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INVESTIGATING THE REALISATION OF NATURE-BASED SOLUTIONS

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Executive Summary

The European Commission (EC) defines Nature-based Solutions (NBS) as cost-effective solutions that are inspired and supported by nature, simultaneously providing environmental, social and economic benefits to help build resilience (European Commission, 2015). Central to NBS is the principle of producing knowledge and learning to improve human wellbeing and address environmental challenges, including the effects of climate change. While NBS as a concept is recognised to create a multitude of benefits, the implementation of NBS has been limited and unsuccessful in generating enduring change (van Buuren et al., 2018).

For the wide-scale realisation of NBS, a key obstacle is a difficulty in linking knowledge and action systems. Barriers between these systems result in discord between the knowledge required for realisation by actors and the knowledge that is ultimately delivered (Cash et al., 2003). This thesis examines knowledge-action systems and their implications for using NBS knowledge for future implementation to explore the obstacles to wide-scale NBS realisation.

The highly contextual nature of NBS produces the inability for a one size fits all approach to implementation (Cohen-Schacham et al., 2016). As knowledge-action systems are influenced by context, this creates further complexity in linking knowledge and action and impacts the production of comprehensive, in-depth information required for widespread implementation. This lack of prevalent NBS information significantly contributes to the limited uptake of NBS practices (Ershad Sarabi et al., 2019).

Before this study, the comprehensive documentation of lessons learnt was not a priority in NBS implementation. Using knowledge from projects executed by EcoShape, it is possible to identify the key lessons learnt that aid NBS implementation across several cases. Examining this knowledge alongside the theoretical assumptions of knowledge-action systems within NBS helps inform how to influence and support future NBS realisation. To examine these gaps, this thesis explored the following research questions:

1. Among critical stakeholders, what were key perceptions of lessons learnt driving the realisation of NBS in Building with Nature (BwN) projects?
2. Considering the obstacles to NBS implementation and key lessons learnt, how can NBS realisation be better supported by enhancing inherent strengths and opportunities and can any knowledge be added to the existing knowledge base?

To explore the obstacles to wide-scale NBS realisation, this thesis examines knowledge-action systems and their implications for the use of NBS knowledge for future implementation. The purpose is to identify a method to address obstacles and support links between knowledge and action. The primary data sources utilised to perform this research were from interviews conducted with NBS actors and analysed in conjunction with academic literature.

Conventional approaches to linking knowledge and action typically confine the two concepts in separate, self-contained communities (linear model) (West, van Kerkhoff, & Wagenaar, 2019). Despite what the literature on the linear-based model describes, the application of knowledge cannot flow automatically from understandings produced by well-translated findings. It is instead a product of context and how the knowledge aligns with existing physical, societal, and political structures, amongst other factors (van Kerhoff & Lebel, 2006). The dynamic approach to knowledge-action systems accepts the involvement of stakeholders in knowledge development and action, co-existing and 'co-producing' simultaneously (West, van Kerkhoff & Wagenaar, 2019). This perspective highlights how knowledge 'relates' to action for the challenges this thesis examines. With these assumptions, the complexities of utilising NBS knowledge in other projects surround miscommunications between the knowledge required for realisation by actors and the knowledge that is ultimately delivered. Little contextual consideration and integration can cause issues with comprehension and acceptance of knowledge. This limitation can reduce the relevance of knowledge and the capacity for applying knowledge and confine the development and improvement of new and existing knowledge.

Van Kerhoff and Lebel (2006) consider obstacles within knowledge-action systems, outlining four main categories to counter the significant obstacles between knowledge and action: participation, integration, learning and negotiation. These responses assimilate dynamic and iterative relationships between knowledge and action, stakeholders' integration and spatial context variability. More effort must be devoted to engagement, interactive problem framing, knowledge integration and real-world experimentation (Cornell et al., 2013).

This thesis adopts the research paradigm of relativism. Knowledge in this context is subjective and determined by one's relationship with the surrounding context. This theoretical perspective requires interaction between the investigator and the subjects of enquiry (Guba & Lincoln, 1994). It is also necessary to reflect on external factors that may influence such knowledge.

As such, this thesis utilised a qualitative research approach which included interviews with key stakeholders as the primary method of data collection and desk research within four selected NBS projects; Honsdbossche Dunes, Marker Wadden, Marconi Delfzijl and BwN Indonesia. A combined case study perspective of the four NBS projects was adopted to explore this data, utilising a cumulative approach. This approach supports the aggregation of information from NBS projects at several sites in different contexts, each collected at different times.

The cumulative approach is most beneficial to draw comprehensive lessons from research question one as it can group lessons learnt from various contexts.

Key lessons learnt were distinguished using a SWOT analysis to address research question two. These were then categorised based on van Kerkhoff and Lebel's (2006) approach to overcoming boundaries between knowledge and action. This process further delineated how stakeholders can support the realisation of NBS in future applications.

The outcome of the interviews resulted in the determination of approximately 103 lessons learnt. Through analysis, these lessons learnt were aggregated, resulting in 39 key lessons which detail the outcome of research question one. Based on this, the methodology was followed to categorise and delineate key lessons learnt to determine how NBS realisation can be better supported.

For strengths, 'learning' and 'integration' are the two primary themes of the lessons learnt, comprising 37% and 26% of the learnings, respectively. For opportunities, 'participation' makes up 37% of learnings, with 'negotiation' comprising 27%. Within weaknesses, 'integration' and 'negotiation' are the dominant themes comprising 33% of learnings each. Finally, 50% of learnings with the threats categories are associated with 'learning', with 'integration' making up another 25%.

Based on these methods of analysis, the researcher could determine what actions can be taken to overcome obstacles between knowledge and action to support the realisation of NBS. This outcome is produced from learnings identified as strengths and opportunities during the SWOT analysis.

Learnings considered as strengths are internal and often controllable positive factors that exist and are inherently built into NBS. This means that the ability to create beneficial outcomes between knowledge and action can be influenced by engaging these strengths and amplifying their importance within future NBS projects. The strengths identified communicate that as NBS becomes widespread, their understanding within industry and the community continues to expand. Further, the inherent flexibility and adaptability of NBS create the potential to better address the varied contextual environments of future NBS.

Learnings considered opportunities are external and uncontrolled positive factors that exist but are not inherently built into NBS implementation. While this means the ability to directly influence outcomes may be limited, opportunities assist in understanding external factors in NBS that can be explored and expanded upon to relate knowledge and action. Overall, opportunities lie in facets of relationships between knowledge developers and their user communities and through the creation of room for different political interests. Learnings identified under the theme of opportunities are therefore considered to highlight prospects for further exploration to support successful NBS realisation.

Although there are many areas in which research can be furthered, it is essential to note that the outcomes of this paper have provided considerable insight into the interactions of knowledge systems. This paper has helped to identify action areas that may support NBS realisation. Stakeholders can prioritise resources on specific methods of interaction within NBS projects to better link knowledge and action. Additionally, finances can be better targeted to areas that this thesis identified as supporting NBS realisation. In doing so, the challenge becomes more approachable and NBS outcomes more attainable.

Acknowledgements

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Chapter 1. Introduction

Chapter One provides an overview of the proposed problem addressed in this master’s Thesis. The paper examined stakeholders' perceptions of the NBS realisation process and obstacles in utilising NBS knowledge in future projects. Based on this information, this thesis provides actions to support the implementation of NBS.

This chapter begins with the conception of this thesis. It continues with an overview of the current crisis providing context to the nature of the research. The problem statement, the aims and research questions were described from this. The study's contribution to the NBS field is discussed, concluding by outlining the remaining chapters of this thesis.

1.1 Current Crisis

Increasing urbanisation and climate change impacts such as global warming, rising sea levels and catastrophic weather events have been identified by the UN Intergovernmental Panel of Climate Change (IPCC) as the most defining issue of our time and unprecedented in scale (Masson-Delmotte, e. al., 2018). Half of the world's population lives within 60 km of the ocean, and three-quarters of all large cities are coastal. Erosion and inundation due to hazards such as storm surges and rising sea levels threaten humans and associated infrastructure in the coastal zone. These impacts have increased as the quantity and value of coastal infrastructure have grown and continue to do so. Further, coastal communities outside capital cities generally have less adaptive capacity than capital city communities, causing more adverse effects from climate change impacts (Department of Climate Change [DCC], 2009).

Increases in communities' vulnerability to coastal hazards are projected due to future climate changes. The influence of climate variables exacerbates these hazards, increasing sea level and wave height and causing more intense and potentially more frequent storm events (Department of Climate Change [DCC], 2009). The IPCC report estimated a global sea-level rise of up to 79 centimetres by 2100, with the risk that the contribution of ice sheets to sea level could be substantially higher (Department of Climate Change [DCC], 2009). With this, up to 4.6% of the global population may experience annual flooding by 2100. At least 70% of beaches worldwide are eroding or have a negative sediment budget, resulting in shoreline erosion and inland displacement. Identifying effective intervention methods to protect and mitigate against contemporary and future hazards is arguably one of the most pressing challenges facing coastal communities today.

Traditional human-built ('grey') infrastructure, consisting of artificial structures such as dams and pipelines, is currently used to protect against contemporary hazards such as flooding, sea-level rise and other natural disasters (WWAP, 2018). However, these approaches frequently do not address the core issues and may even contribute to environmental challenges. The recognition that ecosystems, climate, and biodiversity are influential determinants of human health, wellbeing, and social cohesion (Naeem et al., 2015), has led to a greater focus on finding solutions that work with the natural environment. Consequently, the concept of Nature-based Solutions (NBS) has evolved and gained momentum to provide adaptation and mitigation of climate change impacts. The defining problem in this pursuit is factors challenging the realisation of NBS and how to overcome these challenges to support the implementation of future NBS projects on a wide scale. The realisation in this thesis refers to the process of producing desired deliverables, expected benefits and outcomes. Implementation refers to the physical act of planning, preparation and deployment of a solution.

1.2 Nature-based Solutions

The European Commission (EC) defines NBS as “solutions that are inspired and supported by nature, which are cost-effective, simultaneously providing environmental, social and economic benefits to help build resilience” (European Commission, 2015). NBS has also been defined in multiple ways in literature and has evolved as an umbrella concept incorporating various approaches. NBS solutions can combine hard and soft infrastructure (green walls and green roofs), as well as ecosystem-based approaches, such as 'green-blue infrastructure', 'ecological engineering' and 'natural capital, which re-install or encompass a part of an ecosystem (urban wetlands and natural embankments) (Maginnis, 2016). However, central to all these approaches is the principle of learning and utilising natural ecosystems to improve human wellbeing and address environmental challenges such as water management and the effects of climate change. The EC determines that through locally adapted, resource-efficient, and systemic interventions, NBS bring diversity in nature, and natural features and processes into cities, landscapes, and seascapes (European Commission, 2015).

NBS is a relatively new concept, having emerged in the last decade (Somarakis et al., 2019). NBS is encouraged by the EC and promoted as innovative solutions to environmental challenges, with the ability to produce knowledge and contribute to participant learning. Despite this, implementing these solutions has been limited and significantly less successful in generating enduring change (van Buuren et al., 2018). Wide-scale NBS implementation, which involves the uptake and integration of NBS projects in multiple contexts, has become a fundamental pursuit.

1.3 EcoShape and Project Cases

Founded in 2008, the consortium EcoShape has contributed significantly to understanding nature-based approaches. EcoShape began with an initial Building with Nature innovation program (BwN I) (van Eekelen, Sittoni, van der Goot & Nieboer, 2019), of which the first four years were used to stimulate changes in thinking on hydraulic engineering solutions (EcoShape, 2020). After this first program, in 2012, EcoShape and its partners established an ongoing BwN program (BwN II). In BwN II, knowledge developed from BwN I was tested in field pilot applications in various environments (van Eekelen et al., 2019). These have been undertaken in five environmental contexts (locations): sandy shores, estuaries, tropical coastal seas, shallow shelf seas and delta lakes (de Vriend & van Koningsveld, 2012). It is from EcoShape that the four projects explored in this thesis have been drawn.

Over the past 12 years, the BwN program focussed on developing foundational NBS experience, cooperation with multi-stakeholders, and monitoring and drawing guidelines to contribute to an extensive knowledge base (EcoShape, 2020). This program was undertaken with the public-private EcoShape partnership, including dredging contractors, equipment suppliers and engineering consultants. Government agencies, local authorities, research institutes, and universities were also involved in this consortium (see Figure 1.1) (de Vriend & van Koningsveld, 2012).

Figure 1.1 EcoShape Consortium.

1.4 Obstacles of wide-scale realisation

A key obstacle to wide-scale NBS realisation is difficulties linking knowledge to action or knowledge-action systems. These systems consist of agents, practices, and institutions connected by formal or informal relationships that dynamically combine knowing, doing, and learning to bring about specific actions for sustainable development (van Kerkhoff and Szlezak, 2010). Therefore, knowledge-action systems are simply networks of actors involved in the production, sharing and use of relevant knowledge (Munoz-Erikson, 2014).

Barriers between knowledge and action result in discord between the knowledge required and the knowledge delivered (Cash et al., 2003). As such, it was necessary to explore how this gap between knowledge and action can be bridged to support the use of NBS knowledge in future projects.

