and cultural roots and the influence of multi-layer safety through the EU Flood Directive, the responsibilities of the main stakeholders have been described. Moreover, essential policy and knowledge programmes that are important for both FRG and the further implementation of NBS were introduced. The regional water authorities were identified as crucial actors in implementing NBS as they are mainly responsible for maintaining the majority of the current primary defence line of the Netherlands. While the participatory aspect has been described as crucial in the reviewed literature, the interviewees only touched upon this superficially. In light of the uptake of NBS, the first challenges have been identified, e.g., the lack of additional space for wider and more extensive solutions.

The above-described results show that Dutch FRG is well structured and demonstrates high coordination. The country's long history has uniquely shaped its water governance, and comprehensive rules have been implemented that have effectively protected the country and its inhabitants. Nevertheless, this has also shaped the governance into a somewhat rigid system.

The system's rigidity makes changes challenging to achieve. Therefore, implementing new solutions such as NBS is challenging to get started. Moreover, most concrete goals mentioned in policy documents are only defined until 2050.

Several programmes and projects with a broader approach than solely dike reinforcement were already in place earlier. The programme *Room for the River* should be mentioned here. In the past ten years, however, the FRG seem to be in a stagnation phase, which it is only slowly leaving. Several promising approaches in the form of new programmes (NL2120, PAGW) are starting that have the potential to contribute to a wider implementation of NBS.

The HWBP is a major and important programme of RWS and the regional water authorities. As the main responsible for complying with the safety standards by 2050, the regional water authorities will continue to play a major role in FRG and, hence, also in the implementation of NBS.

To gain more insights into why some projects were implemented successfully and how this could improve the implementation in the future, two cases were chosen to evaluate their barriers and enablers. One of the projects was part of *Room for the River*, and the other is still in a pilot phase and part of the HWBP.

5

Learning from two Case Studies

This chapter includes the results of two case studies conducted to answer SRQ3 *"What are the current barriers and enablers in designing and implementing nature-based solutions?"* and SRQ4 *"What needs to be improved in the current governance to enable routine implementation of nature-based solutions?"*. First, the two case studies will be introduced, and the governance framework in which both projects have been realised will be described. Then, each project's barriers, enablers, and potential improvements will be outlined and compared.

The interviews conducted for this part of the research were transcribed and coded with the help of *atlas.ti* to create a first overview of all barriers. Main themes have been created using *Excel* to narrow down all created codes.

Visualisation of Case Study 1: Room for the River Waal in Nijmegen (H+N+S Landschapsarchitecten, 2024)

5.1. Case Study 1: Room for the River Waal: Nijmegen

The first case study that will be examined is the project Room for the River Waal near Nijmegen and the city of Lent on the opposite side of the river. This project was part of the national programme *Room for the River*, which has been introduced before (see Chapter 4.4).

Although the project involves a significant amount of hard engineering, it can still be regarded as one with nature-based features, as the primary objective of the *Room for the River* initiative is to restore the natural dynamics of the river systems in the Netherlands. Due to various constraints, including navigation, recreation, and urban development, a complete restoration of the natural state of the rivers is unfeasible. Consequently, the project focuses on restoring a condition that more closely aligns with the river's natural development, incorporating elements such as enhanced meandering. Moreover, this case study has been selected because it represents the largest and most complex project within the *Room for the River* programme. As such, it provides valuable insights and potential applicability to similarly complex future projects.

Historically, the area has been prone to fluvial flooding from the Waal River. The river's tight curvature in this region has led to recurrent flooding in Nijmegen. The project aimed to mitigate these flood risks by creating additional space for the river.

The project is widely regarded as a successful endeavour within the *Room for the River* programme. However, it is noteworthy that prior to its successful implementation, the project faced considerable opposition, resulting in a phase of stagnation. Only after being integrated into the Room for the River programme did it progress, ultimately accounting for the largest portion of the programme's costs.

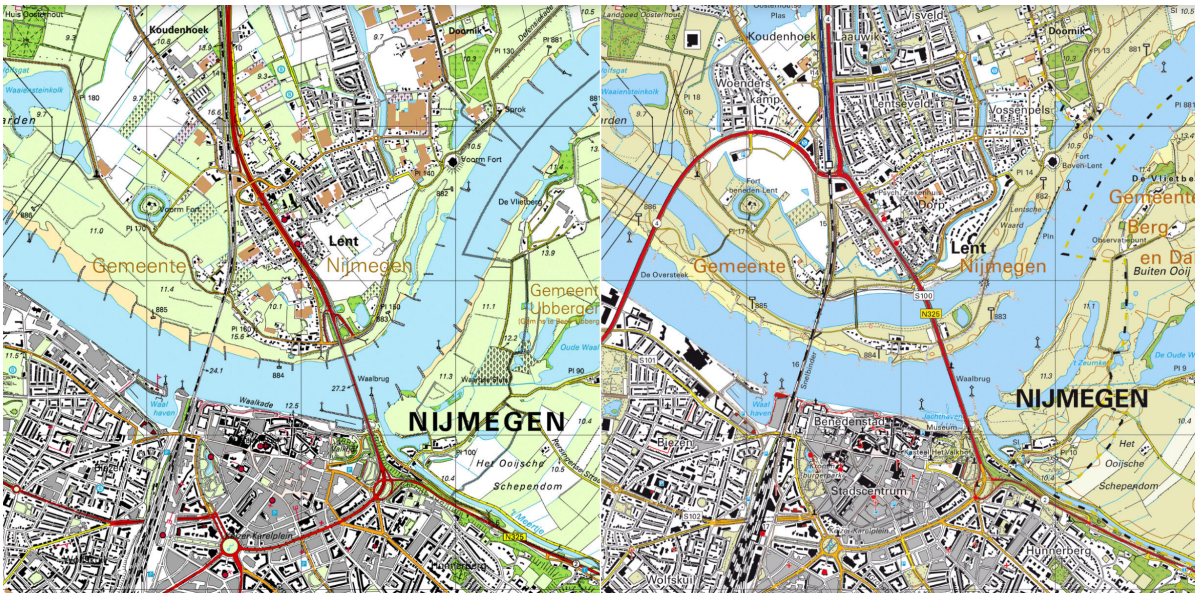

Figure 5.1: Two maps of the situation of Nijmegen/ Lent in 2008 (Left) and 2021 (Right). On the right side, the side channel has been created (Topotijdreis, 2024)

5.1.1. Barriers

Table 5.1 provides an overview of the identified barriers which hampered the suggested implementation of Case Study 1. The most significant barrier is the local opposition since the project had a major impact on the local level, including the removal of houses for citizens and changes in zoning plans for the municipality of Nijmegen.

Table 5.1: Barriers identified in Case Study 1

Barrier	Supporting Quotes
Financing	*"There was no money available for spatial quality. So all bridges were actually low-cost and not looking really attractive to people to go there."* (Interviewee CS1.1)
Uncertainties	*"And there is an insecurity in it, right? [...] It's not predictable exactly 100% how the, what kind of vegetation will emerge. So, you work with assumptions."* (Interviewee CS1.3)
Local opposition	*"And we had some discussions and people who live there started lawsuits. [...] Lawsuits telling this project is too big. There's no balance between the local benefits or the local issues and the national benefits. So, that project actually from 2003 to 2006 stopped, because there was too much protest."* (Interviewee CS1.1)
Lack of incentives	*"Relocating a dike is always much more expensive than going for the better strength of the existing dike. So it's not a question of that they are willing or not willing, but it's not their responsibility and their possibility to do it themselves."* (Interviewee CS1.2)
Spatial planning issues	*"But of course, the demolition of houses and not going, being able to create, I think, 400 houses or something like that, that was really a financial thing for the municipality."* (Interviewee CS1.2)
Effectiveness of NBS	*"So, it's not only about water safety, it's also about accommodating other functions in the floodplains. And you should be honest about it, because the water safety component is quite small in the main parts of the Netherlands, only in Limburg, it's substantial. But when you see we have, in the dike reinforcements, we sometimes have 30, 40 centimeters more height that we need. And with room for the river, you can maybe get a reduction of that with five centimeters. So, you have to be honest on how much contribution you have for water safety."* (Interviewee CS1.2)

Effectiveness of dike relocation
Several experts drew attention to the fact that a dike relocation is not as cost-effective as the simple reinforcement of the existing dike line. In the first round of interviews and during the talk for this case study, interviewees indicated that a traditional dike reinforcement would have cost less money. Hence, if the issue of flood safety is looked at from a solely flood safety perspective, reinforcement would always be the cheaper option. For this case study, this can be considered a hindering factor, especially because a reinforcement without relocation would have been much less imposing on the area and its citizens.

Local opposition
The biggest challenge for realising this project was its significant impact on the local level. As depicted in Figure 4.3, the execution of this project resulted in a considerable loss of area. Even more, approximately 50 houses had to be removed, which first caused protests among the inhabitants.

Spatial planning issues
Initially, when the idea of a dike relocation in Nijmegen was brought up, only recently did the municipality of Nijmegen get approval for a large housing project for the area, which would have been affected by it now. Additionally, as described above, the inhabitants of Lent did not favour this idea either (Rădulescu et al., 2021).

Uncertainties
Several interviewees pointed out that uncertainties related to the new solutions that had been developed were a challenge in implementing this project. For example, the development of a threshold entailed certain uncertainties as it had not been built before. Moreover, interviewee CS1.3 emphasised the difficulty of balancing between reaching the specified discharge capacity and the planning of planting in the area, as this always entails uncertainty. Furthermore, the maintenance of the newly created natural areas also entailed uncertainties.

Financing
Firstly, the proposed idea of a dike relocation, including compensating citizens for expropriation in this area, meant a huge impact that has not been feasible for the regional stakeholders alone. This led to the project stagnating for a while before further implementation took place.

5.1.2. Enablers

Table 5.2 provides an overview of identified enablers in Case Study 1. The *Room for the River* programme, with its national influence, can be considered the most crucial enabler for the project's success.

Table 5.2: Enablers identified in Case Study 1

Enabler	Supporting Quotes
People-factor	*"And it requires procedures and governance and open-minded people willing to really achieve quality goals and sometimes taking a step back and again, opening up a process because the whole group believes that it's worth it to do it because it would be a pity to, let's say, not take that step. But, yeah, you cannot do everything. You need to balance, it requires time."* (Interviewee CS1.3)
Programme-driven	*"The thing that was really crucial was the room for the river program. Because as I mentioned, even before we started this project already in 2003, as a single project, but we weren't successful. And the reason why we weren't successful, because there's a huge impact at the local level."* (Interviewee CS1.1)
National influence and Financing	*"That's why, especially the story about the nature-based solutions, how to stay close to the actual natural system and how to integrate all ecological values within the project, yeah, they were more than willing to do so with national money. They didn't spend any money of their own, which made it a lot easier. To make nice promises to the people who live there."* (Interviewee CS1.1)
Collaboration	*"I know that from [...] the client, that being both the city and Rijkswaterstaat, [...] they were a group themselves, and they were mirrored. So there was a person there thinking about spatial quality, and there was for us someone. There was something about project management from them and from us. So [...] in the core team, there was a mirror to where it was equal, everybody had their counterpart. And this makes it very balanced and very possible to really have a well-informed discussion on the topics that always emerge, and together determine the right path forward. So I think that everybody was very happy with how that went. And we also, as a consortium of market parties, have continued that collaboration since in other projects."* (Interviewee CS1.3)
Double goal	*"And there was two main goals for the Room for the River program on the national level. It was not only the discharge, making the Netherlands future-proof, but also improving spatial quality at local level. And that was really, really helpful. That decision on national level really helped to make this project feasible at the municipality of Nijmegen."* (Interviewee CS1.1)
Stakeholder involvement	*"Well, we had a klankbordgroep [focus group], that's, so we had this professional groups and then a klankbordgroep with inhabitants of the village, where you had the 'Dijkers', the 'Wijkers' and the 'Kijkers'. [...] There was a platform, there was a vereniging [association] for cultural history, the nature gatherings, so they were from all kinds of types, there were people in that klankbordgroep, and they could express their opinion, and they also asked us to make another alternative [...]."* (Interviewee CS1.2)
Framing	*"And it started at that moment. And what we did in the second project was involve those new people and make them start dreaming about the new situation. What do you consider is important? So no longer all 50 people were opposing against the project. But 10,000 people were dreaming about the project and only 50 were opposing. So the situation really changed by time and because of the housing in this location."* Interviewee CS1.1
Trust	*"And we started to build on acceptance. Nijmegen became in charge. We gained trust, made a plan and now people are proud."* (Interviewee CS1.1)

Programme-driven collaboration
Without a doubt, the decisive factor for the realisation of this project was the fact that it became part

of the *Room for the River* programme. Due to a key planning decision taken by the government in 2005 (Dutch: Planologische kernbeslissing), the decision to create more room for the river has been taken from a higher level.

Double goal
One key Enabler for implementing an integrated concept of the project was that *Room for the River* entailed two goals. Next to the first goal of improving water safety by allowing a higher discharge capacity of the rivers, another goal considered equally important was the improvement of spatial quality. Due to the fact that the programme entailed this goal, it was possible to seek multi-functional solutions. Hence, money was also available for additional measures other than flood safety measures.

Stakeholder involvement
Only when the local stakeholders were involved in the new vision of the project it was deemed successful.

Positive framing and promotion
First, the idea of a dike relocation, including the loss of land and the removal of 50 inhabited houses, was perceived very negatively. One interviewee pointed out that ultimately a mindset change had taken place. After the national decision, the general mood changed from fear over acceptance to pride. The interviewee explained that the story was changed from the fact that 50 local homeowners were protesting against the project to creating a vision for the whole area, including the development of a new area both in front of and behind the new dike line.

Creation of Co-benefits
The Creation of several Co-benefits ultimately enabled the success of this project. The area that used to be behind the dike has been changed into a river park connected with bridges to both Nijmegen and Lent. The park offers appealing quays with space for recreation, public facilities, opportunities for water sports and housing and has ultimately been seen as a positive development, bringing together the cities of Nijmegen and Lent.

5.2. Case Study 2: Clay Ripening Pilot and Wide Green Dike

The second case study contains two interconnected projects: the *Clay Ripening Pilot* and the *Wide Green Dike* [Dutch: Brede Groene Dijk]. Both projects are located in the northeast of the Netherlands in the province of Groningen. The Hunze en Aa's water authority is responsible for this area. Several programmes from different levels have been relevant for the implementation. The HWBP is involved as it contributed to the dike reinforcement strategy. Moreover, a more regional programme called *Ems-Dollart 2050* has contributed substantially to the project's success.

Due to the fact that more sediments are brought in during high tide than taken out in low tide, the silt concentration of the estuary and therefore, the turbidity of the Ems-Dollart estuary is increasing. Due to the higher turbidity less sunlight permeates the water and fewer algae and benthic species evolve. This problem takes an effect on the whole food chain leading to a loss of fish and birds. Not only ecologically but also economically, the big sediment intake is detrimental to the area. *Groningen Seaports*, the port authority for the ports of Delfzijl and Eemshaven, needs to dredge silt out of their shipping channels 365 days per year. The *Clay Ripening Pilot* and the *Wide Green Dike* have been brought up as an one idea to solve multiple problems in the future.

In addition to increasing silt concentrations, the current dike line protecting the Ems-Dollart estuary from flooding requires reinforcement to comply with newly specified standards. The standard approach would be to reinforce the existing dikes with a top layer of asphalt. However, the regional water authority did not favour this solution, as it would significantly alter the flood defence's appearance. Therefore, efforts have been made to find a solution that could address both the increasing silt concentrations and the need for reinforcement while also preserving the dike's green surface layer and maintaining its traditional appearance.

The idea was to use the silt from the estuary to create a dike with a milder slope. For this, the silt needs to be dried or "ripened". Hence, the two projects have been started. For the silt to not take a very long time to dry, several ripening methods have been tested in real-scale experiments near the dike line. One clay ripening area has been set up close to the waterway of the port of Groningen Seaports. The other fields have been set up in front of the part of the dike which has been in need of reinforcement, on the salt marsh. This salt marsh is part of a Nature 2000 area which makes this project a unique situation because usually any changes within this area are not permitted. By the end of 2023, the results of this experiment have been published.

In 2021, the first pilot phase of the *Wide Green Dike* was implemented, involving the construction of a 700-meter section with clay from three different locations. Following a period of monitoring and evaluation, the water authority plans to extend this dike approach to approximately 15 kilometres of the dike line in 2025.

Figure 5.2: Picture of a clay ripening field (Van Oord, 2020)

Figure 5.3: Aerial view of the construction of the Wide Green Dike (EcoShape, 2022)

5.2.1. Barriers

Table 5.3 provides an overview of the identified barriers which hampered the suggested implementation of Case Study 2, including an example quote from the interviews. Then, the identified barriers are explained.

Table 5.3: Barriers identified in Case Study 2

Barrier	Supporting Quotes
Traditional legislation	*"I think the policies are relatively rigid, particularly in the Netherlands. We have flood safety in building dikes. [...] It's really well defined in the policies [...]. So, our failure mechanisms for our dikes, the way to calculate it, the way to deal with it, but also the way, what type of materials are allowed to build a dike with. It's all prescribed. There are codes for it, there are regulations for it, there are standards for it."* (Interviewee CS2.2)
Rigid standards	*"In that way, we were changing the shapes of our dikes. If we were going to study the possibility of making the dike safe with clay and grass, we would need much more space, as the word wide green dike says by itself: It's a wide dike with a slope, which is not 1:4 - the standard slope - but 1:7 which is capable of withstanding the impact of waves. But you need much more space adjacent to Nature 2000."* (Interviewee CS2.1)
Financing complexity	*"Everyone is sort of seeing that and is in agreement on that. What is necessary is that you need various funding streams organized to make it all happen, because it's clear that there is a lot more cost to it than just dike strengthening, but it also is doing much more than just dike strengthening. So, it's logically that both from the Ems-Dollart 2050, the province, nature organizations, the harbor, everyone needs to contribute basically. But getting that aligned is the biggest challenge. To make sure that all at the same time, the financial decision can be taken. Yes, we're going to develop this clay ripener."* (Interviewee CS2.2)
Collaboration as a challenge	*"The main challenge was also the different types of organization in my project team. Everyone knows the point on the horizon, that we know where we need to go. But yeah, in my project team, Rijkswaterstaat, Waterboard, Province of Groningen, Stichting Groningen Landschap, there were many times we need to discuss with each other some changes in the contract, there was extra money needed, and that were the tough discussions."* (Interviewee CS2.3)

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Table 5.3 – continued from previous page

Barrier	Supporting Quotes
Risk aversion	*"If you are doing a sort of real scale experiment, then if it fails, it needs to be, a) cleaned up, and b) the absence of a good result should be covered as well. And those are enormous, enormous risks. I mean, we were building a 14 hectare area in which we were ripening clay. It's no small thing when you need to organize all of that. So we really had to distribute these risks, because no party alone would be willing to take that risk. So we really distributed that quite well."* (Interviewee CS2.2)
Local opposition	*"But at the end of the project, we need clay for what was it, 30 kilometers with lorries. And in the northern part of our province, there are not many routes for lorries. And one village, all the lorries need to go through that village. It was a little village, small roads, and all those people said, that's going to give us a lot of noise, change. We don't want the lorries in our village. It almost was a riot, almost, and our solution was using a bypass. We contacted a farmer, can we make a temporary road on your land? And that was possible, so that the lorries don't need to go through the village."* (Interviewee CS2.3)
Time constraints	*"Because that is maybe that is the most time-consuming thing of this all. The idea is very simple but changing rules, changing the perspective of different organisations to work together not only as of free will- just like it's nice to work together - payments should also be made and that takes time."* (Interviewee CS2.1)
Uncertainties	*"Because we really want that certainty. But, because you take that high level, you actually start over-dimensioning. And there, the competitiveness of the nature-based solution with traditional solutions becomes less and less. So, that is sort of... Here in the Netherlands, we are really busy with that trade-off, whereas in other parts of the world, people don't necessarily care, because the positive effects of the nature-based solution in flood defense are just a bonus in itself."* (Interviewee CS2.2)
Lack of incentives	*"But, of course, the money that they get is for coastal protection and they need to demonstrate that they are effectively and efficiently spending their money on coastal protection. So, there is no incentive for them to effectively do nature restoration, recreation and coastal protection."* (CS2.2)
Responsibilities	*"I think nearly all waterboards face this. They have an enormous operation of doing so many kilometers of dike and keeping and making sure that these all get strengthened. Then, of course, they put in project managers that have, say, good project management skills in sort of avoiding assuring that the process of this strengthening process is taking place and will be finished."* (Interviewee CS2.2)
Spatial issues	*"Because again, when you want to do the remainder of the Brede Groene Dijk in the same fashion, what you need is clay ripener, an operational large-scale clay ripener, which is going to take quite an area of land in which this needs to take place."* (Interviewee CS2.2)

Traditional legislation
One of the primary barriers for this project had already been identified during the initial round of interviews and confirmed in this case study: the existing legislative framework did not adequately support the proposed innovative concepts. The regional water authority recognized that reinforcing the dike with an asphalt layer would likely not be a broadly accepted solution for the future. However, the proposed alternative, which involved creating a milder slope, required significantly more space, as the dike would need to be much wider than in its current state. Since expanding inward would result in the loss of farmland, the decision was made to expand towards the sea. However, the land adjacent to the sea is a salt marsh protected under Natura 2000 legislation.

This legislation establishes essential regulations for preserving important natural areas. Nevertheless, as several interviewees noted, the conservative nature of this regulatory framework not only prevents negative impacts but also hinders potentially positive changes.

Rigid standards
Another barrier can be affiliated with the challenge of *Traditional legislation*. In the Netherlands, the codes and standards regarding flood protection measures, such as dikes, are well-defined, which makes it somewhat rigid at the same time. Hence, a dike with a mild slope, such as the *Wide Green Dike*, has not been considered before and, therefore, is not part of any kind of tool for calculating

dike safety. Also, the ripened clay, which is supposed to be the building material for the dike, does not comply with the regular standards of the material.

Spatial issues
In the Netherlands, space is increasingly limited. Consequently, developing a wider dike, which requires more land, poses a significant challenge for planners. The loss of agricultural land, particularly farmland, was deemed unacceptable, limiting expansion options. As a result, the extension of the dike was only feasible towards the salt marsh.

Another spatial constraint arises concerning the clay ripening fields. To produce clay from the silt of the nearby estuary, the silt must be dried in designated fields. While this was not a major concern during the pilot phase of the project—where only 750 meters of dike required clay—the planned expansion involves applying this method to 15 kilometres of the dike. This larger scale will necessitate collaboration with local farmers, who own much of the land adjacent to the dike. Interviews conducted for this case study highlighted this issue, with all participants recognising it as a key challenge.

In this pilot project, one clay ripening field was established directly before the new dike. However, another portion of clay had to be transported from a different area near the waterway. The road infrastructure in this region is not designed to accommodate frequent heavy traffic, such as lorries, and consequently, the local roads have already sustained damage. A key conclusion drawn from this experience is that, for future phases of the project, clay ripening fields should be located in close proximity to the dike sections requiring reinforcement.

Local opposition
One of the few challenges regarding local stakeholders was complaints about the nuisance caused by lorries transporting the clay to the site. This led to the fact that for this project, a side road has been created to avoid the heavy traffic crossing a village. Apart from this issue, none of the interviewees experienced significant local opposition.

Risk aversion
A good project manager can identify, minimise and avoid risks. Moreover, they comply with the responsibilities that are instructed. As NBS at this moment entail the use of untested and new methods, more risks are involved. Hence, this works against the nature of the project manager's risk aversion, which often leads to the fact that traditional methods are still preferred.

Within this, case study, the outcome of the *Clay Ripening Pilot* and the feasibility of the clay for dike reinforcement was unknown. Hence, this risk had to be tackled.

Financing complexity
Another barrier that follows from risk aversion is the resulting financing complexity. If a nature-based solution is planned to be implemented, it will most likely entail more costs, at least at the beginning. Hence, the risks and, consequently, costs need to be divided among several parties. Interviewee CS1.1 pointed out this challenge as one of the most significant, regularly hindering NBS implementation. And also in this case study, the allocation of finance streams was a complicated challenge.

Collaboration as a challenge
It has already become obvious that one prerequisite for a project team implementing a building with nature approach is a collaborative environment, and this can sometimes be a challenge. All interviewees have pointed this out.

Uncertainties regarding the effectiveness of an NBS solution
The properties of clay obtained from extracted silt differ from those of conventional clay typically used. Consequently, its suitability for such measures had not been previously tested. Given the high safety standards that must be met, the effectiveness of this material needed to be demonstrated. For this case study, a full-scale dike model was tested at the *Delta Flume* facility of *Deltares* to validate the applicability of the *Wide Green Dike*. The results ultimately confirmed that the dike meets the

required standards.