A factor within knowledge-action systems is the influence of the context. Context is a dynamic set of relations between an actor (or group) and their social and material environment (Wagenaar & Cook, 2011). The highly variable contextual nature of NBS produces the inability for a one size fits all approach to implementation (Cohen-Schacham et al., 2016). These factors create further complexity in linking knowledge-action systems and impact the transfer of comprehensive and in-depth information. This lack of wide-ranging NBS information significantly contributes to the limited uptake of NBS practices (Ershad Sarabi et al., 2019).

Within the EcoShape consortium, from which this master's thesis was commissioned, the goal of the BwN program (2008-2020) was to develop foundational NBS experience to contribute to an extensive knowledge base. Before this study, the comprehensive collection and documentation of lessons learnt was not a priority in NBS implementation within the BwN program. Utilising this resource may allow processes explored in this thesis can be strengthened with real-world experiences of NBS realisation.

This thesis examines knowledge-action systems and their implications for using NBS knowledge for future implementation. In the context of NBS, it also explores the implications of knowledge transfer between projects. A method to address obstacles and support the relationship between knowledge and action is identified based on the investigation. To strengthen these findings, this thesis examines the experiences of stakeholders involved in NBS projects to gather key learnings which support the implementation of NBS in the future. This knowledge was gathered not only for documentation purposes but also to provide evidence to verify methods of overcoming obstacles and facilitate the use of NBS knowledge.

1.5 Problem Statement and Aim

The potential of NBS has gained significant global attention, being viewed as a cost-effective and sustainable approach for water management, air quality, and other environmental issues (WWAP, 2018). Despite this, realisation on a larger scale remains problematic in dominant practice (mainstreaming) (van Eekelen et al., 2019). It is suggested that this stems from obstacles limiting the relation of knowledge and action for NBS realisation. The lack of widespread and in-depth information across spatial scales makes these challenges more complex.

This thesis, therefore, aims to collect lessons learnt from multiple NBS projects, exploring perceptions of lessons of NBS implementation and realisation. Based on these findings and those in academic articles on knowledge systems, recommendations will be made to support the realisation of NBS in different contexts.

1.6 Research Questions

Using the knowledge from projects executed by EcoShape, it was possible to identify the key lessons learnt that aid NBS implementation across several cases. Examining this knowledge alongside the theoretical assumptions of knowledge-action systems within NBS helps inform how to influence and support future NBS realisation. To examine these gaps, the research questions to be explored are:

1. Among critical stakeholders, what were perceptions of key lessons learnt driving the realisation of NBS in BwN projects?
2. Considering the obstacles to NBS implementation and key lessons learnt, how can NBS realisation be better supported by enhancing inherent strengths and opportunities and can any knowledge be added to the existing knowledge base?

1.7 Scientific and Societal Relevance of the Proposed Research

Currently, political commitments and targets have been made for NBS implementation in the Paris Agreement, the Sustainable Development Goals (SDGs) and the Sendai Framework for Disaster Risk Reduction (EcoShape, 2019b). With support for NBS increasing, there is a growing need to communicate knowledge to support the mainstreaming of NBS practices. Documenting the lessons learnt driving NBS realisation, exploring obstacles between knowledge and action and discussing methods to overcome these challenges are intended to make NBS more accessible for stakeholders. Doing so provides tools to increase exposure and understanding of alternative concepts that are more sustainable, maintainable and contribute more to societal and economic development.

Exploring methods to improve relations between knowledge and action to drive NBS realisation, the aim is to shift conversations around solving societal issues away from traditional approaches towards more sustainable practices. The findings of this thesis are intended to create an impact beyond the boundary of NBS.

1.8 Outline of the Thesis

Following this introductory chapter, a literature review was undertaken of available literature on relevant theories for NBS and knowledge transfer and the development of a conceptual framework utilised to answer the research questions (Chapter 2).

Chapter 3 describes the contexts of the four NBS projects from the BwN EcoShape program investigated as part of the research. Chapter 4 outlines the methodology used in this research, identifying and justifying relevant approaches to extract and analyse data.

Chapter 5 presents the results, which have undergone several modes of analysis to address the research questions detailed above. Following, Chapter 6 comprises a discussion of how the results can be interpreted to support the realisation of NBS. This chapter addresses the results in the context of the adopted framework for overcoming boundaries between knowledge and action (explored in Chapter 2). Chapter 7 presents the research outcomes, seeking to answer the research questions. To conclude, Chapter 8 presents a critical reflection of the research and recommendations for further research.

Chapter 2. Literature Review and Theoretical framework

This chapter reviews the literature on critical concepts regarding the realisation of NBS. Specifically, this explores knowledge and complexities associated with NBS knowledge and methods to support knowledge development and application for wide-scale NBS realisation. Chapter 2 begins by exploring a uniform framework for NBS implementation. This framework, once established, can be utilised as a method of collecting and structuring lessons learnt from NBS projects. Section 2.1 examines the implications of knowledge systems regarding how different dynamics can influence knowledge development, collection, and perception, particularly across contexts. This section highlights the challenges of linking knowledge and action regarding the unique characteristics of physical, socio-cultural and political contexts in NBS. Finally, considering the structure and dynamics of knowledge systems, Section 2.4 examines responses to the challenges and boundaries between knowledge-action systems. Through these responses, it concludes with a model to adopt in linking knowledge and action across contexts.

2.1 Implications of Knowledge Systems: The Obstacles between Knowledge and Action

Linking knowledge to action is considered imperative in sustainability due to the need to address issues such as climate change through active solutions (West, van Kerkhoff & Wagenaar, 2019). While existing boundaries between knowledge and action can serve to protect science from the influence of politics or help to allocate ownership (Cash et al., 2002), they can also create issues between these domains with "communication, collaboration, coordination and integration" (Cash et al., 2003). This theory applies directly to NBS, with problems in complex relationships such as human-environment systems (Cash et al., 2003). Boundaries between knowledge and action can materialise in knowledge being either too ambiguous or too technical for users and can also create mistrust of knowledge, hindering its acceptance.

To overcome boundaries between knowledge and action, assumptions and dynamics within knowledge systems are critical components. The deeper, fundamental assumptions on how knowledge-action systems (knowledge systems) are viewed and operate create different implications of how to overcome associated boundaries. Exploring these dynamics can aid in identifying an appropriate approach to overcome the boundaries highlighted in this paper.

2.1.1 Singular Linear Knowledge-Action Systems

Conventional approaches to linking knowledge and action confine the two concepts in separate, self-contained communities (West, van Kerkhoff, & Wagenaar, 2019). In such a linear, unidirectional perspective, knowledge is developed and "applied to" action to arrive at a solution (see Figure 2.1). This approach sees accurate knowledge as being essential to, and coming before, effective action (West, van Kerkhoff, & Wagenaar, 2019). In this view, researchers associate knowledge and policy actors with action (van Kerkhoff & Lebel, 2006).

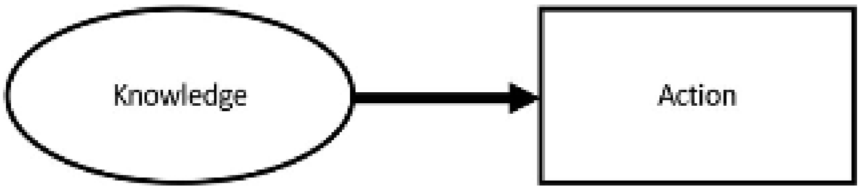


Figure 2.1 Linear system for linking knowledge and action (West, van Kerkhoff, & Wagenaar, 2019).

Coalitions define structures of a social process in which various actors work closely together to produce information (van Buuren & Edelenbos, 2004). This definition implies that the issue exists in interactions within an individual group of actors. Aligned with the linear approach, the model in Figure 2.2 perceives the main challenge of linking the two communities to exist within a single knowledge coalition.

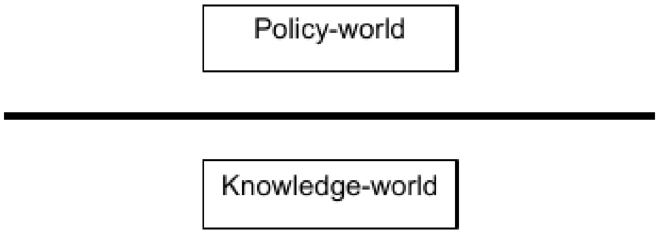


Figure 2.2 A conventional approach to understanding interactions between knowledge and action (van Buuren & Edelenbos, 2004).

Thick lines represent the main barrier in knowledge transfer as interactions between the policy and knowledge worlds.

Linear progression between knowledge-action systems fails to recognise the inherent "wickedness" of sustainability challenges due to their complexity, unpredictability and contestable facts and values (West, van Kerkhoff, & Wagenaar, 2019). This perspective also neglects the inherent presence of multiple knowledge coalitions within multiple contexts in NBS projects.

Despite what literature on linear-based models assumes, the application of knowledge cannot flow automatically from understanding produced by well-translated findings. It is instead a product of context and how the knowledge aligns with existing physical, societal and political structures, among other factors (van Kerhoff & Lebel, 2006).

2.1.2 Multiple Complex Knowledge-Action Systems

Addressing sustainability challenges such as climate change, towards which NBS is oriented, is a complex problem requiring dynamic models for linking knowledge and action. Knowledge development and application are not ordered sequentially but coincide, operating in a feedback loop (Figure 2.3).

In contrast to a linear-based approach, a dynamic approach to knowledge-action systems accepts that stakeholders are involved in both knowledge development and action. These arenas co-exist and "co-produce" each other rather than being ordered sequentially (West, van Kerkhoff & Wagenaar, 2019). These assumptions refute the common conceptualisation of isolated roles of the knowledge arena and the action arena.

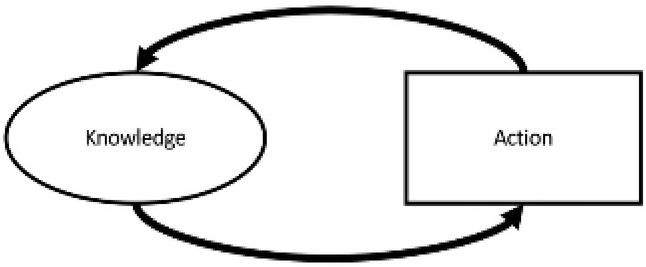


Figure 2.3 Complexity-orientated system for linking knowledge and action (West, van Kerkhoff, & Wagenaar, 2019).

Within NBS, it is also vital to acknowledge that knowledge systems existing within coalitions are inextricably linked to their context. Van Buuren & Edelenbos (2004) argue that the challenge of linking knowledge-action systems exists not within a single knowledge coalition but between multiple coalitions (Figure 2.4). These comprise multiple sets of stakeholders from different contexts, combining different bodies of knowledge or knowledge streams from multiple social and institutional levels (Ershad Sarabi et al., 2019).

The dynamics between these coalitions enable several forms of logic and paradigms to exist side-by-side (van Buuren & Edelenbos, 2004). As such, knowledge can often be contested and rejected by a different collection of users not included in the project (van Buuren & Edelenbos, 2004). Actors may not view knowledge as credible if it does not correspond to the dominant paradigm and institutional context within a different group of users (van Buuren & Edelenbos, 2004).

Within NBS, stakeholders with diverse backgrounds participate in its realisation and, therefore, in the knowledge systems that contribute to it. For this thesis, the obstacles between knowledge and action and, therefore, wide-scale NBS realisation is consistent with the 'complexity-orientated system' perspective.

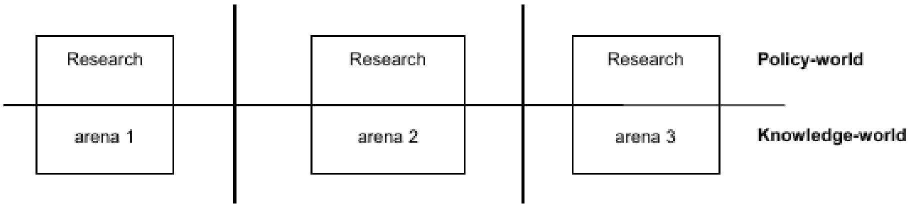


Figure 2.4 Expanded perspective on the main challenge of interaction between knowledge and action (van Buuren & Edelenbos, 2004).

Thick lines represent the main barrier in knowledge transfer as interactions between different groups of creators and users of knowledge.

2.1.2.1 Application of the Complexity-Orientated Perspective

Although this approach seeks to eradicate the distinct delineation between knowledge and action, it continues to allude to linear and single systems. For example, the idea of "linking" knowledge and action use language consistent with this linear concept. According to van Kerkhoff and Lebel (2006), this is flawed as a fundamental link exists between knowledge and the processes that have created it.

Despite criticisms for the idea of "linking" knowledge and action, it provides a helpful visual in the endeavour to better connect knowledge-action systems, including coalitions involved in these systems, to minimise issues with communication, coordination, collaboration, and integration (Cash et al., 2003). Instead of linking knowledge to action, this perspective can highlight how knowledge "relates" to action.

2.2 Complexities of Realising NBS Knowledge

Knowledge is not absolute but rather a relative and contingent mix of experiences, values, and insights (Alvesson, 2004). Increasing NBS knowledge shows that they are locally adapted solutions to societal contexts, which generate multiple benefits (Nesshöver et al., 2017; Raymond et al., 2017). There is, however, limited research on how NBS knowledge can be translated across contexts to enable their realisation.

With these assumptions, the complexities of utilising and applying NBS knowledge in other applications surround miscommunications between what knowledge is needed and what is being delivered. With the presence of multiple knowledge streams comprising multiple stakeholders and contexts, issues with comprehension and acceptance of knowledge also result from a lack of contextual input and integration into knowledge. This lack of integration limits the locational value and relevance of knowledge, can restrict the learning capacity and can confine the development and improvement of new and existing knowledge. The sense of ownership over knowledge can also be impacted, affecting project realisation's success.

2.3 Establishing a Structure for Universal Knowledge Use

One of EcoShape's primary aims was to develop valuable knowledge by monitoring the outcomes of NBS projects. Therefore, collecting and documenting these lessons becomes a key priority, which until now has not been done across multiple EcoShape projects.

For new concepts such as NBS to succeed in the future, a clear and widely accepted understanding of the foundations of NBS is necessary (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). Exploring frameworks in NBS can address the lack of operational clarity regarding uncertainty in implementation, providing purposeful knowledge for the wide-scale implementation of NBS.

Further, it is reasonable to suggest that a framework to collect and structure knowledge is a critical tool to build foundations for overcoming obstacles in using NBS knowledge. This thesis explored frameworks and guidelines for planning and implementing NBS projects. Examining multiple tools allowed the framework to be informed and verified by a solid material foundation.

2.3.1 Expanded Proof of Concept and Demonstration Stages of NBS

A framework developed by Raymond et al. (2017) called the Expanded proof of concept and demonstration stages of NBS (Figure 2.5) discusses how solutions can be innovated (right side of figure) and how NBS can be successfully implemented (left side of figure) (Raymond et al., 2017). For the collection and organisation of lessons learnt, this thesis considered the left side only. The framework comprises seven stages outlined below (Raymond et al., 2017).

1. Identify the problem or opportunity

This stage is associated with identifying the needs or challenge areas that the project addressed. This way, it looks at the project's opportunities and the benefits NBS can provide. This stage also identifies proposed alternative solutions.

2. Select NBS and related actions

Stage two discusses the identification of project objectives and how they were drawn. This stage links how the project actions ensure the effectiveness of the solution.

3. Design the NBS implementation process

Stage three focuses on the engagement of multidisciplinary teams and how this is conducted. It connects to the dynamics within the team and relationships across various levels of institutions and organisations.

4. Implement NBS

This stage surrounds the execution of the project itself. In this stage, Raymond et al. (2017) explore how the implementation process is conducted. This includes the management of uncertainty in the project, managing negative perceptions from stakeholders, and actions of successful NBS projects.

5. Frequently engage stakeholders and communicate co-benefits

This stage is considered ‘stakeholder engagement’. It explores how stakeholders are involved in the project and the methods used to engage them.

6. Monitor and evaluate co-benefits

Monitoring is considered by Raymond et al. (2017) to be a continuous process in all stages of the NBS implementation process. Evaluation refers to how project benefits and objectives can be assessed. Stage 6 explores methods and indicators of how to measure and monitor the benefits of NBS actions. It also examines potential barriers to monitoring and evaluation.

7. Transfer and upscale NBS

This stage looks at processes and characteristics in implementation that may support upscaling NBS. It also discusses the value of learnings that feed into mainstream processes.

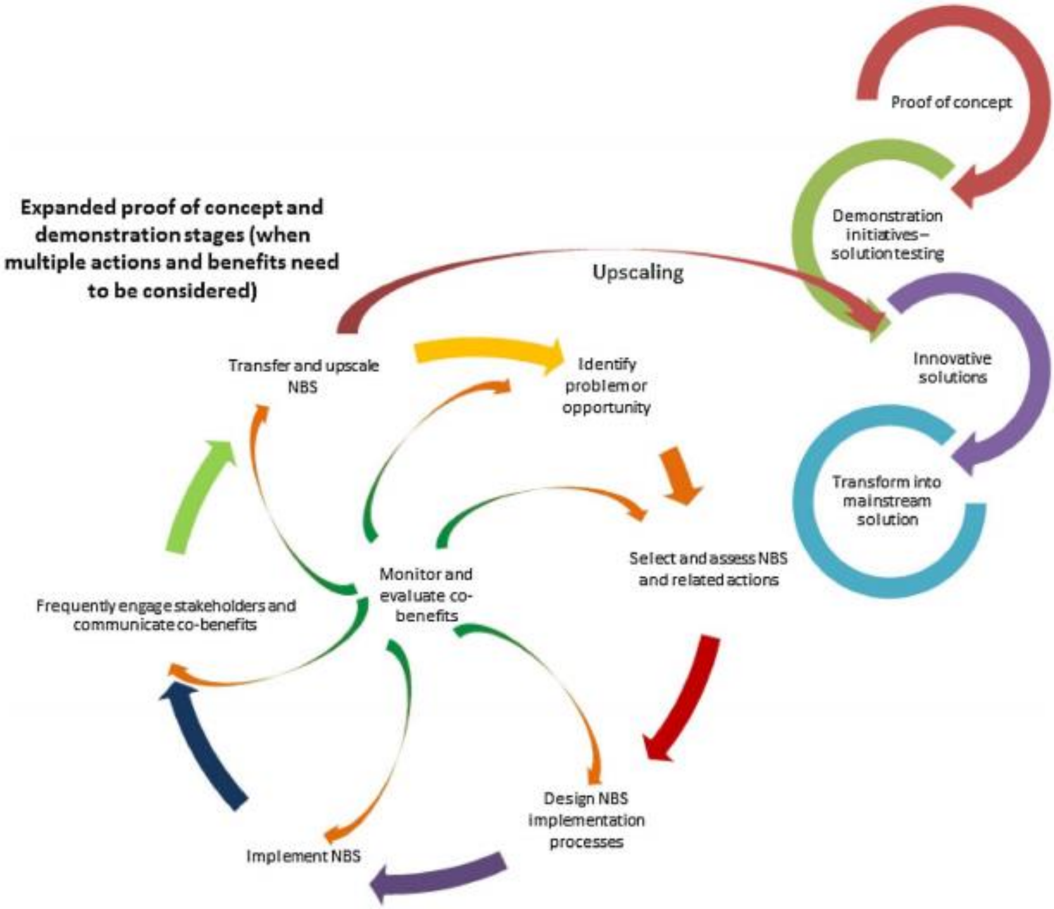


Figure 2.5 Expanded proof of concept and demonstration stages of NBS implementation (Raymond et al., 2017).

2.3.2 Building with Nature Guideline

The Building with Nature Guideline developed by Deltares (n.d.) comprises two processes to be integrated for the generation of NBS design and project realisation. These have been developed through analysis of practical NBS cases (Deltares, n.d.). The first consists of five steps for generating NBS designs:

Step One: Acquire an understanding of the system (physical, socio-economical and governance) in which a project is planned

Step Two: Identify realistic alternatives that provide real win-win solutions providing services beyond mitigation and compensation that make use of the system's potential.

Step Three: Assess the inherent qualities of the alternatives and combine them into one optimal integral solution. Valuate the NBS alternatives and compare them with traditional designs.

Step Four: Elaborate on selected alternatives considering practical restrictions and governance context

Step Five: Handle the practical bottlenecks of the solution for implementation in the next phase on the road to realisation.

The approach above can be applied throughout any stage of project realisation (detailed below) (Deltares, n.d.). They are, however, recommended to be integrated as early as possible to provide the most impact and optimal flexibility (Deltares, n.d.). Four key steps to project realisation as per Deltares guidelines are outlined as follows:

1. Initiation:

The first stage involves defining the problem or opportunity at hand and scoping potential solutions. This stage looks at taking a broader perspective and aiming for multiple objectives or co-benefits in the solution.

2. Planning and design:

Stage 2 surrounds developing alternative strategies within a given scope and selecting preferred alternatives. This stage focuses on longer-term, incremental development and adaptive management, with financing strategies a critical component. It focuses on utilising natural processes as an integral part of developing strategies.

3. Construction:

This stage discusses the approach to project execution. It involves careful selection of materials and optimisation of the design layout. The involvement of stakeholders in this process helps provide project support and cooperation. Within this stage, experimentation and adaptive project management are encouraged.

4. Operation and maintenance:

This stage comprises the realisation phase and ongoing maintenance. Considering maintenance aspects early in the implementation can optimise the design and significantly reduce lifecycle costs. It also allows for incremental adaptation to changes in system dynamics, environmental conditions, or operation practices, generating additional environmental and cost benefits.

2.3.3 Application

These frameworks allow the researcher to develop a link between the dynamics of knowledge and action and the action of extracting and structuring knowledge. As a first step, outlining the dynamics of knowledge-action systems in NBS produced a solid foundation to examine the capabilities frameworks to gather relevant lessons learnt.

The frameworks of NBS realisation from Deltares (n.d.) and Raymond et al. (2017) exemplify all necessary attributes and consider the critical variables within their structure. The framework in Figure 2.5 was helpful as it recognises stakeholders' influence in successful NBS projects. Raymond et al. (2017) reflects that attention must be given to the “design, implementation and evaluation of NBS demonstration projects in partnership with multiple stakeholders and citizens…” (Raymond et al., 2017). Similarly, the framework by Deltares (n.d.) recognises the influence of stakeholders and highlights the importance of considering alternatives in NBS design. These frameworks also support understanding the dynamic and non-linear approaches to linking knowledge and action through their iterative structure.

Each framework replicates similar characteristics. Processes for successful NBS projects are outlined with essential factors to consider in each stage. For example, stage one of both frameworks explores opportunities and potential solutions by assessing and comparing their benefits and co-benefits and how these effects may change over time. Similarly, the construction stage (stage 3) in Deltares (n.d.) framework replicates the implementation stage (stage 4) of Raymond et al. (2017) framework.

Similarities between the two frameworks lend reliability to their use for this thesis. Examining multiple methods for NBS realisation provides a solid foundation to inform a structure to collect lessons learnt.

Despite this, the shortcomings of these frameworks are reflected in their intended use for NBS planning and realisation. Using these frameworks to collect and structure lessons learnt is yet to be tested beyond this thesis. As such, the ability to gather knowledge that can support NBS realisation is uncertain. In addition, benefits gained by utilising frameworks to address uncertainty in NBS realisation rely on the assumption that the framework is widely adopted and applied to increasing numbers of NBS projects.

2.4 Relating Knowledge and Action

Drawing fundamental assumptions of how knowledge and action interact within the NBS arena are essential concepts to establish for NBS realisation. The objective was to recognise how to support NBS realisation across multiple contexts. To do so, researchers must understand how knowledge and action can be related.

Within the complexity-oriented perspective, a core idea surrounds multidisciplinary stakeholders or ‘knowledge coalitions’ participating in an iterative process between knowledge creation and application. Another critical idea was that NBS knowledge is the product of context, and therefore knowledge use depends on its alignment with existing physical, societal, and political structures (van Kerhoff & Lebel, 2006).

Where ideal paths for integrating knowledge and action are conditional due to the rapidly changing world, more effort must be devoted to engagement, interactive problem framing, knowledge integration and real-world experimentation (Cornell et al., 2013). These methods aim to foster 'learning-by-doing', recognising the importance of multiple influences on knowledge and action, rather than just traditional expert knowledge and political users (Tengö et al., 2014; Lee, 1993).

It was necessary, however, to pay attention to which methods are pursued in relating knowledge and action. Within the theme of multidisciplinary participation, practices such as transdisciplinary and co-production research are often pursued. These methods receive criticism that their approach to engaging knowledge and action remains captive to linear assumptions, with knowledge coming first and providing foundations for effective action (West, van Kerkhoff, & Wagenaar, 2019). In contrast, approaches such as 'learning-by-doing' are understood as processes that allow people to make sense of their experiences. These are experiences in which stakeholders actively engage in making things and exploring the world, thus contradicting this particular criticism (Bruce & Block, 2012).

2.4.1 Overcoming Boundaries between Knowledge and Action

Opinions on how to traverse boundaries between knowledge and action vary widely in sustainability. This factor is due to variability in assumptions associated with knowledge systems, where issues fundamentally lie, and how actors within these systems interact.

Van Kerhoff and Lebel (2006) consider obstacles within knowledge-action systems and build on dynamic responses to such obstacles. They outline four main categories to counter the significant obstacles between knowledge and action: participation, integration, learning and negotiation. Complex systems such as NBS assimilate dynamic and iterative relationships between knowledge and action, the involvement of multiple stakeholders and knowledge coalitions, and the variability within different spatial contexts. This framework is similar to the work of Cash et al. (2003), which explores three functions that contribute most to 'boundary management' or managing obstacles in knowledge and action. These include communication, translation, and mediation. However, Cash et al. (2003) tend to adopt the linear assumption of knowledge-action systems (as explored in Section 2.1.1).