Interviewees highlighted several instances where uncertainties regarding the effectiveness of NBS had to be mitigated through over-dimensioning, thereby reducing the potential of cost savings. One example cited was the construction of wave-attenuating measures for the dikes at the Noordwaard polder in the province of North Brabant, Netherlands. In this case, different species of willow trees, with varying pruning cycles, were planted in three rows on the dikes to ensure that at least one row would always provide sufficient biomass to attenuate wave impacts effectively.

Time constraints
Considering the additional efforts to organise a project team and sufficient financing, time constraints are often a significant factor in implementing an NBS. Only if sufficient time is available will the project team be able to arrive at an integrated solution for the area. The interviewees pointed out that for this case study, time was considered their "best friend" as it allowed them to conduct several experiments and organise everything well.

Lack of incentives
The above-described barriers imply that responsible project managers often lack incentives to proceed with an NBS concept. As traditional solutions are still considered cheaper and entail lower risks, the decision often turns against them.

Responsibilities
To understand why the regional water authority Hunze en Aa's supported the pursuit of this project, the interviewees highlighted that their involvement extended beyond their formal responsibilities. As the primary authority responsible for dike reinforcement in the Netherlands, regional water authorities are key stakeholders in implementing NBS. However, their responsibilities are clearly defined and already considered substantial. This situation is also linked to the challenge of a "lack of incentives." Stakeholders are diligent in fulfilling their assigned responsibilities, yet they are not encouraged to exceed these obligations.

5.2.2. Enablers

After elaborating on the barriers, the following will introduce the identified enablers enabling the implementation of the *Clay Ripening Pilot* and the *Wide Green Dike*.

Table 5.4: Enablers identified in Case Study 2

Enabler	Supporting Quotes
People-factor	*"I think a big part is personal. So, [...] they really want it. It's also a real strong... I think a real strong aversion to asphalt dikes, sort of a proudness that there are green dikes that are going into the... Towards the salt marsh. That sort of is a landscape element. It's really something that they take pride in, that that's there. And that is really... And also the sort of the strong belief that with this circular approach, that you are solving more than one issue than only flood safety, and that you want to take that on board because of sort of sustainability principles. That is really strongly founded. But that is, of course, in the end, it's not policy-driven. It's really people-driven."* (Interviewee CS2.2)
Programme-driven	*"One main thing, that was the samenwerkingsverband Ems-Dollart 2050. Also the environmental foundations are in that samenwerkingsverband".* (Interviewee CS2.3)
Financing/ Risk-sharing	*"It's no small thing when you need to organize all of that. So we really had to distribute these risks, because no party alone would be willing to take that risk. So we really distributed that quite well. And I think that sort of made it possible to conduct this clay ripening experiment."* (Interviewee CS2.2)
National influence	*"So all of these steps were necessary. And yeah, definitely the innovation program of HWBP was a facilitator in that."* (Interviewee CS2.2)
Collaboration	*"And I think the clay ripening experiment and the Brede Groene Dijk one kilometer experiment that we did, that we conducted, is actually really an example of how, together with a couple of partners, we joined forces and decided we are going to challenge, say, the normal practice and the codes to demonstrate that in a slightly different way you can also build a strong dike."* (Interviewee CS2.2)
Co-benefits	*"And there is another approach here because nature-based solution, building with nature, in my opinion, it means that you are taking two different goals and combine them into one. That's what we are doing in our approach: We combine dike reinforcement with a nature goal, which is also responsibility, European responsibility to achieve a kind of natural state of all the waters, also the estuary waters."* (Interviewee CS2.1)
(Local) Stakeholder Management	*"If you have the most critical people around you, then others will rely on these critical experts. You say, OK, if Peter is in this group, he's taking care of our concerns. If he's in the group and he approves, then it will be OK and then our concern is covered. And sometimes it's not easy because you are criticised by somebody or by people on with whom you have an agreement that you want to reach the end goal. So it is criticism towards something which we all want, namely not an asphalt dike, but a nice dike which fits nicely into the Nature 2000 surroundings."* (Interviewee CS2.1)
Creating trust	*"And then in the end, it also comes down to relationships. The very fact that we have done this in this way, and the way, I think also, the way that the nature organizations could see how we within the designing phase were really taking the utmost care to be developing this, has really helped to build the trust that is necessary for them to cooperate. And maybe the willingness to accept or to cooperate in the next project, our starting points are better."* (Interviewee CS2.2)
Time	*"Our biggest friend in this whole project was time. We didn't have a great urgency to reinforce the dike. We were able to investigate all of this to see if it's working and how it's working."* (Interviewee CS2.2)
Framing	*"But it's very important [...] not to use the word compensation because compensation is like, OK, you are suffering from something which I am responsible for. I will compensate you. Sometimes it's the words. In this case, it's not compensation. It's a new business model. They earn more by growing clay than by growing grain. And that's the way, I think, in this project it's the way how you approach people to get them interested."* (Interviewee CS2.1)

People-factor
Across all the conducted interviews, it became apparent that the success of this project can largely be

attributed to the influence of key individuals rather than legislative frameworks. These individuals acted as the primary driving force behind the implementation of innovative and novel approaches, demonstrating a strong commitment to realizing change.

Programme-driven collaboration
Next to the *People-factor* as a main driving force that has been identified, the *Programme-driven collaboration* has been an essential success factor.

The *Ems-Dollart 2050 Programme* has been called attention to, particularly by Interviewee CS2.3, who considers this as the foundation for the success of the case study. This programme aims to improve the Ems-Dollart estuary's environment, and the two projects in this Case Study 2re part of the solution. The programme is a collaboration between the Province of Groningen, the Ministry of Infrastructure and Water Management, the Ministry of Economic Affairs, the Ministry of Agriculture, Fisheries, Food Security and Nature, *Groningen Seaports*, the *Nature and Environmental Federation of Groningen*, *Collaboration of Companies of Eemsdelta*, and the *Coalition Wadden Natuurlijk*.

While the province of Groningen is described as the leading party in the strategy for the extraction and beneficial use of fine sediment, several other public and private parties, such as the Ministry of Agriculture, Nature and Food Quality, the water authority *Hunze an Aa's*, and Groningen Seaports are involved, too.

Other programmes that are in place have contributed to the success as well. Even though several interviewees considered the HWBP to work mainly mono-functionally, its innovation programme contributed to its success by providing partial funding for the *Clay Ripening Pilot*. Since the Wide Green Dike is all about dike reinforcement, the HWBP also granted a subsidy for this.

Collaborative Financing and Risk Sharing
Another crucial factor for the success was that both projects were co-financed by all sides of the involved parties. The Clay Ripening Pilot is a real-scale experiment, which means that its outcome could also be negative. In case of failure, removing the clay ripening field and restoring the original state would result in high costs. Hence, this part of the project has been financed through different funding streams.

The costs for setting up two clay ripening areas were divided into different stakeholders and funds. The biggest contribution, with 59% of the costs, came from the *Waddenfonds*, a joint programme of the Dutch provinces bordering the Wadden Sea (Friesland, Groningen and North Holland). Further contributors came from the regional water authority with money from the innovation programme of the HWBP, RWS, Ecoshape, the province of Groningen, Groningen Seaports and the Ministry of Economic Affairs. The reason for each contribution is very different. However, every party had their reasons and benefits from participating in the project.

Co-benefits
The collaborative approach in this case study has been successful because different *Co-benefits* have been sought and found for every stakeholder included. Among others, this can be considered a crucial success factor.

The water authority needs to improve the primary dike line to comply with the newly set safety standards. At the same time, the national and regional government has an interest in improving the ecological condition of the estuary. Furthermore, *Groningen Seaports* benefits from less turbid water and a regular customer who takes over the dredged silt.

Moreover, a large number of market parties that are organised in a consortium called *EcoShape*, which includes contractors, consultancies as well and research institutions, were interested in contributing their expertise and arriving at a new and innovative solution for dike reinforcement.

Another benefit that was crucial for the project's success and to receive the permission to proceed

in a Nature 2000 area was that by building the so-called “Klutenplas” (Avocet Pond), a new benefit for the nature area has been created. The “Klutenplas” is an island created in the salt marsh in front of the constructed Wide Green Dike. By dredging silt to the adjacent clay ripening fields the island was created to facilitate a protected land for endangered species of birds, in Dutch called the “Kluut”. The birds are disturbed in their breeding by foxes that live in the area. Hence the created island provided a safe environment for breeding where foxes cannot go to and the area was improved. Therefore, environmental organisations were interested in supporting the project. This co-benefit has been one of the most significant reasons why the projects were granted permission.

To conclude, creating a network of interdependent co-benefits promoted the continuous effort of all parties in this case study.

Time
The regional water authority must comply with the specified safety level until 2050. This puts a time constraint on them and hence, the HWBP is trying to accelerate the process of dike reinforcement in a way that this goal is achieved. For the *Hunze en Aa's water authority*, sufficient time was available to organise this new solution with all necessary steps.

(Local) Stakeholder Management
Connected with the *People-factor*, the water authority was convinced that reinforcing the dikes with an asphalt layer is a solution that is not desired for the future. At the start of the project, a symposium was organised in which the idea of maintaining the green dike line was promoted, and support was quickly found among local citizens and NGOs. Nevertheless, it became clear, in order to achieve this, the water authority was in need of everybody's support. Therefore, the connection to environmental organisations has been sought from the very beginning.

Within the interviews, it became obvious that good stakeholder management was a crucial success factor. Interviewee CS2.1 outlined that they tried to include people representing the most critical viewpoints to make sure that, if they agree, there will be overall acceptance.

Creating trust
What has been pointed out, particularly by the project manager of the water authority, is that the creation of trust between all parties is a crucial factor for the success of this case study. The water authority built sufficient trust with every stakeholder, which has been considered vital for receiving overall acceptance and permission for the project.

Positive Framing and Promotion
Interconnected with *Creating trust*, *Positive Framing and Promotion* are considered an important enabler. For upscaling this dike reinforcement, the project manager emphasised that a lot more land to “ripen” the clay is required. Therefore, it is important to promote this idea in a good manner towards farmers, presenting them with a new business model to earn money by “growing” clay instead of crops.

5.3. Cross Case Analysis

Even though to different extents, similar barriers have been identified in both case studies. Table 5.5 and 5.6 provide an overview of the detected barriers and enablers from both case studies. Moreover, several barriers and enablers were combined to create wider themes, which will be used to build a framework in the next step.

National influence
Compared to CS2, the national influence in CS1 can be considered much bigger. In CS2, the province of Groningen was responsible for the Clay Ripening Pilot, and the regional water authority was responsible for the dike reinforcement, and both took an intrinsically motivated leading position in the project. In Nijmegen, the municipality, funded by RWS, took a leading position.

People-driven vs Programme-driven
Case Study 1 was made possible due to much influence from the state and its programme *Room for the River*. Before this decision was put in place, a final decision on how to pursue did not take place.

On the other hand, Case Study 2 did receive help from national ministries and over-regional funds, such as the Wadden Fund and the innovation programme of the HWBP. However, the initial motivation had to come from a more local level or even from highly motivated individuals who wanted to pursue this idea.

Local opposition
Case Study 1 had a more imposing influence on a local level, also because the density of homes in this area is much higher. Nevertheless, in Case Study 2, the responsibles sought contact with locals, environmental agencies and NGOs from the very beginning. In Case Study 1, on the other hand, for the first years, local stakeholders were not included in the project and, therefore, were protesting against the idea of a dike relocation and the loss of land. Hence, the impact on local citizens was too large, and the budget for compensation measures was not sufficient.

Positive Framing and Promotion
Both case studies have ultimately been promoted successfully, contributing to their success. While CS2 started to promote the project ideas in a positive way successfully from the very beginning, in CS1, this has taken more time. Only when an appealing plan of the area, including a public river park and new housing development, has been introduced, the people's perspective has been changed.

Trust creation
In both case studies, creating an environment of trust was a decisive factor in making the projects successful. While in Case Study 2, this trust has been predominant from the beginning, in Case Study 1, this was developed over time.

Role of the regional water authority
One of the regional water authorities' main responsibilities is maintaining the dikes. Therefore, when dikes are relocated, they only take a side role. This has been the case for Case Study 1. They have been part of the development of the project, however, more as a consulting authority. As in Case Study 2 the dike remained within its responsibility, the regional water authority took a leading role.