2.4.1.1 Participation

For van Kerkhoff and Lebel (2006), participation refers to how actors not traditionally involved in research or knowledge development become involved. Otherwise known as a participatory approach, benefits include gaining access to alternative, less available knowledge sources, mobilising resources, sharing responsibility for actions, and developing purposeful initiatives (van Kerkhoff & Lebel, 2006). Participation also helps to gather support for decisions by addressing common problems. For example, participation in NBS projects can improve integration between project goals and the local community's desires (Short, Clarke, Carnelli, Uttley & Smith, 2019).

The participatory approach can involve collaborative research and validation of findings between stakeholders with different forms of knowledge. This leads to delivering practical knowledge to intended users (Meadow et al., 2015). Participatory approaches are also beneficial for including traditional knowledge sources within technical alternatives to address problems such as climate change.

There are concerns around participatory approaches, however, with academics claiming that participation opportunities often occur too late to meaningfully affect the scope or nature of decisions (Reed, 2008). Similarly, it was found that if participation did occur, it did not continue through to the implementation phase of the decision-making cycle (van Kerkhoff & Lebel, 2006). This reflects criticisms by West, van Kerkhoff, and Wagenaar (2019), who highlight that methods of relating knowledge and action must consider stakeholder integration in knowledge development and its application.

2.4.1.2 Integration

As calls for integration are often from those that are not active knowledge developers, this approach focuses on the structural, institutional and governance issues in linking different knowledge coalitions to connect knowledge and action (van Kerkhoff & Lebel, 2006). Integration in this context responds to the fragmented relationships between knowledge developers and their user communities, calling for greater integration of stakeholders within and between these groups. According to van Kerkhoff and Lebel (2006), integration can be achieved in three arenas: geographic scales, jurisdictions, and researcher-user chains.

In sustainable development, opportunities to address obstacles between knowledge and action stretch over ranges of geographic scales, including global, national policies, and local decision-making (van Kerkhoff & Szlezak, 2016). Encouraging integration at these levels involves linking global-scale science with local-scale actions and vice versa. Knowledge must also be intertwined with different scales of politics and their power struggles. This arena relates directly to the complexity of cross-contextual dynamics, which are necessary for wide-scale NBS realisation.

Integration across jurisdictions is also particularly relevant for NBS as actions within the natural system of one jurisdiction (nation, province, or town) can significantly affect adjacent systems and jurisdictions. As NBS are often designed to mitigate climate change effects, traditional approaches of tying operations to a single jurisdiction without considering impacts on other jurisdictions and vice versa are unacceptable (van Kerkhoff & Lebel, 2006). Across jurisdictions, integration must involve linking disciplines involved in NBS implementation (engineers, social science, and project managers). Further, creating governance structures where critical stakeholders participate in priority setting and decision-making (landholders, researchers, and governmental representatives) is also critical. These approaches can help address obstacles between knowledge and action (van Kerkhoff and Lebel, 2006).

Van Kerkhoff and Lebel (2006) also note the importance of integration between production-to-use chains. Integration at this level connects academic knowledge with users by blurring the lines between producer and user. Within integration, the critical element is the interaction of multidisciplinary stakeholders across various levels. In this context, cooperative research programs and integrated projects can be successful. These approaches often involve co-funding and arrangements where users jointly set agendas and participate in developing findings that connect the various stakeholders involved in the project (van Kerkhoff and Lebel, 2006).

2.4.1.3 Learning

Efforts to better relate knowledge-action systems for sustainable development have also surrounded learning-based models. Van Kerkhoff and Lebel (2006) highlight a social learning model that engages researchers and practitioners to build ecologically sound practices (Leys & Vanclay, 2011). This approach follows the idea that innovation and knowledge emerge and can be enhanced through the interaction of social actors as they begin to understand their contribution to a knowledge system. As this develops, participants become more purposive, directed and deliberate in their actions and interactions to support learning and innovation (van Kerkhoff and Lebel, 2006). This model translates well to NBS projects, mainly when local communities are significant stakeholders. For NBS, approaches based on learning recognise the fundamental role of local stakeholders directly impacted by projects in both the application and development of knowledge, mainly where ownership resides with local communities.

Adaptive Environmental Assessment and Monitoring is another model proposed under the concept of learning, also known as adaptive management. This approach emphasises flexibility and resilience in the face of uncertainty (van Kerkhoff and Lebel, 2006). This uncertainty is present in the management of natural systems where there is underlying uncertainty in what causal factors account for the problem and what will happen if a particular strategy is used (Stankey, 2005). Adaptive management adopts the idea that new concepts should involve regular assessment and monitoring, which combine social learning concepts as a basis for ongoing learning. Adaptive management is central to NBS as it integrates natural systems and social dimensions within an interdisciplinary space where stakeholders work together in productive and ongoing relationships (van Kerkhoff and Lebel, 2006).

2.4.1.4 Negotiation

The final approach to relating knowledge and action is through negotiation, which focuses on power-sharing. This assumes that knowledge creators are somewhat political and must create room for different political interests. Van Kerkhoff and Lebel (2006) discuss three models to relate knowledge and action through negotiation: advocacy, boundary work and mode two research.

In advocacy models, action is informed through knowledge creators' participation in advocacy coalitions. These coalitions comprise multidisciplinary and multi-level actors who share beliefs and therefore seek to influence action accordingly (van Kerkhoff & Lebel, 2006). Distinguishing groups by ideas rather than institutional affiliation supports the idea of stakeholders dynamically involved in knowledge and action rather than in two separate communities.

Van Kerkhoff and Lebel (2006) also highlight boundary work as a method to influence the success of knowledge and its evolution to implementation. With multiple knowledge coalitions present, boundaries can make it easy for policymakers to select the knowledge that is most politically or practically feasible (Boswell, 2009). Boundaries can also create issues due to miscommunication and lack of coordination and integration between knowledge coalitions (discussed in Section 2.1). Boundary work to address this involves actions such as joint fact-finding, collaborative dialogues and "interactive social science" (van Kerkhoff & Lebel, 2006). Within the theme of joint knowledge production, these approaches allow stakeholders with different viewpoints and interests to collaborate to develop data, analyse facts, and cultivate common and informed assumptions to reach decisions together (Klijn & Edelenbos, 2007). The connections formed are intended to give particular knowledge impact within different coalitions. Similar to advocacy, boundary work reframes sustainable development as a negotiation among groups involved at distinct boundaries.

Finally, Mode 2 research is a research structure that challenges conventional approaches to knowledge production and dissemination. Mode 2 seeks to actively involve society – researchers and those affected by research outcomes – in the research process. Negotiating between knowledge-action systems is the norm, as traditionally, external stakeholders (government, citizens and industries) expect more significant influence on research and its outcomes (Cornell et al., 2013). Advocates of this negotiation model discuss that the ability to cross boundaries, learn, and negotiate increases as education levels increase, civil society strengthens, and researchers are forced to engage in new relationships outside academia (van Kerkhoff & Lebel, 2006).

2.5 Conceptual Framework

Within the four responses to the challenges of relating knowledge and action, each approach seeks to integrate multidisciplinary stakeholders from different coalitions, levels, and perspectives, into dynamic relationships. By engaging these stakeholders, each approach discusses strategies to reach common visions or goals to support knowledge-action relationships and thus NBS implementation. This concept is visually represented in the conceptual model in Figure 2.6.

This model operationalises the core problem of wide-scale NBS realisation and methods to overcome obstacles, as discussed in Chapter 2. It provides a foundation of how new NBS knowledge may be developed and existing knowledge integrated iteratively, allowing its utilisation in NBS projects. It also provides room for the broad spatial scales that NBS seek to operate across, reflecting on the four responses made by van Kerkhoff and Lebel (2006) to relate knowledge and action.

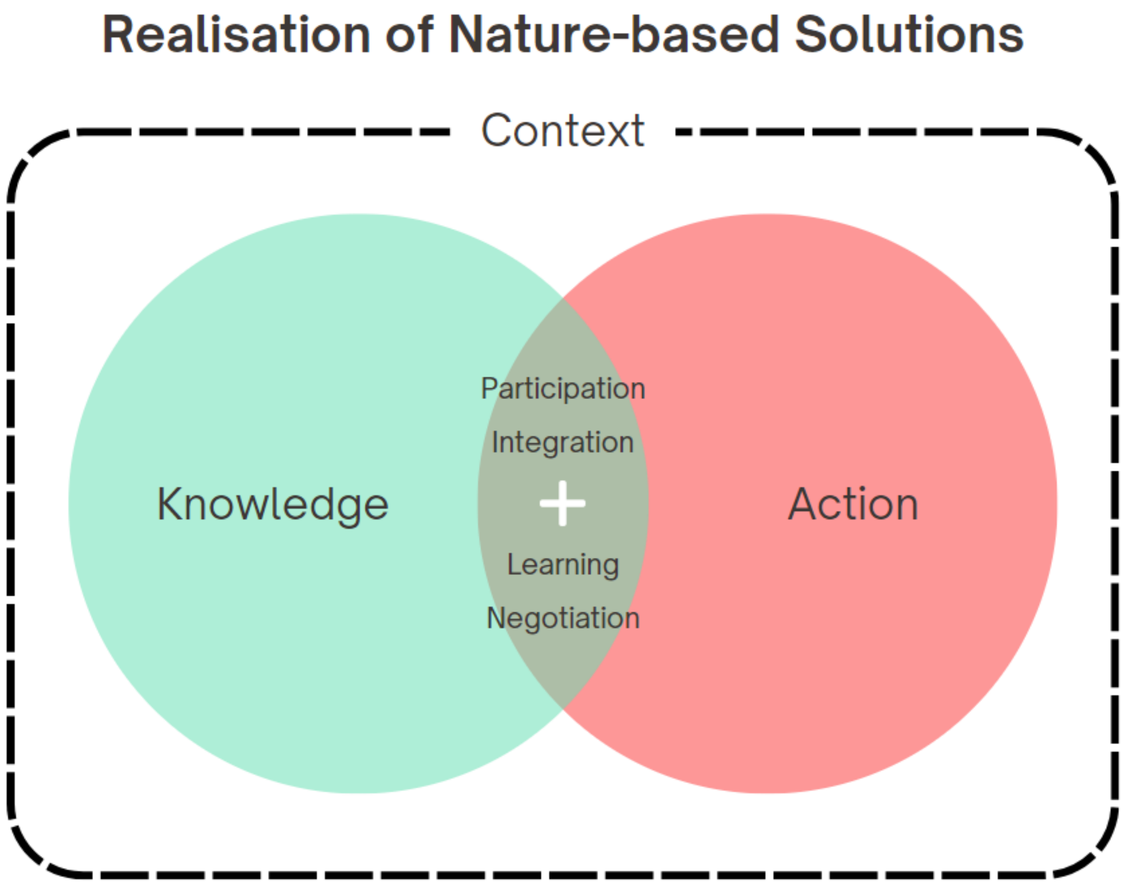


Figure 2.6 Conceptual model for relating knowledge and action in NBS.

Chapter 3. Project Context

The following chapter provides a brief overview of the four project cases in which each interviewee took part.

3.1 Project Cases

The four NBS projects used in this thesis are part of a broader scope of related projects. Figure 3.1 outlines the BwN program conducted by EcoShape, depicting projects currently underway or completed. The green boxes indicate projects directly supervised by EcoShape, often surrounding pre-market knowledge development projects. The white boxes relate to competitive projects carried out by EcoShape partners outside the boundaries of EcoShape. Those outlined in red are the projects selected for this thesis.

For this thesis, no precise differentiation was made between the projects that differ in project type, structure or stage of realisation seen in Figure 3.1. The purposes of data collection centre on the broader scope of NBS realisation rather than the influence of project structures or stages.

Subsequent sections provide a brief overview of each project, where further detail can be viewed in Appendix 3.7.

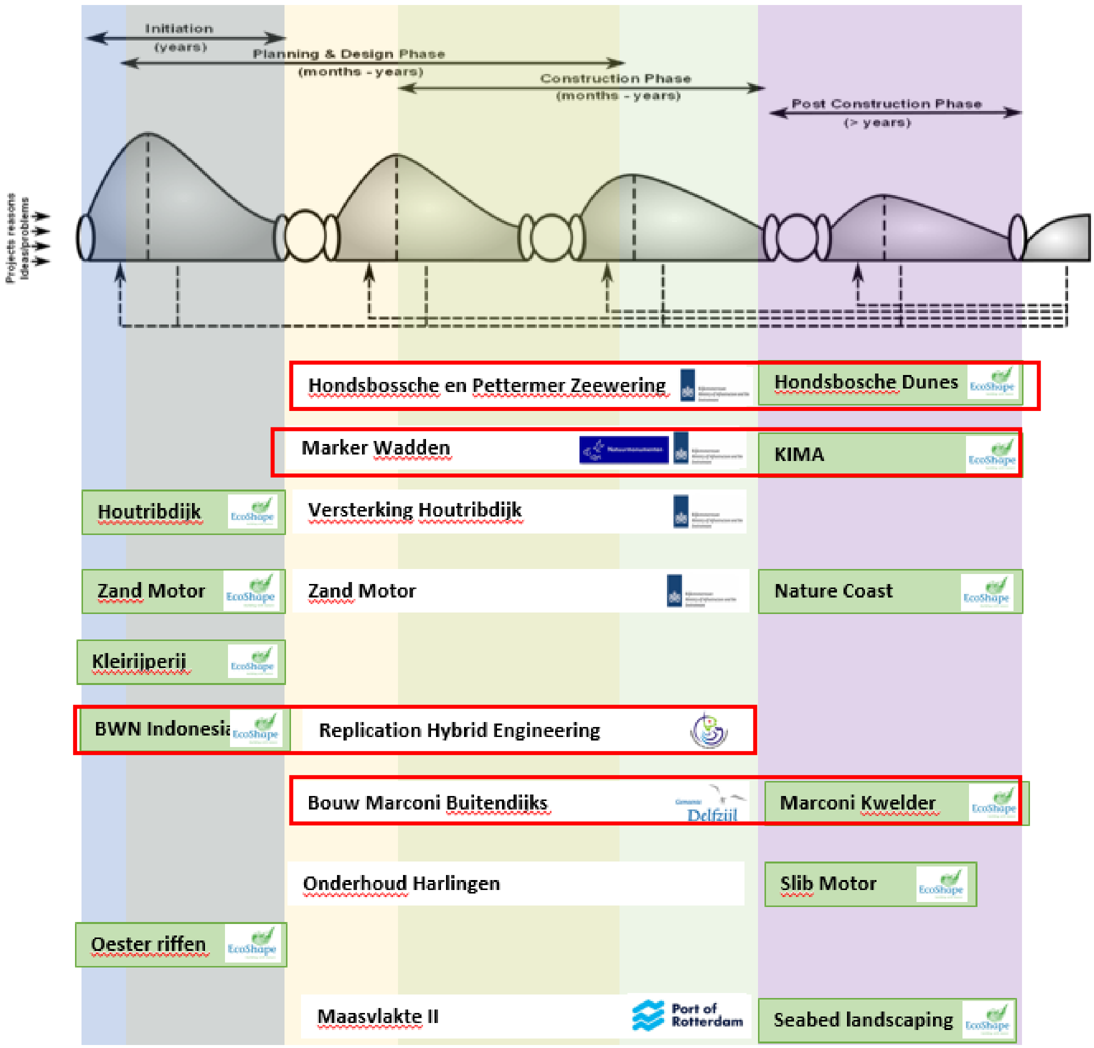


Figure 3.1 Project structures.

3.1.1 Case One: Hondsbossche Dunes (HPZ)

Figure 3.2 Hondsbossche Dunes (EcoShape, 2018).

The Hondsbossche comprises a natural barrier of 35 million cubic meters of sand along 8km of coastline to serve as an alternative to a traditional sea dike. This solution aimed to address increasing flood risks along this stretch of coast and the existing sea dike no longer meeting safety standards. Opportunities for spatial quality were also found in this case due to the nature of the solution.

The project began construction in 2014 and comprised several organisations, with initiators being the national water authorities (Waterboard Hollands Noorderkwatier and Rijkswaterstaat). Consultants Boskalis and Van Oord were primarily responsible for the design, construction and maintenance processes. The contract incorporated necessary finances with the requirements to fulfil a maintenance period of 20 years (to end in 2036) (EcoShape, n.d.b).

After construction, a monitoring and innovation research project was initiated, renaming the area Hondsbossche Dunes (from Hondsbossche and Pettemer sea dike [HPZ]). EcoShape partners HKV, Witteveen+Bos, WUR, Arcadis and Deltares, were responsible for executing the Hondsbossche Dune research project. Research themes involved improving the predictability of engineering habitat development, design optimisation, and community and visitor perception of coastline defences (IJff & van Zelst, 2018). The resulting research opportunities sought to develop knowledge about the added value of NBS approaches compared to 'grey' solutions.

3.1.2 Case Two: Marker Wadden

Figure 3.3 Marker Wadden (Natuurmonumenten, 2018).

The Marker Wadden project was initiated due to a series of events that resulted in the deteriorating ecological condition of the Markermeer, one of the largest freshwater lakes in Western Europe (EcoShape, n.d.a). The bottom of the lake now contains a thick blanket of mud which impacts the lives of plants, fish and shellfish.

The nature conservation organisation Natuurmonumenten and the Dutch government collaborated to improve the natural environment in Lake Marker (EcoShape, n.d.a). The project comprises an enclosure of sandy ridges within which silt, supplemented with sand and clay (all from the Markermeer), are used in the Marker Wadden to establish a productive marsh landscape (EcoShape, n.d.a). The construction of a 600-hectare island in 2016 by Boskalis was partially opened to the public in 2018 (International Association of Dredging Companies, n.d.). These islands are expected to create an attractive location for enhancing biodiversity, providing leisure opportunities, and enhancing water quality.

KIMA was launched after the construction of Marker Wadden Began (EcoShape, n.d.a). The KIMA project connects fundamental research to applied research, coordinating collaboration between sectors and disciplines and stimulating innovation (Rijkswaterstaat, Deltares, EcoShape & Natuurmonumenten, n.d.). The knowledge acquired regarding building with mud in freshwater systems is intended to aid in similar projects in saltwater environments in the Netherlands and other parts of the world (van Eekelen et al., 2017).

3.1.3 Case Three: Marconi Delfzijl

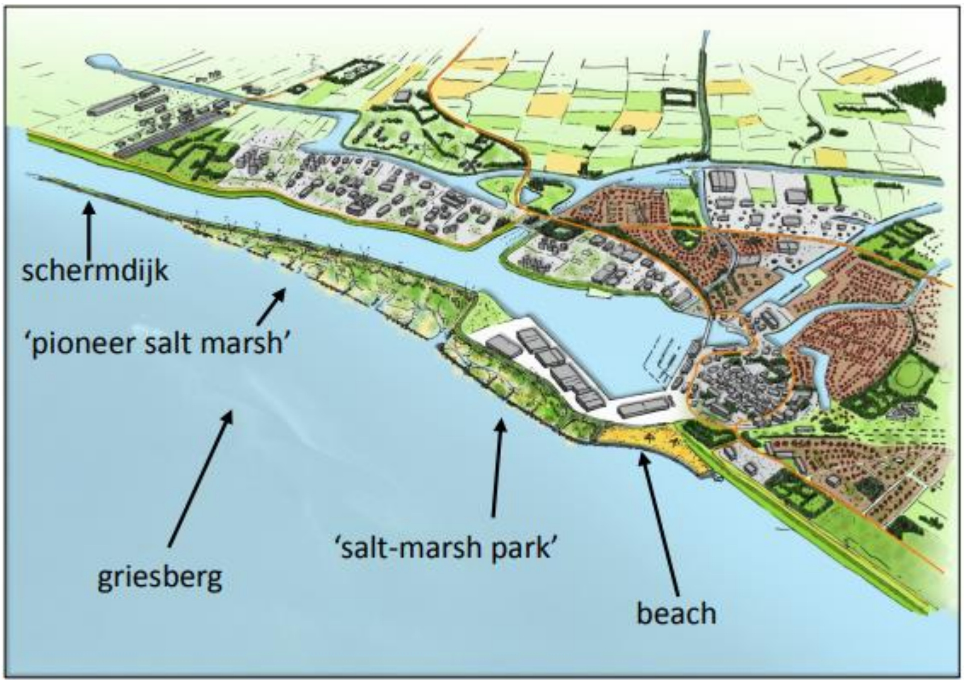


Figure 3.4 Marconi Delfzijl (Ecoshape, n.d.).

The Marconi Delfzijl project comprises two salt marshes created for recreation, coastal protection, and nature (Groot & Duin, 2013), which make use of available dredged material from the port of Delfzijl and the Eems-Dollard Estuary (EcoShape, 2019a). This project aims to address several significant issues faced by the municipality (shrinking population, seal level rise combined with subsidence and the poor ecological condition of the Ems-Dollard) (EcoShape, 2019a).

They can dampen waves and trap silt, reducing the load on the dikes behind the marsh (Groot & Duin, 2013). Salt marshes also provide valuable ecosystems in the transitional zones between land and water with high levels of biodiversity.

Experimentation investigated the best way to restore salt marshes by reusing sediment and developing nature that contributes to the water quality, ecology, coastal defences and coastal appearance (Baptist, 2017). The project was intended to generate knowledge about how salt marshes can be created, developed or restored with local material under different circumstances (EcoShape, 2019a). The project involved cooperation between multiple stakeholders, including the municipality, the Province of Groningen, water boards and Rijkswaterstaat (Groot & Duin, 2013). The Wadden Fund provided financial support for knowledge development relating to salt-marsh construction, with the remaining amounts financed by EcoShape partners (EcoShape, 2019a).

3.1.4 Case Four: Building with Nature Indonesia

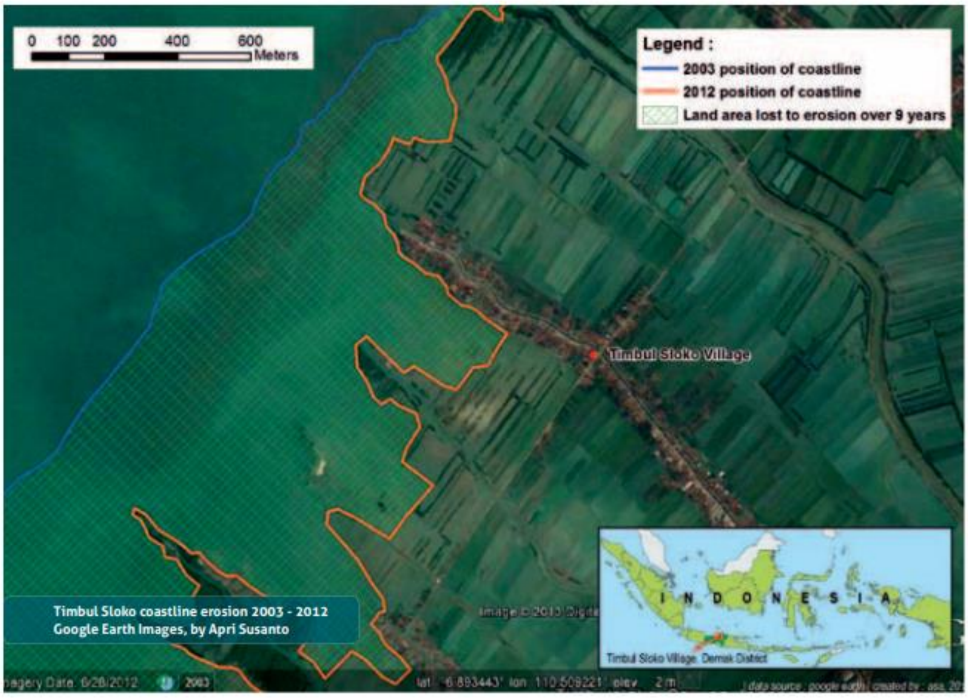


Figure 3.5 BwN Indonesia (EcoShape, n.d.).

On the northern coast of Java, Indonesia, the removal of mangrove belts for intensive aquaculture farming, coastal infrastructure disturbing sediment build-up, and groundwater extraction resulted in land subsidence and increased the severity of erosion. It is estimated that by 2100, 6km inland will be flooded, impacting 70,000 people and 6000 hectares of aquaculture ponds (EcoShape, 2018).

The traditional mitigative solution of concrete barriers was not only unstable and expensive, but they exacerbated coastal erosion. They also failed to deliver the economic, environmental and social services that the natural coastal protection provided (EcoShape, 2018). Based on a pilot using learnings from a similar project in the Netherlands, the Ministry of Marine Affairs and Fishers co-invested in a full-scale replication of the project alongside a Dutch fund, The Sustainable Water Fund. The project comprised a series of permeable structures that encouraged sedimentation, promoting mangrove regrowth. Once the coastline began to stabilise, existing aquaculture ponds were revitalised, and new ones were created.

Project objectives also aimed to foster local ownership of the project. Community groups and bio-rights mechanisms were developed to financially support local participants' active engagement in environmental conservation and restoration (BwN Indonesia & EcoShape, 2016). Involving local stakeholders throughout the implementation process and introducing sustainable, multi-functional land uses was critical to enable inclusive economic growth once the coastline is stable (EcoShape, 2017). This involvement was achieved using education and training programs on sustainable aquaculture and alternative livelihoods.

A subsequent phase also began involving the mainstreaming of BwN, institutionalising these concepts within Indonesia. This involves researching the performance of measures, addressing underlying problems and using results to upscale projects at a national level.

Chapter 4. Methodology

The following chapter explored the methodology utilised in this thesis, centred around the theoretical paradigm adopted. It details the research design and operationalisation and the research strategy used throughout. It also explores how the researcher has sought validity and reliability in the methodology of the thesis.

4.1 Research Paradigm

According to Guba & Lincoln (1994), the research paradigm encompasses the “basic belief system…that guides the investigator not only in choices of method but in ontologically and epistemologically fundamental ways” (Guba & Lincoln, 1994). Despite the approach taken in research, there is no way to establish the ultimate truthfulness of its theoretical perspectives. As such, the paradigm used should be considered when judging this research's usefulness.