Case Study 1	Case Study 2	Barrier	Framework Theme
	●	Traditional Legislation	Institutional Inflexibility
	●	Rigid standards	
❍	●	Financing Complexity	Financing Complexity
	●	Risk aversion	Risk Aversion
❍	❍	Lack of incentives	
●		Responsibilities	
❍	●	Uncertainties	Uncertainties
●	❍	Effectiveness of NBS solution	
	●	Collaboration (as a challenge)	Collaboration
●	❍	Local opposition	Local opposition
●	●	Spatial issues	Spatial issues

Table 5.5: Barriers identified in case studies and corresponding framework themes;
● showing strong identification, ❍ showing slight identification

Case Study 1	Case Study 2	Enabler	Framework Theme
❍	●	Scope Management	Multi-functional thinking
❍	●	Co-Benefits	Creation of Co-benefits
●		Double goal	
●	❍	Programme-driven	
●		National influence and Financing	
	❍	National influence	
	●	Financing/ Risk sharing	Shared Risk & Collaborative Financing
●	●	Collaboration	
●	●	Creating Trust	Create interdependencies & Trust
●	❍	Framing	Positive Framing and Promotion
❍	●	People-factor	
	●	(Local) stakeholder management	(Local) stakeholder involvement
●		Stakeholder involvement	
●	●	Time	Sufficient time

Table 5.6: Enablers identified in case studies and corresponding framework themes;
● showing strong identification, ❍ showing slight identification

5.4. Solutions

In the chapter above (Chapter 5.3), the identified barriers and enablers were presented in tables to arrive at themes for a framework. As a next step, Table 5.7 shows a list of potential improvements which were pointed out in the interviews regarding both case studies.

Table 5.7: List of recommended actions

Recommendation	Supporting Quotes
Create a strong driving force	*"I think at this moment, the ministry has to be more clear what they want to achieve. Because they tend to go towards, ah, you have to see in the region what is possible. But when you don't have a clear goal, how much discharge capacity you want to accommodate, then it's going to be a little bit here, a little bit there. You need a strong motor, I guess, for room for the river. Because when you can't answer the question, why is it needed here, then you don't get it done."* (Interviewee CS1.2)
Create and seek co-benefits	*"When we keep approaching things monofunctionally, then we are not getting nature-based solutions as our main outcome. So, yes, from, sort of, the higher policy levels, there should be really… Sort of, the starting point should be far more focused on multifunctional, more integral landscape type of solutions, so to say."* (Interviewee CS2.2)
Crafting a cohesive project narrative	*"So, the shared vision, and then in a hierarchy, being very clear about leading principles, guiding principles, for example, in terms of nature-based solutions and why they are valuable and why they are maybe safe, in my opinion, a safe way, but thinking about resiliency, that story needs to be told much clearer than it is now, and it needs to also be quantified, so there needs to be sort of shared facts on the water system and on what we expect, and then based on those together, the facts and the principles, and we can talk about the difficult choices."* (Interviewee CS1.3)
Integrated Approach	*"I find it difficult because it actually is the interaction. [...] You can't do one without the other. I think that's your main point. You can't do one without the other. [...] So, on national level, there should be acceptance that, say, if there is a real strong point from local community level or regional level and then upwards and we want this, then, of course, national policy should be allowing for it. And the same way around."* (Interviewee CS2.2)
Flexibilizing the legal framework	*"So either all these standards and codes, et cetera, should be enhanced to include also nature-based solutions. So for instance, if you have willows in front of your dike, or if you have a beautiful salt marsh in front of your dike, how to calculate any wave reduction caused by it. So either the code should be enhanced to include all those kind of effects, or the codes should allow for that, when you demonstrate a potential effect of an ecosystem or other types of systems that are in front of your dike, that you're allowed to use that and to calculate with it. I think that's a sort of really a necessary [...] but our technical frame of the codes for flood safety, they are really sometimes prohibitive of nature-based solutions."* (Interviewee CS2.2)
Creating incentives	*"So there should be, if we want to change that, there should be really strong incentives in the beginning for these risk averse project managers to start thinking about this. So either, well, I don't know, financial incentives or that it's more easy to get funding from HWBP if you have a nature-based solution. Well, I think of, or let's say, the finding you get of always a lot of co-benefits."* (Interviewee CS2.2)

Creating a strong driving force
Interviewees suggested that a strong driving force is needed for the wider implementation of NBS. Currently, there are insufficient incentives for implementing NBS; the current driving force is created through individuals willing to implement solutions that go beyond their responsibilities. The interviews pointed out that from the higher level, hence the ministries, there should be more guid-

ance in the future, going from people-driven implementation toward policy-driven implementation.

Create and seek co-benefits
NBS can comply with the specified safety standard and deliver additional benefits simultaneously, for example, for nature restoration and recreation. Moreover, in terms of uncertain scenarios regarding sea-level rise, they offer better adaptability than traditional measures. Several interviewees suggested that for NBS to be successful, these co-benefits must be sought and utilised.

Integrated approach
Next to the importance of seeking co-benefits within one project, several interviewees emphasise the importance of seeking an integrated approach. Due to climate change, flood safety does not stand alone, but with issues such as drought management and water quality issues, the issue cannot be approached from one direction. In their final recommendation, Interviewee CS2.2 highlights that the interaction of all governance levels should improve, mentioning that "de-siloing" is a necessary step towards the success of routine implementation of NBS.

Seek and enable diversified finance streams
In most cases, NBS are and will be more costly than traditional methods for flood defence measures. However, they also deliver more benefits than just safety for different stakeholders. Therefore, those stakeholders must be sought, and different financing methods and available funds must be explored. Several programmes and funds exist; however, funding is complicated for a project that fulfils multiple purposes. Interviewee CS2.2, for example, remarks that within a project that is part of the HWBP, the connection to additional funding streams should be facilitated.

Crafting a cohesive and inclusive narrative
The two case studies showed that the formation of a compelling vision has the power to make a project successful. The interviewees pointed out that the creation of a shared vision can contribute substantially to a more successful implementation. Interviewee CS1.3 elaborates that this shared vision should be created on all levels of governance. This means that the national government should present a clear agenda, which should then be followed by the regional water authorities and promoted towards the local level. *Room for the River* provides a good example for this, as it provides a very high-level target which has been accomplished through implementation on a local scale.

Flexibilizing the legal framework
It has been pointed out that the legal framework should allow for potential improvements of the environment rather than only conserving it. Furthermore, the legislative framework should be made more flexible for innovative solutions. The new solutions developed in Case Study 2 were difficult to implement since they did not align with the traditional codes and standards. Moreover, the 2000 legislation worked against the implementation of the suggested solution. The interviewees suggested that this rigidity should be made more flexible.

Creating incentives
The interviewees have pointed out that current incentives for designing or implementing NBS are insufficient. Therefore, more incentives must be created for project managers to consider NBS from the beginning of a project.

5.5. Conclusion

Both Case Studies 1 and 2 are considered to have successfully implemented an NBS approach. However, their success is founded on different factors. Case Study 1 is based on a political decision from a higher level that resulted in a prosperous programme. Combined with a positive framing and mindset change among the local inhabitants, this led to its success. Importantly, the national government was behind this project which enabled additional money. Thus the success is considered policy-driven. On the other hand, Case Study 2's success is grounded in the intrinsic motivation of several project managers who were a strong driving force in implementing a new and innovative approach. Thus, the project was mainly people-driven, backed by a regional programme. The regional water authority and its regional partners had to take a lot of initiative in collaboration, risk sharing, and stakeholder involvement to ensure implementation. To ensure a wider implementation of NBS in the future, the trend should go back to policy-driven implementation.

Coming back to SRQ3 and SRQ4, the following findings can be summarised:

The most important barriers which were identified within the case studies are:

- Institutional Inflexibility
- Uncertainties
- Risk Aversion
- Financing complexity
- Challenges in Collaboration
- Local Opposition
- Spatial issues

The identified enablers are:

- People-factor
- Creation of Co-Benefits
- Collaborative Financing and Risk Sharing
- Programme-driven Collaboration
- (Local) Stakeholder management and involvement
- Trust creation
- Positive Framing and Promotion
- Sufficient time

Lastly, the following potential improvements were gathered from the interviews:

- Creating a strong driving force
- Create and seek co-benefits
- Integrated approach
- Seek and enable diversified finance streams
- Crafting a cohesive and inclusive narrative
- Flexibilizing the legal framework
- Creating incentives

During the analysis, it became evident that both barriers and enablers are interconnected and that potential improvements can be derived from there. Therefore, the following chapter aims to depict this situation in a framework to arrive at potential solutions and policy recommendations.

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6

Development of a framework

This chapter introduces a framework that depicts the interconnection of the identified barriers and enablers from the two case studies investigated. Furthermore, the framework presents recommendations for the Dutch FRG for the uptake of NBS. Section 6.1 explains the interconnections of the framework and introduces the recommendations. The findings have been presented to three experts in evaluation sessions. Section 6.2 describes their feedback and how it was implemented in the framework.

Aerial photo of Marker Wadden - an artificial island group in the Markermeer (Straystone Pictures - Peter Leenen, 2022)

6.1. Development of a framework

The results from the two case studies, combined with the knowledge from the first interviews, were gathered in a framework shown in Figure 6.1. While the left part (red) shows the identified barriers, the middle part (blue) shows the enablers from both case studies. In the end, the right part (green) combines those to arrive at policy solutions for the uptake of NBS. The figure depicts that both barriers and enablers are interconnected. Additionally, the three introduced governance levels, macro, meso, and micro, are implemented in the framework to show which level the governance mechanism most often occurs at.

The framework aims to show how those barriers are interconnected and how the enablers or suggested policy recommendations can mitigate them. An interconnection is indicated by arrows in both directions. If there is an arrow in one direction, it shows a potential mitigation strategy for a barrier.

6.1.1. Interconnection of barriers

One significant barrier identified is *Uncertainties* associated with implementing NBS. Firstly, these uncertainties contribute to *Institutional Inflexibility*, as there is currently insufficient evidence that NBS can achieve outcomes equivalent to traditional engineering solutions. Secondly, the uncertainties are linked to the risk aversion of project managers, who tend to prefer approaches that minimise risks when fulfilling their responsibilities. Consequently, the perceived higher risks associated with NBS complicate their financing, often necessitating multiple, diverse funding streams.

Addressing this *Financing Complexity* leads to *Collaboration as a Challenge* as developing a project team and a coherent financial plan requires good collaboration and compromises. This challenge arises when drawing up a project team on the meso level but can also arise from *Local Opposition*. The reason why local stakeholders are not in favour of a project can be based on many factors. *Spatial Issues* often play a role in this.

6.1.2. Connection to enablers

The aforementioned additional risk and financing complexity can only be addressed when the different stakeholders work together well, thus through a *Shared Risk and Collaborative Financing*. For this to succeed, the *Creation of Interdependencies & Trust* is an important condition connected to the first.

For the different stakeholders to agree on a collaboration, the *Creation of Co-benefits* is another vital prerequisite. Creating co-benefits for every party will ensure they share a common vision and goal, making them work together efficiently. Achieving this requires *Multi-functional thinking*. Considering the *Spatial issues*, multi-functional solutions will become increasingly important as the multi-functional use of space can contribute to solving it. The created public river park in Nijmegen is a good example of this.

Looking at the micro level, the involvement of local stakeholders and their interests is another crucial precondition for a successful NBS implementation. The interviewees emphasised that, ultimately, a project's success depends on acceptance at the local level. Thus, it is important to listen to their concerns and to take them seriously.

A *Positive Framing & Promotion* is another important enabler for both the micro and macro levels. Often, not everyone is familiar with the concept of NBS and their benefits, and therefore, it needs to be promoted. If the approach of Building with Nature is more widely spread among the different levels of governance, a change in mindset is being initiated, and consideration for further projects is more likely.

6.1.3. Recommendations

The following recommendations will be described based on the identified barriers and enablers.

Creating legislative space for innovative solutions
The current legislative framework often impedes NBS implementation in several ways. Hence, the current legislation should be innovated to facilitate more sustainable solutions. Kistenkas (2014), for example, regards the current European Nature 2000 legislation as not contemporary any more with limiting conservation objectives. Instead, he calls for a balancing approach in which an assessment shall be broadened toward a balancing of profit, people and planet ("3P"), enabling better sustainable development. Moreover, the traditional tooling for designing and engineering flood defence measures should be updated and allow alternative options, including NBS.

Include multiple goals in the Flood Protection Programme
It has been identified that the Flood Protection Programme (HWBP) has a strong position in FRG. However, there are missed opportunities that should be exploited. The HWBP already provides a strong basis for collaboration between Rijkswaterstaat and the regional water authorities. However, its scope for now is only monofunctional. In the future, creating multiple goals, such as improving spatial quality, would enable more integrated solutions. By doing so, the management of the current primary flood defence measure would move away from line management toward area management.