4.1.1 Ontology and Epistemology

The question of ontology explores what form reality takes and what can be known about it (Guba & Lincoln, 1994). The research paradigm of relativism is taken in this thesis, which for ontology, is the assumption that absolute truths do not exist but rather are dependent on culture, experience and other external factors, or as Oliver Kim puts it, a 'frame of reference' (Kim, 2008). Guba and Lincoln relate relativism with constructivism. In this, its ontology sees realities understood as “multiple, intangible mental constructions, socially and experientially based, local and specific in nature, and dependent for their form and context on the individual persons or groups holding the constructions” (Guba & Lincoln, 1994).

The epistemological question regards “what is the nature of the relationship between the knower and what can be known?” (Guba & Lincoln, 1994). As such, knowledge is subjective, determined by one's relationship with the context around them. In other words, “cognitive, moral or aesthetic norms and values depend on the social or conceptual systems that underpin them” (Baghramian, 2004).

4.1.2 Methodological Implications

The relativist approach supports the idea that knowledge perception depends on the context or situation. It is challenging to extract and translate knowledge without considering the context from which it originates and is applied.

According to Guba and Lincoln, the nature of relativism in research requires interaction between the investigator and the subjects of inquiry (Guba & Lincoln, 1994). Considering interview participants are intertwined with their context, the use of interviews supported the researcher in gathering appropriate knowledge. It was also necessary to reflect on external factors influencing such knowledge.

4.1.3 Justification

For the research questions within this thesis, the stakeholder's perspective is critical in understanding lessons learnt that drive NBS implementation. As knowledge and a stakeholder's perception of knowledge are fundamentally intertwined with context, methods to support the use of knowledge correlate with contextual factors; the social, political and physical environment. This is particularly relevant when exploring the use of knowledge in different contexts.

Alternative paradigms such as positivism and post-positivism are not appropriate for this thesis due to the complexity of the phenomena studied. The relativist approach enabled the researcher to consider the highly contextual nature of NBS to explore approaches to overcome boundaries between knowledge and action using lessons learnt. This helped to highlight the relevance of context to the development, delivery and utilisation of NBS knowledge. It moves beyond simple observations of practices in NBS to the dynamics of theoretical processes supporting knowledge transfer and application.

4.2 Research Strategy

The research strategy is a guideline for how the research was undertaken (Creswell, 2014). The following considerations were made to determine the research strategy regarding the research questions in this thesis. The fundamental phenomena being researched were approaches that could be adopted in the NBS arena to support the application of NBS knowledge. In this thesis, due to the context-dependent nature of NBS and the presence of multiple stakeholders, the ability to use knowledge is contingent on relationships between knowledge streams and context characteristics.

This thesis utilised a qualitative research approach, including case studies, interviews with key stakeholders and desk research within the four selected NBS projects. A qualitative approach aligns with the typical method considered for a relativist perspective, as assumed in this research. This relies on direct communication with the members of the study subject, in this case, NBS projects (Bhat, 2019).

4.2.1 Case Study Research

Case study research is one method among many to conduct research, including experiments, surveys and histories (Yin, 2003). Case studies are used to address ‘how’ or ‘why’ questions which are effective in identifying the meaning and understanding of experiences within a context (Stake, 1995; Stake, 2006). In this strategy, the researcher's interpretive role is essential, viewing reality as multiple and subjective, based on meanings and understanding (Stake, 2006). This aligns with relativism which assumes the existence of multiple realities (Bryant & Charmaz, 2019). This perspective within case study research facilitated the development of subjective research findings based on the perceptions of stakeholders.

This thesis adopted a combined case study perspective of four NBS projects, utilising a cumulative approach. The cumulative approach supports aggregating information from NBS projects in several sites, collected at different times. Collecting several studies allows for greater generalisation without requiring further or repetitive studies (Colorado State University, n.d.). For research question one, the cumulative approach was beneficial in drawing comprehensive lessons learnt from a variety of contexts.

4.2.2 Case Selection

In this research, four cases were drawn from the BwN projects: Marker Wadden, HPZ, Marconi Delfzijl and Building with Nature Indonesia. These were chosen as they were considered representative examples of the study subject (van Thiel, 2014).

Discussions between EcoShape and the researcher led to the selection and number of projects investigated. These comprised a delta zone, an ecological park, a coastal zone and a port zone structured as long-term maintenance projects, pilots and traditional projects. The selection of these cases was determined based on the availability of lessons learnt and their representativeness as solutions. Variances reflected the representativeness of projects through solution type, the project location, the timeline, and the project scale.

By increasing the representativeness of cases where possible, results were expected to be broadly applicable, providing legitimacy and reliability to the data collected and resultant findings. As Van Thiel (2014) discusses, finding the same results in several cases suggests that these findings are likely to also be valid for cases that have not been studied.

4.2.2.1 HPZ.

Based on the criteria presented in Section 4.2.2, the HPZ project was considered valuable to investigate. This case represents a coastal zone area, utilising dunes to replace a dike. The HPZ project also provided added benefit through the ability to explore the connected monitoring program; Hondsbossche Dunes. This monitoring program assisted in examining successful processes for the design, management and maintenance of similar solutions.

As the HPZ project represents a successfully operating solution coupled with a monitoring program, it provides a valuable opportunity to gain post-project insights and learnings for future solutions. With experience in various project processes, learnings from this case were considered well-informed, widely applicable and highly valuable.

4.2.2.2 Marker Wadden.

The method and objective of restoration on the Marker Wadden project make it unique in the NBS arena. The project was the first instance of excess sediment being used on a large scale to construct natural islands and restore the ecosystem (van Eekelen et al., 2017). Alongside the fact that it was developed by a non-governmental organisation (NGO), this case was valuable to review.

Regarding the criteria outlined in Section 4.2.2, the Marker Wadden project forms part of an ecological park, a vastly different environmental context from other projects. The learnings of this project could assist a significant number of ventures in ecological improvement, recreation, and innovation due to its unique nature (EcoShape, n.d.a). A monitoring program also followed the Marker Wadden project – Knowledge and Innovation Program Marker Wadden (KIMA) – which was established to collect various findings from the project. This opportunity to investigate learnings from both execution and monitoring processes and the interaction between them was a valuable opportunity to utilise.

4.2.2.3 Marconi Delfzijl.

This case was selected by EcoShape, based on the significance of expected lessons learnt from the project. In this project, a product (dredging material), typically considered waste, is used to enhance surrounding communities and protect against flood risks. Showcasing possibilities for widely available waste products to be re-used in beneficial applications reflected the replicability of specific project characteristics. This makes it a worthwhile project to investigate.

Regarding the criteria outlined in Section 4.2.2, Marconi Delfzijl provided an opportunity to investigate a different natural environment and solution type. The Marconi project resides in a port zone and employs a novel solution type compared to the HPZ or Marker Wadden projects. Additionally, as the project is nearing completion, a valuable bank of knowledge can be extracted.

4.2.2.4 BwN Indonesia.

The BwN Indonesia project was an ideal case to review as it represented a unique context in its structure and location compared to the other three projects (IJff & van Raalte, n.d.). Based in Demak, Indonesia, this project is used to inform and inspire coastal managers from the government and private sectors to include and adjust approaches in urban and rural development programs (EcoShape, 2017). The aim is to shift the mindset for addressing societal issues from traditional approaches toward more sustainable alternatives. To do so, the project experiments with different uses, materials and techniques depending on the circumstances of different sites. Lessons are shared in pieces of training and through constant interaction and activities with Indonesian partners and stakeholders (BwN Indonesia & EcoShape, 2016).

The focus on learning, stakeholder involvement, and social and environmental development makes the project valuable for investigation. Based on the criteria outlined in Section 4.2.2, the BwN Indonesia project is a useful example to extract learnings, particularly for cross-context interactions.

4.3 Research Methods

Considering a qualitative approach with a relativist perspective, "instrumentation usually administered…is through interview, observation, document review and visual data analysis" (Dogru & Kalender, 2007). For this thesis, interviews were the primary method of data collection. Alongside desktop research, interviews also provide evidence to verify methods of overcoming obstacles and facilitating using NBS knowledge. In doing so, the reliability and validity of the results are enhanced. This mixed-method approach allows for multiple strategies in research design, analysis, and interpretation (Kitchenham, 2010).

In this thesis, interviews were used to gather learnings from NBS projects. Based on this method, the researcher was able to determine key lessons learned that drive NBS implementation (research question one).

The findings from research question one were valuable in supporting literature that informed on mechanisms of developing and applying knowledge. Doing so highlighted approaches to support NBS knowledge and suggest new areas of knowledge. Figure 4.1 provides a visualisation of the methods used to inform findings for the research questions. It depicts the data type, source, and data collection method used.

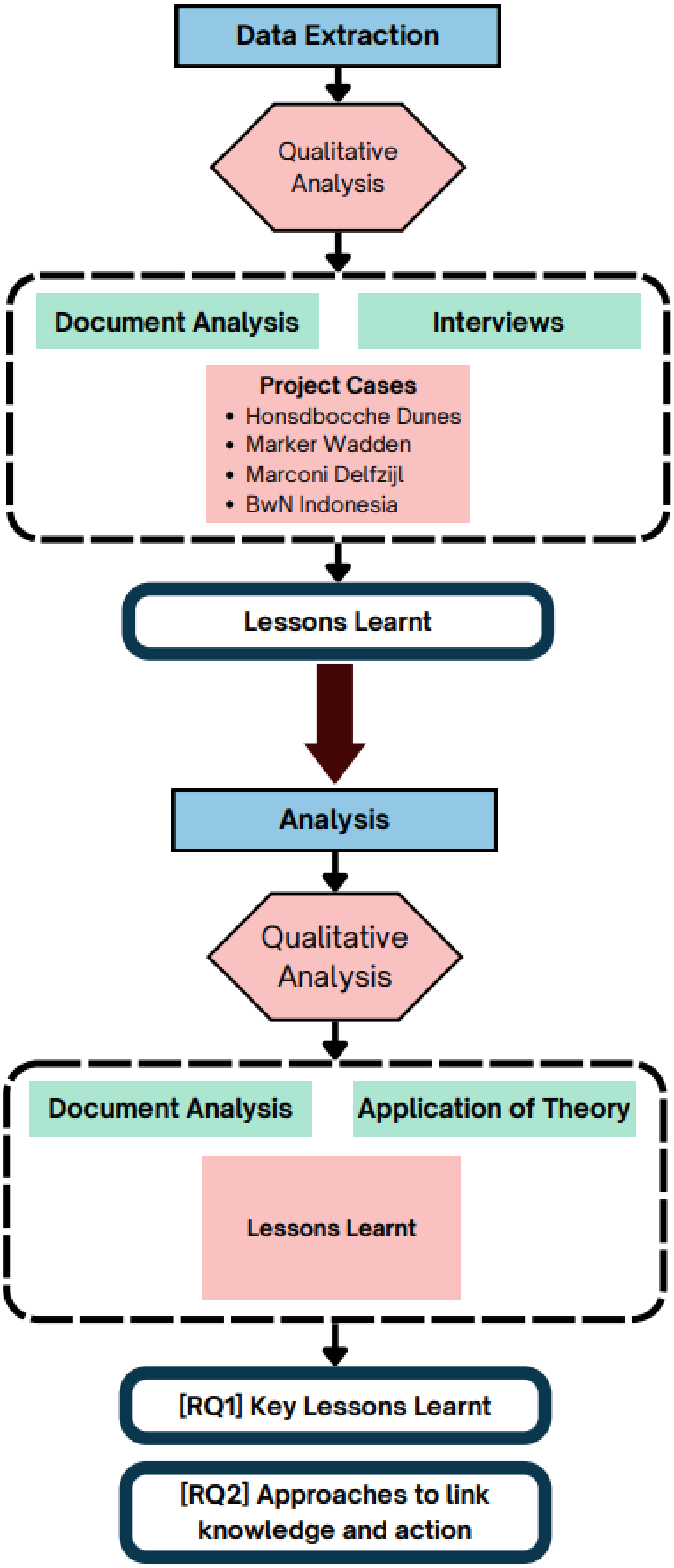


Figure 4.1 Research methodology.

4.3.1 Interviews

Interviews are a research method in which the participants' answers are used as the data (Creswell, 2014). Interviews were used as they can provide complete and detailed results to address complex objectives, such as lessons learnt in NBS projects.

In this thesis, interviews were the primary data source and assumed that participants had in-depth knowledge and understanding of the project dynamics. It was also assumed that participants possessed appropriate recall of the projects to provide the necessary data.

This research method aims to gather insights into the interview participants' perspectives and explore their thoughts and experiences. Semi-structured interviews were adopted, lending flexibility to the researcher when conducting interviews (Adom, Yeboah & Ankrah, 2016). Flexibility is provided through the adoption of open-ended questions, offering opportunities for the researcher to ask follow-up questions on key topics that remain unaddressed in the interviewee's initial response (Creswell, 2014). This approach also allows the researcher to understand the answers received (van Thiel, 2014).

4.3.1.1 Operationalisation.

The data from interviews was operationalised through an interview guide (Appendix 3.1). The interview guide was developed to aid the researcher in obtaining data to answer the research questions, namely, lessons learnt to support NBS realisation. These findings could also be utilised to verify how stakeholders can better support NBS implementation in different contexts.

The interview guide used an integrated framework from Deltares (n.d.) and Raymond et al. (2017) for the realisation and implementation of NBS (see Appendix 3.1). Raymond et al. (2017) framework formed the primary source with factors of Deltares (n.d.) framework used to enhance each implementation stage. Integration of the two frameworks was done by pairing similarities in each stage and incorporating elements that were only mentioned in one. This process created a single, combined structure that utilised each aspect of both frameworks with seven stages of NBS implementation.

The researcher adapted the structure to suggest actions yet to occur to utilise these frameworks for learning rather than planning and implementation. Each implementation stage was modified to represent key themes for interview questions. Key actions within the implementation stages were reframed as indicators to develop questions within each theme (see Table 4.1 for indicators).

Basing the interview guide on this structure allowed the researcher to ask a range of targeted and informed questions to gather comprehensive data. This format also provided a foundation to structure learnings, making relevant knowledge at various stages of NBS realisation accessible and legible. Considering the replicability between the frameworks of Deltares (n.d.) and Raymond et al. (2017), this statement assumes a level of comprehension of the structure.

Table 4.1 Indicators for the operationalisation of NBS realisation.

Concept	Indicators
Part one: Knowledge	
1. Identify the problem or opportunity	*Need for the project/Definition of problem* *Potential solutions* *Co-benefits/opportunities for the project* *Methods of addressing the problem (proposed solutions)*
2. Select and assess NBS and related actions	*Project objectives* *Selection solution* *Risks* *Financing strategies*
3. Design the NBS implementation process	*Team composition/Multidisciplinary team* *Process/organisation of engagement*
4. Implement NBS	*Benefits of solution* *Synergies with alternative infrastructure* *Perceptions towards a selected solution* *Adaptive management*
5. Stakeholder engagement and communication of benefits	*Stakeholder engagement* *Communication methods* *Stakeholder selection*
6. Monitor and evaluate co-benefits across all stages	*Monitoring procedures and objectives* *Project evaluation and procedures/success* *Perceptions of objectives* *Project barriers and uncertainties* *Management of constraints* *Communication of results*
7. Transfer and upscale NBS	*Confidence in the outcome of a solution* *Promising elements for upscale* *Useful/beneficial application of NBS* *Partnerships between actors*

	Learning objectives/procedures

4.3.1.2 Selecting Interviewees.

Twelve interviewees were selected due to their role or discipline, relative experience and knowledge regarding NBS realisation, and involvement in one of the four project cases (Section 4.2.2). Three stakeholders from the four project cases were interviewed for data collection. Participants comprised several roles: management and project directors, project leaders, technical experts and project initiators. Although participants were selected based on their involvement in the highlighted projects, many also had experience on other projects that involved NBS.

All participants were sent an email to ensure they knew how data would be collected and utilised and to confirm their willingness to be recorded. This was completed before the recording of all interviews. All participants provided written and verbal consent to being recorded. See Table 4.2 for an overview of the interview participants.

Table 4.2 Overview of interview participants and descriptions.

Project	Role Description
Case One – HPZ	
Respondent A	Involved in the tender and execution phase of HPZ (design-construct-maintenance contract).
Respondent B	Project secretary for the Hondsbossche Dunes during the final planning stage and the realization and delivery stage. Member of the steering committee of the EcoShape research project Hondsbossche dunes.
Respondent C	Project manager of the EcoShape project Hondsbossche Dunes
Case Two – Marker Wadden	
Respondent D	Coordinator of the governance research for KIMA. Involved in the Hondsbossche Dunes project (stakeholder research) and the BwN Indonesia project (training of trainer's program).
Respondent E	Initiator of Marker Wadden and project director representing government organisation. Member of the steering committee of KIMA.
Respondent F	Involved since 2013. The direct contact for partner activities and the contacts with the Ministries.
Case Three – Marconi Delfzijl	
Respondent G	Initiator of the Marconi project. Involved since the earliest project stages and instigated the experiment and designed the experimental set-up.
Respondent H	Project manager since the beginning of the Marconi project (2011)

Respondent I	Project manager of civil constructions on behalf of the initiator. Responsible for the coordination of the preparation and execution concerning technical implementation and financial requirements.
Case Four – BwN Indonesia	
Respondent J	Project manager for partnering NGO
Respondent K	Project Manager for the implementation of the physical BwN measures in the field in mid-2018.
Respondent L	Project manager and coastal expert for construction and management of execution. Involved in various other BwN projects.

4.3.1.3 Conducting the Interviews.

Participants were interviewed using the guideline developed in Appendix 3.1 (see Section 4.3.1.1). Due to social-distancing guidelines (as a result of COVID), all interviews were conducted via Skype or Microsoft Teams. Skype and Microsoft teams permitted visual connection between the researcher and participants, potentially improving engagement. All interviews were conducted in English with audio recordings transcribed using an online program (Happy Scribe) and manual verification directly after the interview. These transcripts were sent to participants to confirm their accuracy.

4.3.2 Desk Research

"Desk research is an efficient and cost-effective strategy" as an alternative method of data collection (van Thiel, 2014). This was used to gather background information on the four projects used for the case studies. Document analysis was the method of desk research utilised, consisting of online documents, websites, books and reports. In selecting these sources, consideration was given to the context they were collected from, the quality of the data and who produced it (van Thiel, 2014). This was done to ensure the accuracy and appropriateness of the data used.

Using desk research to collect data can present some difficulties. This was a concern due to the apparent differences in the countries explored, particularly regarding access to technology, availability of public information and access to information. Due to these challenges, the unreliability of project documentation meant desk research was not utilised to examine project-specific lessons learnt.

4.3.2.1 Operationalisation

Key factors examined within each project included their locations, origin of project need, objective, type of solution, and progress. As such, document analysis looked for these key themes.

4.4 Data Analysis

This section provides an overview of how data gathered from interviews has been operationalised, interpreted, and used in the research.

4.4.1 Coding

Coding of interview transcriptions was undertaken using thematic analysis. Thematic analysis categorises text to establish a structure of thematic ideas about it (Gibbs, 2007). This process was used to code the data collected from the interviews. This process typically involves six steps (Ryan & Bernard, 2003):

1. Familiarisation: Familiarising oneself with the data through transcribing and reading.
2. Coding: To describe the content of data
3. Generating themes: Identify patterns in codes to develop themes
4. Reviewing themes: Ensure themes are useful and accurate
5. Defining and naming themes: Meaning of each theme
6. Writing up: Finalising analysis

For each project, interview questions were delimited by the seven stages of NBS projects (as discussed in Section 2.3). Responses were therefore categorised within these stages. Responses were re-assigned to a different stage if they did not align with the initial stage under which they were allocated. Often, this was due to differences in the subjective interpretation of the question asked. Where possible, project-specific learnings were removed from project references. Otherwise, learnings were removed from the data, particularly those that were technically specific.

The identification of lessons learnt followed and was extracted from interview responses. This was done by coding key excerpts within the responses. These codes were generated to describe their content, with indicators within Table 4.1 used as a guide. Due to language differences, excerpts were then summarised or re-worded for better legibility where necessary.

The next step was to generate themes. This was done by identifying patterns between codes. Responses were grouped into common subjects, which formed the development of themes (See Appendix 3.3 for code book). These themes were reviewed and optimised to reflect the data most accurately.

These themes used in data analysis can be found in Appendix 3.3. Identifying these themes can also help support the reliability and validity of the research.

4.4.2 Qualitative Data Analysis

These learnings are based on shared experiences and specific learnings based on context. Lessons learnt were drawn from interpretations or direct responses from interviews conducted. While these reflect personal accounts of project processes, interviewees were heavily involved in the research, implementation, construction and evaluation processes, in addition to holding previous experiences in NBS. Due to the level of knowledge possessed by participants, results are considered reliable.

The coding process led to identifying the lessons learnt for each of the four projects. These learnings were cross-examined and collated to provide a comprehensive perspective as part of the cumulative approach. This produced an overarching list of lessons learnt from all four projects (see Appendix 5.1). The lessons were summarised to provide succinct descriptions, which are expanded upon within the chapter.

Lessons learnt were quantified by the number of times they were discussed by interviewees from each project to nominally categorise the value of the learning (see Appendix 5.1 for results). Those learnings that were not mentioned more than two times were removed.

A SWOT analysis was utilised to identify key learnings for research question one and address question two by identifying how stakeholders can better support NBS implementation in different contexts. This represents the strengths, weaknesses, opportunities, and threats of NBS projects. This thesis's strengths are internal and controllable positive factors built into NBS and aid in its realisation. Similarly, weaknesses are internal and controllable factors within NBS, which may hinder their realisation due to limitations or risks in these areas. Opportunities are external and uncontrolled factors that can be explored further in NBS to support its realisation. Finally, threats are external and uncontrollable factors that may require analysis or improvement to support NBS realisation (Farooq, n.d.).

The SWOT analysis tool is intended to allow its users the opportunities to help them build on the strengths it identifies, minimise weaknesses, seize opportunities and counteract threats. For the context of this thesis, the strengths and opportunities will be drawn upon as they are favourable factors that highlight areas in NBS that can be improved or explored further in NBS to support links between knowledge and action. As such, the themes of strengths and opportunities comprise the foundation of key lessons learnt and approaches to support the realisation of future NBS projects.

Utilising the SWOT analysis with the categorisation of learnings allows the researcher to distinguish in which areas lie the strengths, weaknesses, opportunities, and threats of NBS projects. Using this format, the researcher categorised the lessons learnt by the themes explored in Section 2.4.1, which included participation, integration, learning and negotiation. These themes explore methods to overcome the boundaries between knowledge and action and, as such, help to determine how stakeholders can better support NBS implementation.

4.5 Reliability and Validity of the Research

Reliability and validity are critical factors in developing sound scientific research (van Thiel, 2014). To enhance reliability and validity, triangulation is a method employed in this thesis in two forms; multiple data sources and validation of data collected (Fielding, 2012; Salkind, 2010; van Thiel, 2014). The researcher has gathered information from first-hand project experience, theoretical research, online data and literature. Validation of data has been sought through a verification process. This way, results were verified based on a comparison between the projects. This mixed-method approach allowed the researcher to verify suggested findings, adding depth to qualitative understanding (Heale & Forbes, 2013; Fielding, 2012).

As an additional method of triangulation, the lessons learnt were verified by an external resource to ensure their representativeness and validity. To prepare for this, lessons learnt were separated into Dutch and Indonesian projects. Stephanie Ijf, involved in numerous NBS projects throughout the Netherlands and wider Europe, conducted the review process for the Dutch projects (see Appendix 3.4). Tom Wilms, who also possesses a great depth of experience in NBS within the Netherlands and Indonesia, examined the Indonesian projects. The comments from this verification were documented in Appendix 3.5.

4.5.1 Reliability

Van Thiel defines the reliability of data as a “function of the accuracy and the consistency with which variables are measured” (van Thiel, 2014). Regarding accuracy, the interview method was selected as an accurate measurement instrument to capture the research variables (van Thiel, 2014). Considering the objective (extracting knowledge from a system and supporting the realisation of NBS through interactions between knowledge and action), interviews enabled the researcher to understand better the answers given (van Thiel, 2014). This was particularly important considering the variability of contexts and the diversity of projects examined.

To further reinforce the accuracy of the measurement instrument, literature was used to develop good questions. This literature highlighted key characteristics relating to knowledge and action for wide-scale NBS realisation. Interview questions were reviewed by experienced supervisors and colleagues, trialled (pilot interview) and adapted from the feedback before use. Due to the potential variability of questions asked in interviews, however, the reliability of the research may be impacted (Robson, 2002). A semi-structured interview process was adopted to minimise this risk, using core interview questions to gather necessary information and additional questions to expand responses when necessary (further discussed in Section 4.3.1).

Of the two reliability functions – accuracy and consistency – the latter revolves around the idea of repeatability (van Thiel, 2014). As this thesis focuses on people as a source of information, van Thiel states that the ability of people to learn from experience may produce different results in repeated studies (van Thiel, 2014). Therefore, the consistency of results is difficult to guarantee, particularly in case study research (van Thiel, 2014).

Regardless of these possible variables, the methodology described in Chapter 3 documents the processes and procedures followed to enable the study to be repeated and support the repeatability of the research. Methodologies, including data collection, were followed with advice from supervisors to verify that sound processes were followed (van Thiel, 2014). A journal was also kept documenting the coding process undertaken to analyse interview data (see Appendix 3.6). This was done daily or when new actions were undertaken to support the study's repeatability.

4.5.2 Validity

According to van Thiel, different variants of validity can be condensed into two basic types: internal and external (van Thiel, 2014). Internal validity explores whether the researcher has “measured the effect they intended to measure” (van Thiel, 2014). A key factor here is the operationalisation of theoretical concepts, which is believed to be appropriately done within this thesis. Theoretical indicators used to develop interview questions were cross-checked and reviewed by peers and supervisors to ensure they reflected the investigated objectives. The results of this research were reviewed by three supervisors and several peers, contributing to higher internal validity (van Thiel, 2014).

External validity explores the generalizability of the study (van Thiel, 2014). Often, there is concern that the external validity of case studies is limited due to their uniqueness (van Thiel, 2014). Projects were selected based on their location and solution type variability to gather more broadly relevant learnings (expanded on in Section 4.2.2). Interviewees were also selected to minimise risks to external validity by seeking stakeholders from different roles, professions and organisations with relatively broad experience bases (discussed in Section 4.3.1.2).