Several programmes that have the potential to foster NBS implementation have already started. Therefore, the HWBP should also be combined with the Programmatic Approach to Great Waters (PAGW) or the upcoming Integrated River Management Programme (IRM) to realise multiple goals.

Provide an NBS toolbox for the Flood Protection Programme
As presented in Section 4.4, *Room for the River* entailed a toolbox of possible measures that could be taken to achieve the goals of the programme (see Figure 4.3). Building up on this idea to enable routine implementation of NBS, the Flood Protection Programme should be provided with a toolbox of NBS that must be considered from the beginning of a project development.

Moreover, the narrative should be turned around, and the project managers should be mandated to use one of the toolbox options. The Netherlands includes several different areas to which different measures apply, which need to be considered. Van Eekelen and Bouw (2020), for example, presents possible measures for sandy costs, muddy coasts, lowland lakes, rivers and estuaries, cities and ports. Or the International Guidelines on Natural and Nature-Based Features for Flood Risk Management (Bridges et al., 2021) present possible solutions for coastal systems (including beaches and dunes, coastal wetlands and tidal flats, islands, reefs, plant systems and structural measures) and fluvial systems.

Move from line management to area management
The idea of moving from line management to area management was brought up by Interviewee G3 and seems to be a promising approach. Currently, the water authorities' responsibility is to maintain the dikes. Both case studies show that to arrive at NBS, multi-functional solutions that go beyond the dike line need to be considered.

The national government should mandate the regional water authorities to work multi-functional. If implementing a nature-based solution results in more costs than a traditional dike reinforcement would cost, the national government should provide funds and incentives for the NBS to be implemented.

Upscale research to reduce uncertainties
To reduce the connected uncertainties to NBS, more research has to be conducted. Even if interviewees acknowledged the additional value that NBS can bring, many stated that implementing an NBS is currently more expensive than a traditional dike reinforcement. However, for future uncertainties like rising sea levels, NBS may provide better adaptability. Thus, the long term costs effectiveness is

not yet sufficiently explored.

The field of NBS is an emerging research field. Investments by the National Growth Fund of the Netherlands underline this trend. *NL2120* is supported with 110 million euros for the research in upscaling and mainstreaming NBS in the Netherlands, but also because the demand for providing more and more of those solutions is expected to rise. With the investment in *NL2120*, the Fund expects a new contribution to economic growth in the Netherlands. Hence, knowledge programmes such as *NL2120* will deliver important added value for the upcoming future already.

Create incentives
In the current governance, regional water authorities are not sufficiently incentivised to create solutions beyond their responsibility of maintaining the primary dike line and complying with the new safety standards. Therefore, incentives for water authorities to seek collaboration and to create interdependencies need to be created and increased for a wider implementation.

Promote interdependencies through regional programmes with national influence
Both case studies were part of a programme that contributed to successfully implementing the respective nature-based solution. In case study 1, the success is grounded in the fact that it was part of a programme with national interest that entailed two primary goals. Also, case study 2 was part of the *Ems-Dollart 2050* Programme, which aims to utilize the increasing silt from the estuary. The national government should initiate similar programmes for more regions that also include the multifunctional inclusion of the flood defence system.

Make NBS more accessible
To encourage a thorough understanding and use of NBS, it is essential for all levels of governance to become more familiar with the concept. Increasing research in this area is a valuable first step. Since NBS can deliver benefits for flood protection, nature restoration, and recreation, engaging a wider range of stakeholders and government departments in the design and implementation stages is important. Professionals across these areas should be aware of the unique advantages NBS offer and how these can be applied effectively. To support the broader adoption of NBS, the national government should take a more active leadership role, as NBS often bring benefits that extend beyond the interests of any single organization, making higher-level initiation and coordination necessary.

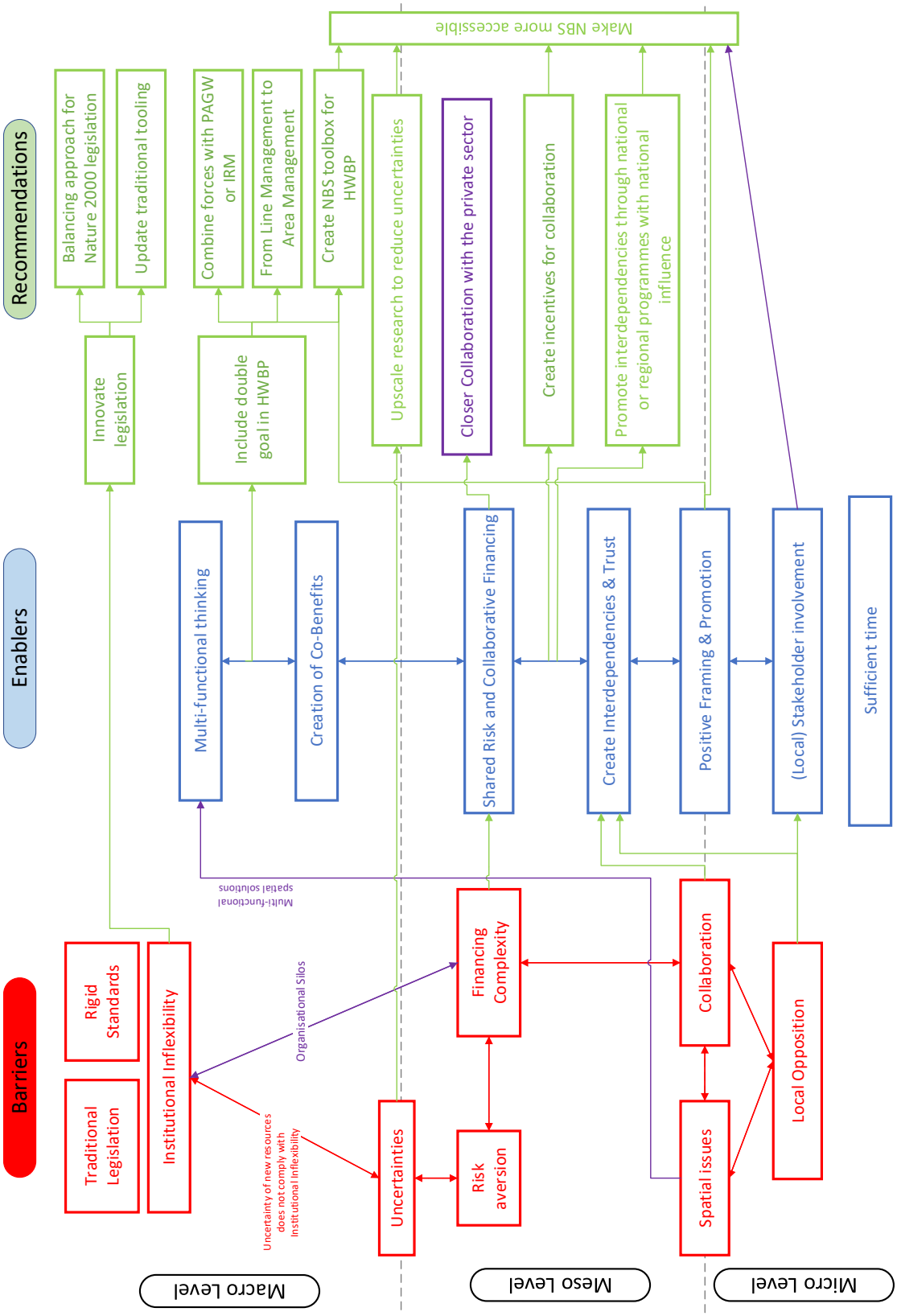

Figure 6.1: Framework demonstrating barriers, enablers, and recommendations in NBS implementation (Created by the author)

6.2. Evaluation

To evaluate this research and the framework, evaluation sessions with three experts have been conducted (see Table 6.1). The framework has been presented to one person with expertise in FRM but a more traditional background in managing failure probabilities (V1). Moreover, two experts with experience in NBS and its implementation were consulted (V2 & V3). By consulting experts with different backgrounds, more deficiencies in the current framework may be identified, ultimately leading to an improved final result closer to practice.

While the experts agreed with the framework idea, several additional connections and improvements will be highlighted in the following. Ultimately, the framework has been improved. Changes within the framework carried out after the evaluation are marked in purple.

No.	Date	Occupation	Experience	Duration	In-Person/ Online
V1	23-10-2024	Senior advisor Rijkswaterstaat	16 years of experience within RWS; Risk manager for *Room for the River* Programme (3 years), Failure risk manager (3 years)	1 h	Online
V2	24-10-2024	Researcher and Advisor	10 years of experience in innovation processes in water management, including Building with Nature	1 h	Online
V3	24-10-2024	Senior Researcher/ Advisor Urban Resilience and NBS	15 years of experience on projects related to Integrated Water Resources Management, Ecosystem-based Adaptation to Climate Change, and Urban Water Management	1 h	Online
Total				3 h	

Table 6.1: List of evaluation sessions

V1 agrees with the overall connections made in the framework. However, they are doubtful about the feasibility of integrating NBS into the HWBP funding system. They suggest that other funds outside of the programme should be sought instead. However, this would again increase the financing complexity, so the recommendation to implement more NBS thinking into the HBWP should still be followed up. It also shows that thinking in "silos" still is very much present. Moreover, V1 expresses that *Room for the River* has mostly been a nature programme rather than a flood safety programme. However, while the programme indeed aimed to improve spatial and ecological quality, another goal was to increase safety by increasing the discharge capacity of the rivers.

V1 adds that the maintenance of the river forelands, which were created through *Room for the River* projects, is considered expensive. Thus, a further recommendation provided by V1 is to demonstrate the long-term cost-effectiveness within the scope of this study. While this is a valuable suggestion, it falls outside the defined scope of this research. Nevertheless, this aspect will be incorporated into the recommendations for future research. Next to maintenance, adaptability is another interesting aspect to consider in the long-term cost-effectiveness. Other interviewees, for example, brought attention to case study 2, for which the adaptability of the chosen solution is better than it would have been with traditional measures.

Moreover, V1 questions whether RWS is the appropriate initiator for the proposed changes, given that the implementation of multi-functional NBS extends beyond the scope of their organisational responsibilities. Nevertheless, considering RWS's significant advisory role to the ministry, it is positioned to influence such decisions.

In presenting the framework to V2, they observed that similar barriers and enablers had been highlighted in previous studies, making it somewhat unclear whether these points stem solely from the case studies or were also shaped by insights from the literature. Although some of the interviewed experts had substantial experience with NBS in other projects, the framework is based exclusively on findings connected to the case studies. Nonetheless, many of the enablers and barriers identified in other studies were also found within these two case studies, reinforcing the findings of those studies with case study-based evidence.

In the initial framework, the financing complexity was connected with uncertainties related to NBS. However, V2 mentions that much of the financing complexity stems from the fact that NBS are inherently multi-functional and, therefore, always address several institutions simultaneously, which is not aligned with the existing governance structure and several separate ministries that are used to thinking in silos. This means they are not thinking outside of their responsibilities.

More complicatedly, NBS may not benefit the institutions which paid for it initially or within the expected time frame. Those issues combined are another important factor to consider regarding financing complexity and, therefore, will be implemented within the framework. Thus, a connection between *Institutional Inflexibility* and *Financing Complexity* will be added.

Moreover, V2 explains that a project manager striving to implement an NBS often is in the dilemma of getting stuck in a chaos of ministries, programmes, and stakeholders, significantly hindering an implementation. Although the implementation succeeded for case study 2, the starting point can be considered similar to the described scenario, emphasising that the current governance does not support NBS implementation.

One of the conclusions from the case studies was that case study 2 was mainly people-driven while case study 1 was policy-driven, concluding that in the future, FRG should allow more policy-driven implementations. However, V2 pointed out that both aspects are equally important: people driving the change but a policy that supports their efforts. V3 also expressed this point of view.

When presenting *Spatial issues* as a challenge, V3 notes that space could be used more multi-functional to solve this. Before, the framework depicted this as an issue that directly does not have a solution or enabler. Hence, the framework will be complemented with a connection to *Multi-functional thinking*.
V3 describes that the goal of the uptake of NBS would be the principle “NBS unless”, or in other words, making use of NBS unless it’s not possible. This idea aligns well with the suggested changes of the HWBP. Including an additional goal next to safety will require more multi-functional solutions. Moreover, adding a toolbox of possible NBS to consider can assist project managers in selecting additional measures.

V3 highlights the value of categorizing the result in the three levels of governance: macro, meso and micro. Furthermore, creating a toolbox for the HWBP was considered an interesting and valuable idea.

Lastly, V3 remarked that the private sector will continue to play an important role in FRG. Private companies may be pushing an NBS development to develop a competitive advantage because of the companies’ beliefs or values or because they are aware of their advantages. Also, V2 elaborates on the fact that investments in flood safety are usually public but that in the future, private actors might play a more important role in the financing. The initial framework did not address this. However, especially for case study 2, private companies have been involved throughout the process. Moreover, EcoShape contributed financially to the Clay Ripening Pilot, too. Hence, the private sector will be integrated into the framework.

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7

Discussion

The following Chapter presents a discussion of the findings. Section 7.1 discusses the results in light of the existing literature, while 7.2 discusses more practical issues. Section 7.3 assesses the quality of the research design. Lastly, section 7.4 presents the limitations of this study.

Wave attenuating willow forest - Noordwaard, North Brabant (EcoShape, 2020)

7.1. Discussion in Light of existing Literature

The current Dutch Flood Risk Governance (FRG) has been investigated, and two case studies were analysed to derive barriers and enablers for the uptake of NBS in FRG. The results have been depicted in a framework that introduces the interconnectedness of both barriers and enablers to arrive at recommendations ultimately.

Van Eekelen and Bouw (2020) introduced six "Building with Nature enablers", which have been introduced in Chapter 3.3. Several aspects that have been identified before were also identified in the two case studies.

One enabler identified by Van Eekelen and Bouw (2020) is "Institutional Embedding". Both the first and second phases of interviews for the case studies have revealed traditional legislation and rigid standards as one of the challenges, which has been named *Institutional Inflexibility* in the framework.

Van Eekelen and Bouw (2020) state that Building with Nature can rarely be implemented by a single party. In both case studies, this statement could be confirmed. In Case Study 2, many parties with different interests combined their knowledge and ambitions to arrive at a solution that delivers specific co-benefits for everyone. Also, Case Study 1 confirmed that the design and implementation required good collaboration. Hence, even if not mentioned explicitly yet, the enabler "Multi-stakeholder approach" aligns well with the identified enablers of *Creation of Co-benefits* and *Create interdependencies and trust*.

Another enabler identified in the case studies is *Positive Framing and Promotion*. With their enabler "Capacity Building", Van Eekelen and Bouw (2020) indicate that people familiar with the philosophy of building with nature are more likely to implement it. Hence, framing and promoting the concept of Building with Nature aligns with this concept and with the final recommendation of *Making NBS more accessible*. However, Van Eekelen and Bouw (2020) go further and suggest educating practitioners on Building with Nature through training programmes. This recommendation appears viable and has already been partially realised. For instance, during this research, it was observed that several courses on *Building with Nature* are offered at TU Delft. However, it is perceived that awareness of these educational opportunities is still relatively low, indicating a need for improved promotion of such courses, particularly as the field of Building with Nature continues to evolve.

The enabler "Business case" has also been found in this research. The identified challenges of *Uncertainties*, which has been connected to *Risk aversion* and to *Shared Risk and Collaborative Financing* underlines that only if a strong business case has been developed for a nature-based solution, the implementation will much more likely succeed.

Through a systematic literature review, Sarabi et al. (2019) identified barriers and enablers for the uptake of NBS in an urban setting. Table 7.1 shows all of the barriers and enablers identified and compares them with those identified in this research.

Even though those barriers were mainly explored for urban settings, most were also identified during the implementation of NBS as a primary flood defence measure. Within "Inadequate financial resources" Sarabi et al. (2019) explain that the related co-benefits are often only long-term, which doesn't align with short-term funding streams. This also corresponds with what was found in discussion with V2, in which they explained that the potential co-benefits are long-term and may not benefit the contributor directly.

"Path dependency" refers to the fact that stakeholders are used to addressing challenges using "gray infrastructure" and that this change in mindset is difficult to achieve. Even though not mentioned explicitly as a barrier, the research has shown that not everyone is yet familiar with Building with Nature. Nonetheless, the identified *Uncertainties* may also be connected with the fact that

knowledge about NBS is not yet spread widely enough among key stakeholders.

"Institutional fragmentation" and "Inadequate regulations" are other two barriers named by Sarabi et al. (2019). The first refers to "sectoral silos" as a problem which implies that different departments work towards their responsibilities without taking into account potential interdisciplinary co-benefits. The latter refers to "scattered" regulations in support of NBS. Both barriers have also been identified as equally important for flood defence measures.

Lastly, "Uncertainty regarding implementation process and effectiveness of the solutions" and "Limited land and time availability" are two more barriers that are equally identified in this research. Spatial issues were one limiting factor for both case studies, and sufficient time was crucial for implementing a new and innovative solution.

Even though collaboration seems to be a key factor for the success of a NBS implementation, particularly interviewees of Case Study 2 emphasised that this collaboration also entails challenges. Therefore, it seems surprising that this has not been mentioned as a barrier in other studies.

While not all of the enablers by Sarabi et al. (2019) are mentioned explicitly within the developed framework, many similarities can be identified. "Partnership among stakeholders" is the most frequently mentioned enabler, and also, in the context of the two case studies, it has been identified. Within the framework, both *Shared Risk and Collaborative Financing* and *(Local) Stakeholder involvement* can be attributed to this.

"Knowledge sharing mechanisms and technologies" refer to establishing technologies like online platforms. However, for the context of this research, creating a toolbox for the Flood Protection Programme (HWBP) can also contribute to this recommendation.

It has been identified that project managers are missing incentives to implement more NBS. Therefore, the creation of incentives has been mentioned as a recommendation. "Economic instruments" as an enabler from Sarabi et al. (2019) aligns with this.

Sarabi et al. (2019) states that "Plans, programs and legislations" can be both a barrier and an enabler. The investigated case studies can confirm this. While the traditional legislation was mainly a barrier, specific programmes were able to promote the implementation of the suggested solutions. On the other hand, programmes such as the HWBP are mainly a barrier to NBS implementation. Therefore, if plans, programmes and legislation become a barrier depends on the goal that stands behind and if this goal supports multi-functional solutions.

Further, Sarabi et al. (2019) mention "Education and training", "Effective monitoring and valuation systems for implementation process and benefit", "Open innovation and experimentation" as three enablers. While the three enablers have not been identified individually, the recommendation to *Upscale research to reduce uncertainties* and to *Make NBS more accessible* does correspond with this.

"Combining NBS with other urban elements and gray infrastructures" is another enabler identified within the research by Sarabi et al. (2019). While their research mostly refers to an urban setting, a similar approach can be expected to work for FRM in the Netherlands. Several interviewees have emphasised that due to its very low-lying land, the future Dutch FRM will continue to depend on traditional measures. Nonetheless, the combination of green and grey infrastructure has the potential to create solutions with more added value for more stakeholders. *Room for the River*, for example, did restore a more natural flow of the rivers, but dikes have not been fully removed.

Sarabi et al. (2019) mention "Appropriate planning and design" as an enabler, referring to aesthetical aspects which may play an important role in the acceptance on the local level. However, this seems to be a fundamental requirement for any construction project. Moreover, it became evident that when considering the identified enablers from the framework, appropriate planning and design

will arise automatically.

Also, other authors generally align with the findings (Christopher et al., 2024; Nelson et al., 2020). However, Nelson et al. (2020) noted that one should be careful not to "oversell" NBS. They argue that even though NBS entails the word "solution", ecological and social uncertainties remain, necessitating trade-offs regarding financing, risks and benefits.

The created framework was put into three level of governance based on the introduction of the actors by Sarabi et al. (2019). Based on this, also the two rounds of interviews were conducted, addressing the questions regarding macro, meso and micro levels. However, looking back to Chapter 3, a categorisation into the three-layer model of water governance could have also been useful.

This research supports the current literature by identifying similar enablers and barriers through case study research. However, none of the reviewed literature demonstrates the interrelations of those. This thesis contributes to the literature with an attempt to identify and demonstrate their interconnections. Moreover, the framework was categorised into three levels of governance: meso, macro, and micro. Experts in the evaluation sessions noted that there are far more barriers. Nevertheless, this research emphasises that barriers and enablers are part of a web of interrelations. Additionally, several practical recommendations are given.

Barriers identified by Sarabi et al. (2019)	Barriers identified within this research	Enablers identified by Sarabi et al. (2019)	Enablers derived from this research	Recommendations derived from this research
Inadequate financial resources	Financing complexity	Economic instruments	Shared Risk & Collaborative Financing	
Path dependency	Organisational silos			
Institutional fragmentation Inadequate regulations	Institutional Inflexibility	Plans, acts and legislations		Innovate Legislation
Uncertainty regarding implementation process and effectiveness of the solutions	Uncertainties	Education and training		Make NBS more accessible; Closer Collaboration with the private sector
		Open innovation and experimentation		
		Knowledge sharing mechanisms and technologies		
	Collaboration (as a challenge)	Partnership among stakeholders	Create Interdependencies & Trust; (Local) stakeholder involvement	Promote interdependencies through national or regional programmes with national influence
Limited land and time availability	Spatial issues		Sufficient time; Multi-functional thinking; Creation of Co-benefits	Move from line management to area management
		Combining NBS with other urban elements and gray infrastructures	Multi-functional thinking	Include double goal in HWBP
		Effective monitoring and valuation systems for implementation process and benefit		
		Appropriate planning and design	Multi-functional thinking	Move from line management to area management

Table 7.1: Identified Barriers, Enablers, and Recommendations in comparison with findings by Sarabi et al. (2019)

7.2. Further Discussion points related to practice

The current National Water Plan (2022-2027) highlights the need for stronger collaboration between the HWBP and other programmes focused on nature restoration. This direction reflects the growing awareness identified in this research.

However, the shift in mindset regarding NBS appears to be progressing slowly. While some of the experts interviewed were quite familiar with the concept of NBS, others seemed convinced that current strategies could continue without significant changes.

Several flood safety advisors expressed that reinforcing embankments remains the most effective and cost-efficient solution. From the perspective of a flood safety advisor, this may indeed be true, but it emphasises the challenge of recognising all the potential benefits of a multifunctional approach. This underscores that flood safety issues are often approached mono-functionally, whereas NBS can potentially create value for a wider range of stakeholders. As stated before, it is difficult to assess the co-benefits of an NBS implementation. Raymond et al. (2017) provide a framework for assessing and implementing co-benefits of NBS. Even if this is focussed on urban areas, it could prove useful also for NBS in the setting of flood defence systems. They emphasise that design and implementation require a holistic approach which entails a deep understanding of the environmental and socio-economical co-benefits.

Interestingly, several experts, particularly those outside government organisations, were more inclined to view NBS as important than their counterparts in governmental agencies. This suggests that for the future adoption of NBS, a more integrated mindset is needed among ministries, encouraging them to think beyond their primary responsibilities. As highlighted by two experts during the evaluation session, the private sector can play a significant role in advancing NBS, as illustrated by case study 2. Davids et al. (2024) call for a transdisciplinary approach to NBS rather than a multidisciplinary approach. They argue that within a multidisciplinary approach, several entities are working side-by-side, however, within their boundaries. This aligns with the identified silo-thinking of the current Dutch FRG. Only when a transdisciplinary is followed can NBS be effectively implemented. Sarabi et al. (2019) has identified transboundary actors as important stakeholders in NBS implementation. Particularly within case study 2, the private stakeholders can be seen as a transboundary actor helping for the NBS to be implemented.

The concept of adopting an ”NBS unless” approach may initially appear highly optimistic, particularly given the persistence of several uncertainties. Nevertheless, early pilot projects have demonstrated promising outcomes, providing compelling examples of the broader benefits that NBS can deliver, such as enhanced opportunities for recreation and tourism. Furthermore, the proposal inherently incorporates an ”unless” condition, acknowledging that in certain cases where the implementation of NBS is not viable, more traditional FRM measures may still be adopted. This approach is less about mandating the use of NBS in every instance and more about shifting the prevailing narrative to prioritize NBS as the preferred option where feasible. Moreover, Sarabi et al. (2019) explain that NBS does not need to be an ”either-or” case but that hybrid solutions are also viable options in the future. The developed solutions from both investigated case studies can also be seen as a hybrid solution since dikes are still in place at both sites.

While it is crucial to comply with safety regulations within specific time frames, regional water authorities should also be encouraged to develop new, innovative, and potentially adaptable solutions.

The current goal of the HWBP is to complete all projects by 2050, which can only be achieved if boundary conditions remain strict. Nevertheless, rather than approaching upcoming projects with a singular focus, future initiatives should consider adopting the principle of “NBS unless,” meaning that NBS should be pursued unless they conflict with meeting safety standards by 2050.

7.3. Assessing the quality of the research design

Reliability and validity are considered crucial for the research's quality (Saunders et al., 2023; Yin, 2018).

The term **reliability** is distinguished into two terms: internal and external reliability. While internal reliability refers to consistency within the research project, external reliability refers to reproducibility if the research is repeated, potentially also by another researcher.

The term **validity** also distinguishes internal and external validity. Internal validity is associated with quantitative studies and, therefore, does not apply in this case. External validity refers to the extent to which the findings of a study can be generalised to other settings beyond the conditions of the original study (Saunders et al., 2023).

Saunders et al. (2023) argue that the role of reliability and validity within qualitative research is contested. In qualitative research, reproducibility often is neither possible nor intended because it captures the socially constructed interpretations of participants specific to a particular context and moment in time (Saunders et al., 2023), as also described in the world view of interpretivism. Nevertheless, several authors suggest how to ensure the credibility of qualitative research. One way to ensure the validity of the research is to provide an extensive description of the research, which is the aim of Chapter 2 in particular.

Triangulation
The principle of triangulation refers to using more than one source of data to confirm the credibility of a study (Saunders et al., 2023). As the word implies, Yin (2016) argues using at least three ways of verifying a procedure, piece of data or finding. Conducting this research as a multi-method qualitative study contributes to arriving at more complex and richer results. Not always have three ways of verification been found. However, the facts stated within the interviews have been checked through a literature and document study.

Participant Validation
By sending back the cleaned transcripts to each participant, validation has been done, strengthening the accuracy of the data used for the analysis, ultimately leading to better-quality results.

Evaluation sessions
Lastly, the results and the created framework were evaluated through evaluation sessions with experts who have not been involved in the research before. To conclude, the steps taken contribute to increasing the credibility and transferability of the research.

7.4. Study limitations

For every research, limitations remain (Saunders et al., 2023), which shall be mentioned in the following:

- Sample Size and Representativeness: The number of experts interviewed may not fully represent all stakeholders or viewpoints in FRM or NBS, limiting generalisation.
- Transferability: The applicability of results to other countries might be limited since the case studies focus on specific instances in the Netherlands.
- Context-Specific Findings: The findings may be highly context-specific. All the experts interviewed were long-time professionals who mostly collected their experience in the Netherlands. Cultural, institutional, or geographic differences could limit the application of the findings to other regions or governance systems.

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8

Conclusion and final recommendations

Aerial view of the "Double Dike", Province of Groningen (Van de Veen, 2022)

8.1. Answer to sub-research questions and main research question

This thesis set out to address the question: "How can Dutch Flood Risk Governance facilitate the design and implementation of nature-based flood risk solutions?" To answer this, the research was divided into four sub-research questions, each tackled in dedicated chapters. Below is a summary of how each question has been addressed, concluding with answering the main research question.

SRQ1: What are the key principles of Flood Risk Governance, and how do they integrate nature-based solutions?

The literature review established that NBS are a diverse, evolving set of approaches contributing to environmental, social, and economic resilience. FRG is moving from a centralised model towards a more participatory framework involving multiple stakeholders across scales, from international to local. Integrating NBS into FRG requires effective collaboration, stakeholder engagement, and adaptive management, emphasising not just flood defence but the broader co-benefits of ecological, social, and economic outcomes. The principles that support this integration include fostering partnerships, creating a shared vision among stakeholders, and promoting holistic, sustainable management.

SRQ2: How is the current Dutch Flood Risk Governance organised?

Current FRG in the Netherlands is well-structured, with highly coordinated responsibilities to safeguard against flooding. The unique history of drastic flood events has made the Netherlands what it is today, with the world's most advanced flood defence systems. However, the existing framework is also characterised by rigidity, making the adoption of innovative measures like NBS challenging. Implementing NBS is new and requires new ways of thinking, which can be difficult in such a strong and established system. Although past programs like *Room for the River* demonstrate successful integration of broader approaches, the current governance appears to have been in a stagnation phase, with progress in NBS implementation occurring gradually. Nonetheless, this change has started, as evidenced by ample policy documents that are made publicly available. New initiatives, such as *NL2120* and *PAGW*, hold promise for fostering wider NBS adoption. The regional water authorities and RWS will continue to play crucial roles in the implementation of NBS, especially through the Flood Protection Programme (HWBP).

SRQ3: What are the current barriers and enablers in designing and implementing nature-based solutions?

Analysis of the two case studies revealed several key barriers and enablers in designing and implementing NBS. The main barriers identified include *Institutional inflexibility*, *Uncertainties* regarding NBS effectiveness, *Risk Aversion*, *Financing complexity*, *Challenges in collaboration*, *Local opposition*, and *Spatial issues*. On the other hand, the enablers included the intrinsic *People-factor*, *Creation of Co-benefits*, *Collaborative Financing and Risk Sharing*, *(Local) Stakeholder involvement*, *Trust creation* and *Positive Framing and Promotion*. The case studies demonstrated that success in NBS implementation could be either people-driven, with motivated stakeholders at the regional level, or policy-driven, backed by national support and funding.

Lastly, a framework has been developed showing that the identified barriers and enablers are interconnected.

SRQ4: What needs to be improved in the current governance to enable routine implementation of nature-based solutions?

To enable routine implementation of NBS, several improvements in the current governance framework are necessary. These include creating a strong driving force for NBS, pursuing an integrated approach that seeks co-benefits, enabling diversified financing streams, and crafting inclusive

narratives. Enhancing collaboration across multiple stakeholders is essential, as is incentivising regional water authorities to pursue multi-functional solutions and improving the adaptability of legal frameworks. These improvements will help address the barriers identified and ensure that NBS can become a routine part of FRM.

Main research question: How can Dutch Flood Risk Governance facilitate the design and implementation of nature-based flood risk solutions?

In conclusion, to facilitate the design and implementation of NBS, FRG must evolve towards a more flexible, integrative approach. Key to this evolution is legislative innovation that creates space for sustainable solutions, such as NBS. The Flood Protection Programme must embrace multifunctional goals beyond flood defence, incorporating ecological and spatial quality improvements. Developing a toolbox of nature-based measures for routine project use can further standardise NBS adoption. Additionally, shifting from line management to area management can help unlock multifunctional benefits of NBS that extend beyond primary flood defences.

The national government must take a more active leadership role by fostering initiatives that align regional and local interests with national goals. Creating incentives for regional authorities to collaborate beyond traditional mandates and investing in further research to reduce uncertainties surrounding NBS efficacy is also critical. Through these measures, the Dutch FRG framework can more effectively incorporate NBS, thereby enhancing resilience to future climate-related challenges.

8.2. Recommendations

8.2.1. For the European Commission

- **Innovate the Nature 2000 legislation to a more balancing approach, allowing positive changes**

  The current Nature 2000 legislation is very restrictive regarding any changes within an area under its legislation, even if those changes aim for improvements. The current Nature 2000 legislation stems from a time when such changes were not considered. However, a contemporary update of this legislation could contribute significantly to the uptake of NBS in the Netherlands and beyond.

8.2.2. For the Ministry of Infrastructure and Water Management

- **Foster further interdisciplinary programmes**

  Several policy, knowledge or implementation programmes have been introduced throughout this research. However, collaboration between them is often lacking, underlining the presence of different silos working next to each other rather than with each other, focussing on their responsibilities. Therefore, interdisciplinary approaches between existing programmes should be encouraged, and new programmes should implement this approach from the beginning.

- **Combine goals of PAGW with the HWBP**

  Resulting from the recommendation above, as a more concrete measure, the programme goals of the Flood Protection Programme (HWBP) and the Programmatic Approach to Great Waters (PAGW) should be combined. Both programmes entail essential goals: the HWBP for flood safety and the PAGW for ecosystem restoration. However, those two goals should not be seen as two independent ones. Rather, the programme goals should be combined.

- **Promote interdependencies through national or regional programmes with national influence**

  It became evident that a collaborative environment built on trust can foster multidisciplinary solutions, including NBS. One important reason why both investigated case studies succeeded was that they were part of a national or regional programme that fostered collaborative behaviour. For the uptake of NBS, it will be important that similar interdependencies are created.

- **Create more incentives for collaborative approaches in flood risk implementation**

  Next to initiating programmes that foster collaboration, the Ministry of Infrastructure and Water Management may also incentivise projects done collaboratively rather than using a traditional approach. This could be done by providing subsidies for projects that pursue multiple goals.

- **Innovate national legislation**

  It became evident that the current legislation can be somewhat restrictive when innovative solutions are aimed to be implemented. To foster the uptake of NBS, the system should provide more flexibility for such solutions.

- **Allow innovative tools if they prove to be working**

  The rigid application of traditional tooling needs to be broadened for NBS to be applied on a broader scale. Solutions such as a wider slope for a dike or the implementation of biomass for wave attenuation have proven to work in practice. They must be more widely available for future implementation.

- **Make NBS more accessible**

  To foster the uptake of NBS, a wider range of experts needs to be familiar with the concept. Therefore, a promotion among experts, scholars, students, and society can contribute substantially to their uptake.

8.2.3. For Rijkswaterstaat

- **Use advisory role towards the Ministry of Infrastructure and Water Management to initiate policy changes**

  As identified before, RWS acts as a policy advisor for the Ministry of Infrastructure and Water Management and, therefore, has the opportunity to guide political decision-making. This function should be utilised to drive the recommended changes.

- **Introduce a second goal or multiple goals in the Flood Protection Program (HWBP)**

  50% of the money for dike reinforcement projects is provided through national money and through RWS. More multifunctional thinking will be enabled by introducing a second goal (or multiple goals) in the current HWBP. RWS should use its strategic position in the Dutch FRG and introduce a second (or multiple) goals for projects within the HWBP.

- **Introduce toolboxes of NBS in the HWBP**

  The *Room for the River* program utilised a toolkit of opportunities to achieve increased safety through higher discharge capacity while enhancing spatial quality simultaneously. The Flood Protection Program (HWBP) is recommended to adopt a similar toolkit, prioritising the consideration of NBS from the initial stages of project planning. Toolboxes, as specified, for example, by Van Eekelen and Bouw (2020), presented to project managers of HWBP projects have the potential to contribute to the "NBS unless" approach.

8.2.4. For the regional water authorities

- **Seek further collaboration with the private sector**

  Case Study 2 showed that private companies can drive more innovative solutions in FRG. The regional water authorities should seek further collaboration with the private sector to achieve modern solutions.

- **Consult stakeholders early in the decision-making process, including environmental NGOs and local citizens**

  It became evident that a project's success often depends on its acceptance at the local level. Therefore, all stakeholders interested in a certain flood defence project should be consulted early to ensure wide support for an intended endeavour.

8.2.5. For TU Delft

- **Provide more information about NBS within the Master programme of Construction Management and Engineering (CME)**

  The Master programme MSc Construction Management and Engineering (CME) is an interdisciplinary and inter-faculty Master programme preparing students for a dynamic environment. Therefore, as NBS, by nature, are considered multifunctional, they provide a promising opportunity for students to learn about managing several stakeholder interests in a complex environment. By doing so, more students will be familiarised with NBS, ultimately making it more accessible.

8.2.6. Recommendations for further research

The further uptake of NBS requires further research. Based on the identified limitations, the following areas are suggested for further research:

- **Comparisons of the Dutch governance structure with other countries to generalise findings;**
- **Research into the long-term cost-effectiveness of NBS with regard to the uncertainty of climate change and sea level rise;**

  Solutions such as the Wide Green Dike of Case Study 2 provide better adaptability regarding future sea level rise scenarios. Nevertheless, more research related to the long-term cost-effectiveness will be needed.

- **Further research regarding the effectiveness and reliability of NBS**

  Even though projects that have already been implemented with an NBS approach are widely considered successful, several uncertainties remain. Moreover, potential benefits are sometimes hard to predict and do not necessarily benefit the party financing it initially. The Sand Motor, for example, not only safeguards the sandy coast of Kijkduin sustainably before floods but also provides opportunities for more biodiversity to develop as well as for recreation and tourism.

- **Research regarding maintenance opportunities of NBS;**

  Several uncertainties are also connected to the maintainability of NBS. For example, natural applications must be pruned regularly in a fluvial setting to ensure navigability and sufficient discharge capacity for flood events. More long-term studies will be needed to draw more certain conclusions.

- **Gathering more qualitative data from NBS implemented in primary flood defence measures to support the findings**

  NBS are a broad concept that applies to several areas. Much literature, for example, focuses on an urban setting. To strengthen (or challenge) the results of the research more experts from other case studies in the field of FRM should be consulted.

- **Research on the holistic, long-term benefits of NBS considering a thorough overview of all stakeholders**

  The long-term benefits of NBS application are often difficult to assess. A framework by Raymond et al. (2017) provides a good approach, but more research will be needed for more reliable predictions.

- **Research on how participatory aspects can contribute to the uptake of NBS**

  During this research, citizen participation emerged as an important aspect of the uptake of NBS. Due to its multi-functional character, including more stakeholders, can lead to more accepted results. The interviews in this research focussed on the main actors in the Dutch FRG, but further research should include a wider perspective of the micro level.

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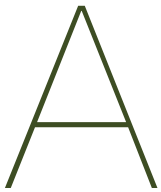

Literature used to identify the Knowledge Gap

Table A.1: Literature used to identify the knowledge gap

Author	Flood Risk Governance	
	Collaborative and participatory aspects	Resilience/ NBS aspect
Challies et al. (2016)	"[…] how, and under what conditions, participatory and collaborative governance contributes to effective and legitimate efforts to confront flood hazards, reduce exposure and vulnerability of communities, and thereby foster sustainable flood risk management."	
Pontee et al. (2016)		"At present, guidelines for NBS are limited and implementation is still predominantly case specific. As such, information from existing projects can provide valuable information on appropriate designs, implementation techniques and techniques for cost–benefit assessments."
Waylen et al. (2017)	"[…] what specific approaches and settings best allow those engaged in flood risk management to recognise and re-examine their views and expectations, and identify how these shape their work practices and collaborations?"	"[…] the evidence base on NFM is relatively young, with many gaps and uncertainties […]."
Driessen et al. (2018)	"A prime example is the involvement of citizens in fluvial flood risks in The Netherlands. While flood consequences in The Netherlands are relatively large, there is a serious lack of flood awareness and corresponding action being possible or taken by residents […] that is only changing gradually."	
Janssen et al. (2020)		"Despite the recent advancement, routine implementation beyond pilot projects remains limited."
Matczak and Hegger (2021)	"[…] the literature focusing on the need to have broad and inclusive societal debate on the normative starting points of flood risk governance has mainly shown how large and urgent the knowledge gap is as regards insights on how to stimulate such debates and make FRG [flood risk governance] more inclusive."	"The concept of nature-based solutions as it appears in studies concerning ecosystem services can also offer conceptual insights."
Martin et al. (2021)	"Despite the growing body of literature on NBS enablers and barriers […], further research is still needed to guide decision-makers and practitioners on NBS realisation, both from a technical perspective and governance perspective."	
Kiss et al. (2022)	"Overall, consensus is elusive on how much citizen participation contributes to sustainable outcomes in NBS. The nexus of citizen participation, NBS and sustainability outcomes is relatively new and unstudied […]."	
Den Heijer et al. (2023)	"In the literature, little attention has been given to the conditions for successful cooperation between organisations in flood defence asset management."	
Takin et al. (2023)	"Flood resilience is a relatively under-explored field of research, with limited existing studies directly exploring the connection between flood risk management, flood resilience, and green infrastructure […]."	

B

Data collection protocol

B.1. Interview protocol to answer SRQ2

AIM:
Answer SRQ2: *How is the current governance in flood risk management organised?*

PART I: Introduction

- General introduction to myself and the topic
- Introduction of the interviewee

PART II: Macro Level (International, national)

1. How did the Flood Directive (2007) of the EU influence the Dutch Flood Risk Governance?
2. Literature has suggested moving towards a more resilient flood risk management rather than only focusing on a defence-oriented approach. Does the current governance address this goal, and if yes, how?
3. How are nature-based solutions incorporated into the current policies, regulations, or programmes?
    - How do programmes such as the Delta Program or the Flood Protection Program (HWBP) promote the implementation of nature-based solutions (NBS)?
4. Can you provide examples of supportive policies or incentives that have helped advance nature-based solutions?

PART III: Meso Level (Provinces, Water Boards, Municipalities

5. What role do the water boards and the municipalities currently play in the governance of flood risk management and the implementation of nature-based solutions?
6. The Regional Water Authorities (Water Boards) often don't seem interested in implementing NBS because they are more focused on meeting their main responsibilities of flood defence with budget constraints. In literature, this is called "the nature-based flood defence dilemma" (Janssen et al., 2020). Is this familiar to you, and do you know if this "dilemma" is being addressed? And if yes, how?

PART IV: Micro Level (Citizens, landowners, businesses, citizen groups, NGOs

7. How are local communities and other stakeholders (NGOs; the private sector) involved in the decision-making process for flood risk management?
    - Can you provide examples of community-based initiatives or partnerships in flood risk management?
    - What is the intended goal of involving local communities and stakeholders, and does the involvement currently work as expected?
8. What social or community-related challenges occur when implementing nature-based solutions?

PART V: Practical questions

9. Which successful nature-based flood risk management projects come to mind?
    - What governance factors have contributed to its success?
    - How was the stakeholder participation organised?

Ask for potentially more interview contacts.

B.1.1. Invitation Document for interviewees (SRQ2)

Invitation to participate in MSc Thesis Interview

Flood Risk Governance and the Implementation of Nature-based solutions

Dear Participant,

You are invited to participate in a research study titled "Flood Risk Governance and the Implementation of Nature-based Solutions". This study is being done by me, Finn Bartels. I am a master's student from TU Delft. To fulfil the requirements for the degree of Master of Science in Construction Management and Engineering, I am currently working on my Master's thesis in cooperation with Rijkswaterstaat. From TU Delft, I am being supervised by Dr. Ir. Marian Bosch-Rekveldt, Ph.D. (Candidate) Yara Kharoubi and Dr. Ir. Martine van den Boomen. My company supervisor from Rijkswaterstaat is Dr. Ir. Alexander Bakker.

The purpose of this research study is to investigate how flood risk governance can facilitate the implementation of nature-based solutions. Your valuable insights and experiences are crucial to the success of this. Therefore, I intend to interview several experts familiar with flood risk management and governance processes on several levels (international, national, provincial, water authorities, municipalities, NGOs, and citizens' groups).

The interview will take approximately 1 hour. I intend to record and transcribe it. This is solely done to analyse the information obtained and arrive at general findings that will help answer the thesis' research questions. The final thesis will be published in the TU Delft Repository.

In this first phase of my research, I am focusing on the current state of flood risk governance. I will ask you to answer questions about this and your perception of the implementation of nature-based solutions.

As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers to this study will remain confidential. We will minimise any risks by anonymising any personal data. The recordings and transcripts are stored on services provided by TU Delft and will be destroyed as soon as the master's thesis has been defended.

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

Feel free to contact me if you have any questions before or after the interview.

Finn Bartels

Contact Details:
E-Mail: f.f.bartels@student.tudelft.nl
Mobile: [redacted]

Figure B.1: Invitation Document for Interviewees (SRQ2)

B.2. Interview protocol to answer SRQ3 & 4

AIM:
Answer SRQ3 & 4:

SRQ3: What are the current challenges and success factors in designing and implementing nature-based solutions?

SRQ4: What needs to be improved in the current governance to enable routine implementation of nature-based solutions?

PART I: Introduction

- General introduction to myself and the research topic
- Introduction of the interviewee and the case study

PART II: Macro Level (International, national)

1. At the national (or international) level, what policies or frameworks have been instrumental in successfully implementing this project?
2. How did the Innovation Program of the Flood Protection Program (HWBP) help this project?
3. What are the primary challenges at the national (or international) level that hindered the implementation of this project?
4. How was the project financed?
    - How did national funding mechanisms impact the project implementation?
5. What changes at the national (or international) level, do you believe, would most significantly enhance the next phases of this project (wider implementation)?

PART III: Meso Level (Provinces, Water Boards, Municipalities)

6. Why was the regional water authority interested in implementing a nature-based solution?
7. Can you provide examples of how regional or local governance structures have successfully supported the implementation of your project?
8. What were the significant barriers at the regional or local governance level that affected the implementation of your project?

PART IV: Micro Level (Citizens, landowners, businesses, citizen groups, NGOs)

9. How were local communities and other stakeholders (NGOs; the private sector) involved in the decision-making of your project?
10. How has community engagement contributed to the success of nature-based flood management solutions at the project level?
11. What social or community-related challenges occurred in this project?

Concluding questions

12. What challenges does the upscaling (wider implementation) of this project entail?
13. Considering the macro, meso, and micro levels, what do you see as the most critical governance improvement needed to facilitate the upscaling of this project?

B.2.1. Invitation Document for interviewees (SRQ3 & 4)

Invitation to participate in MSc Thesis Interview

Flood Risk Governance and the Implementation of Nature-based solutions

Dear Participant,

You are invited to participate in a research study titled "Flood Risk Governance and the Implementation of Nature-based Solutions". This study is being done by me, Finn Bartels. I am a master's student from TU Delft. To fulfil the requirements for the degree of Master of Science in Construction Management and Engineering, I am currently working on my Master's thesis in cooperation with Rijkswaterstaat. From TU Delft, I am being supervised by Dr. Ir. Marian Bosch-Rekveldt, Ph.D. (Candidate) Yara Kharoubi and Dr. Ir. Martine van den Boomen. My company supervisor from Rijkswaterstaat is Dr. Ir. Alexander Bakker.

The purpose of this research study is to investigate how flood risk governance can facilitate the implementation of nature-based solutions. Your valuable insights and experiences are crucial to the success of this. Therefore, I intend to interview several experts familiar with flood risk management and governance processes on several levels (international, national, provincial, water authorities, municipalities, NGOs, and citizens' groups).

The interview will take approximately 45 minutes. I intend to record and transcribe it. This is solely done to analyse the information obtained and arrive at general findings that will help answer the thesis' research questions. The final thesis will be published in the TU Delft Repository.

In the first phase of my research, I focussed on the current state of flood risk governance.

This is now the second phase of my research. In that phase, I intend to interview several experts from two case studies about the current challenges and success factors in projects that implemented nature-based solutions.

As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers to this study will remain confidential. We will minimise any risks by anonymising any personal data. The recordings and transcripts are stored on services provided by TU Delft and will be destroyed as soon as the master's thesis has been defended.

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

Feel free to contact me if you have any questions before or after the interview.

Finn Bartels

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Mobile: [redacted]

Figure B.2: Invitation Document for Interviewees (SRQ3 & 4)

B.3. Explored publicly available documents

No.	Name	Author(s)	Date
1	3e Kustnota - Traditie, Trends en Toekomst	Ministry of Transport and Water Management	December 2000
2	Samen werken met water [translated to English]	Secretariaat Deltacommissie	September 2008
3	National Water Plan 2016 - 2021	Ministry of Infrastructure and the Environment; Ministry of Economic Affairs	December 2015
4	Water Governance - The Dutch Water Authority Model	Dutch Water Authorities	2017
5	Programmaplan Hoogwaterbeschermingsprogramma 2019-2023 [translated to English]	Hoogwaterbeschermingsprogramma (HWBP)	April 2019
6	Nationaal Water programme 2022 - 2027 [translated to English]	Ministry of Infrastructure and Water Management	March 2022
7	2024 Delta Programme	Ministry of Infrastructure and Water Management	September 2023
8	Voorbij de dijk - Keuzes in het waterveiligheidsbeleid [translated to English]	Algemene Rekenkamer	October 2023
9	Draft Integrated River Management Programme	Ministry of Infrastructure and Water Management	December 2023
10	Overzicht Adviezen en Vragen Deltacommissaris 2019 tot en met 2023 [translated to English]	Deltacommissaris	December 2023
11	Ruimtelijke Ordening in een veranderend klimaat [translated to English]	Raad voor de leefomgeving en infrastructuur	June 2024

Table B.1: List of secondary data collected to answer SRQ2

No.	Author(s)	Date	Name
D-CS1.1	Projectorganisatie Ruimte voor de Rivier	June 2005	PKB Deel 1 - Ruimte voor de Rivier - Ontwerp Planologische Kernbeslissing
D-CS1.2	Room for the River	2016	Factsheet Dutch Water Programme Room for the River
D-CS1.3	Room for the River	2015	Factsheet Making room for the Dutch approach
D-CS1.4	Room for the River	2015	Factsheet Making room for governance
D-CS1.5	Room for the River	2015	Factsheet Making room for safety
D-CS1.6	Room for the River	2015	Factsheet Making room for innovation
D-CS2.1	Ems-Dollart 2050 programme	February 2021	Programme plan 2021-2026
D-CS2.2	Ems-Dollart 2050 programme	September 2023	Eindrapportage Kleirijperij
D-CS2.3	Ecoshape	2021	Factsheet Business Case Pilot Kleirijperij

Table B.2: List of documents related to case studies