Although some lessons learnt are taken from individual projects, the results comprise a broad range of learnings that may be useful in multiple settings. As NBS are not yet part of dominant practice, conclusions drawn from this research may aid in current and future NBS implementation. The knowledge drawn from this research may also be valid in applications other than NBS, for example, climate adaptation or risk reduction. Per van Thiel's explanation, the external validity of research results is apparent with relevance to other actors, institutions, moments in time, and locations beyond the projects examined (van Thiel, 2014).

4.6 Research Limitations

Table 4.3 outlines several limitations that evolve within the research of this thesis.

Table 4.3 Research limitations.

Topic	Limitation
Extraction of lessons learnt from projects [see Section 3.1]	Each project explored in this thesis is part of a program of multiple projects. Extracting lessons learnt for this thesis has typically focused on a single project within the larger program. This is due to the availability of research participants that were involved in the projects. Figure 3.1 in Section 3.1 depicts the structure of projects and their relationship. While it is expected that these participants have been involved in multiple related projects and other NBS projects, this is inconsistent across all cases. For example, interviewees involved in the Marker Wadden project may have also been involved in the KIMA project. Reversely, interviewees from the BwN Indonesia project were not involved in any other project within the program, such as 'replication hybrid engineering'. This may influence the knowledge held by interviewees, affecting the data gathered between each participant and thus affecting the results.
Project origins and operation [see Section 3.1]	In Figure 3.1 and Section 3.1, it is clear that the projects explored in this thesis vary in how they were initiated, implemented, and operated. This thesis does not expand or explore these factors' influence on the results. Lessons learnt have been extracted based on the general project processes across NBS implementation. How a project is conducted may influence the relevance of the learning based on that situation. As such, it is essential to acknowledge that since there is variation in aspects of the projects, the data drawn from these projects may not necessarily apply to every situation or context. Mitigating this limitation would involve a different methodology to extract and analyse lessons learnt from a broader sample according to variables such as origins, implementation, and operation.
Project location.	This thesis explores four projects, three based in the Netherlands and one in Indonesia. Due to the uneven spread of project locations, findings from this thesis are expected to

[Section 3.1]	be more relevant to the Dutch context (political, social and environmental conditions). The analysis is also limited because the projects are from only two countries. To mitigate this, more projects could be explored from different countries or an equal division of projects between the Netherlands and Indonesia. This process would also be advantageous for the verification and reliability of results and provide a better representation of the findings.
Desk Research. [Section 4.3.2]	Due to the unreliability of relevant information available through document analysis, this research method was not used to gather or validate project-specific lessons learnt. As a result, this thesis cannot verify the reliability of the lessons learnt.
Limitations of available NBS knowledge.	There appear to be limitations in the availability of NBS knowledge documented within the field. Particularly in *Stages 3, 5 and 6* of NBS implementation, it related to engagement of multidisciplinary teams, stakeholder engagement practices and the management of monitoring and evaluating benefits, respectively. Within these stages, it appears more NBS-specific experience is needed. The relationship of these stages with governance practices implies more targeted governance expertise could be helpful in NBS project teams to support the formulation and collection of this knowledge.
Influence of research methodology.	Characteristics of the research methodology may influence the results, creating limitations in the findings. The particular background of selected respondents could cause differences in interview responses. This may determine the relevance of data to different project types.
Triangulation of results.	The nature of lessons learnt being unique to a context or project makes it very difficult to triangulate. For this thesis, triangulation was, therefore, a verification process. In other words, the results were verified based on a comparison between the projects and some comparisons from NBS literature. In further studies where scope and time permit, it would be helpful to analyse a broad range of documentation from external projects. This could aid in verifying results and allow a comparison between projects not associated with EcoShape.
Sample size.	Findings may be limited due to the small sample of respondents. A larger data sample could be utilised to draw more reliable conclusions about NBS knowledge.
Interviewee Roles	Interview participants varied in their involvement in projects. Roles were somewhat similar; however, they did still differ. As a result, the knowledge held by interviewees cannot be guaranteed and may have also affected the accuracy of lessons learned.
Researcher Bias	It is believed the researcher influenced the outcome of the results due to their involvement in the research and the nature of the interviews. This is understood to be a significant limitation to the development of research. This type of project is considered fundamentally flawed due to the variability from interviews and the methods of quantifying the research.
SWOT Analysis	Although a helpful planning tool, SWOT has limitations. It is one of several business planning techniques to consider and should not be used alone. Also, each point listed

	within the categories is not prioritized the same. SWOT does not account for the differences in weight. Therefore, a deeper analysis is needed using another planning technique (Farooq, n.d.).

Chapter 5. Results

The following chapter presents the cumulative case study research and desktop analysis results. These results were collected using the methodology detailed in Chapter 4.

The results presented are intended to aid in answering the following research questions:

3. Among key stakeholders, what were perceptions of key lessons learnt driving the realisation of NBS in BwN projects?
4. Based on literature explored on obstacles to NBS realisation and the lessons learnt, how can stakeholders better support NBS implementation in different contexts?

5.1 Lessons Learnt

The outcome of the interviews resulted in approximately 103 lessons learnt. These can be seen in Appendix 5.1. Using the methodology detailed in Chapter 4, these lessons learnt were aggregated based on the number of times they were discussed. With this method, those learnings stated less than twice were removed. In doing so, 39 lessons learnt remained and can be seen in Appendix 5.2.

The remaining lessons were typically noted in at least two of the four projects examined, giving them validity as relevant learnings. Further, learnings were evenly distributed across the seven stages of NBS realisation, with five to six learnings highlighted in each. The sections below outline project examples where the learning has been contextualised.

5.1.1 Identifying the Problems and Opportunities

L1: Opportunities to harness NBS are highly context-dependent and often depend on the environmental and social quality and potential risks.

Case 1: The Marker Wadden project was initiated due to official reports on declining natural conditions in the Markermeer, expressly water quality and ecology. Based on these reports, the primary objective of the island construction was to reuse and capture sediments, providing an environment for increased biodiversity and improved recreation. Reports also communicated the benefits of islands to improve environmental conditions, forming the Nature-based approach.

Case 2: In contrast, the Marconi Delfzijl project was initiated primarily due to flood risk associated with "…the rising sea levels and the sinking ground levels" (Respondent I). Increased flood risk and stakeholder objectives to improve the livelihood of the surrounding city of Delfzijl were the catalysts to investigating the use of NBS. NBS, such as salt marshes, was beneficial to protect the dikes without requiring the dike heights to be increased. They were also identified with the potential to improve the environmental and social quality in the area.

L4: Using past designs and pilot research as examples can be beneficial to help address uncertainties, optimise future designs, and evaluate problems or opportunities. Solutions that are trusted and demonstrated are more likely to be selected.

Case 1: In the HPZ project, the design considered practices adopted in other parts of the Netherlands. Respondent A stated that the existing asphalt dike was “the only part of the coast of the northern and southern Netherlands and the islands, which was not a soft solution, but a hard solution”. A nearby project had been completed utilising a mass sand deposit to nourish the Netherlands's north coast (the Sand Engine). In this instance, Respondent A commented, “I doubt if not for the sand engine, whether they would have dared to use [this solution]”.

Case 2: For the BwN Indonesia project, the solution of permeable structures was based on a project within the Netherlands that used similar structures to encourage sedimentation along the coast. This design was optimised, and alternatives were found for the Indonesian context through experimentation and observation of local systems. For example, initial designs of wooden structures were prone to be eaten by shipworm, which was then replaced by bamboo and PVC structures. These adaptations were considered based on the availability of materials, the ease of construction, and local skills.

The final solution incorporated mangroves that were physically and visually appropriate for the local environment. As a respondent noted, “people could remember that mangroves had played a role in the past, and so that is how there was a lot of willingness [for their implementation]” (Respondent L).

L10: Unlike traditional infrastructure, NBS can effectively meet multiple objectives and create multiple benefits within a single solution.

This learning is best represented within the HPZ project. The primary purpose of the HPZ project was the reinforcement of an existing asphalt dike along the North Coast of the Netherlands. This project identified opportunities to incorporate nature development and public recreation. NBS was considered “most effective for future enforcement, and to give impulse to the region for the economy and recreation” (Respondent B). Respondent C commented, “in this case, [the selection of an NBS] was mainly because other values could be incorporated…That makes it easier to get a certain solution realised…”. Opportunities to combine functionality and stakeholder objectives are far more accessible in NBS. While grey solutions were initially explored, they had little opportunity for added objectives.

As Respondent B commented, “we wanted to look for mutual benefits and other opportunities…Stimulus for tourism, stimulus for the development for nature areas”. These added objectives brought political and local support from nature organisations and the local community and financial support, which aids in accelerated project realisation.

L15: Selection between traditional and NBS projects depends on several factors such as the project objectives, available finances or cost, maintenance requirements and potential impacts on surroundings.

Understanding the implications of different solution types (NBS and non-NBS) in a context was a factor for the BwN Indonesia project. The previous implementation of concrete sea walls along the coastline of Demak, Northern Java, exacerbated the issue of coastal erosion. Pure mangrove planting was also an ineffective solution to reducing flooding and erosion. The final solution created synergies between hard and soft infrastructure to address the foundational issue of land subsidence due to groundwater extraction and increasing sea levels.

Permeable structures were used to rehabilitate the mangrove greenbelt and reduce wave heights while providing opportunities to add value to the environment, carbon storage, purification of water, and other benefits (Respondent L). Despite this, mangroves cannot solely protect against flooding, nor do not effectively reduce ground subsidence or sea-level rise. The project had to combine measures to limit groundwater extraction and reintroduce rivers through social initiatives and utilising NBS to rehabilitate and protect mangrove habitats. Due to its projected effectiveness, this integrative approach was met with political and social support. In addition, it also provided the most cost-effective strategy while delivering numerous benefits.

L17: Decision-makers have significant influence over NBS and, therefore, must be advocates for financing and changes to the policy.

In NBS projects, support and commitment from high-level local actors are essential for the project's success (Respondent J). It is vital to receive funding to facilitate mainstreaming, participation in strategies to increase uptake, and navigating academic, political, and societal bureaucracy to inject concepts into dominant practice (Respondent D).

Within the BwN Indonesia program, the success of NBS relies on the commitment and support of all actors. Respondent K reported that the project team regularly works with the local and national governments to ensure they understand the project's purpose. Their commitment also aids in “getting them enthusiastic about the approach and helps to get [NBS] to become part of their standard operating procedure” (Respondent K).

With their political commitment and support, Respondent K reports that the solution type has become quite successful elsewhere. The Ministry of Marine Affairs and Fisheries has replicated the permeable structures in several places across Indonesia.

L18: Understanding the system and evaluating project impacts is necessary to assess project opportunities and tailor the solution accordingly.

Case 1: In Demak, Indonesia, traditional practices such as mangrove planting were used to rehabilitate mangrove habitats in the area. Mangrove planting appeared to work initially. However, it proved ineffective over the long term. This lack of success was due to the unique conditions required for different species of mangroves to survive. Ecological mangrove restoration was promoted as an alternative solution, although it was challenging to convince the community. The team provided the opportunity and freedom to examine and compare restoration methodologies to observe their successes and failures. Only by employing a ‘learning by doing’ approach could they demonstrate alternatives as effective solutions.

Case 2: For the Marconi Delfzijl project, the “objective is, first of all, to see if the marshes will contribute to the protection of the land, for the safety of people living behind the dikes by wave heights impacting the dikes during storms” (Respondent G). This would extend the life of the dike without having to raise it further. Nature was also important:

> *One of the issues was that the Harbour of Delfzijl is getting shallower every year due to the fine particles in the water. An objective was to see if the material could be used, giving it a function on the salt marshes*. (Respondent G)

5.1.2 Selection and Assessment of NBS

L20: Project priorities differ between contexts, so combining objectives to develop mutual goals can encourage cooperation; however, one overarching goal is critical for success.

Case 1: The Marker Wadden project sought to address several broader objectives held by different stakeholders. The Ministry of Agriculture and Nature was invested in the biodiversity aspect, the Ministry of Water Management focused on water quality issues, and the province of Flevoland was interested in providing room for recreation. Private companies were invested in the potential for creating innovation.

An overarching project goal was essential to ensure the resources were best directed for project success. The goal of improving the environmental quality for the Markermeer acted as a platform to incorporate aspects of the broader objectives held by different stakeholders while providing a primary focus.

Case 2: Respondent C from the HPZ project commented on pursuing multiple objectives within the solution. Determining a primary goal was necessary to maintain the quality and integrity of the project:

> *This project had more purposes; water defence, recreation, and nature development. Nevertheless, one of the major lessons learnt was also that there is only one main goal. So, if we want to focus on nature development, we can see what's possible with recreation. But we cannot do them both. Because if the goal is nature development, then a lot of recreation is bad for that objective. So, you have to make choices.* (Respondent C)

L22: System understanding requires expert and local knowledge and understanding of governance systems which is critical to inform the initiation and type of NBS.

The early involvement of stakeholders is a significant component of developing a system understanding. In Indonesia, this involved the local community and various levels of government (district, province and national) (Respondent L). A system understanding in this context included technical, ecological, social and economic knowledge. Understanding operations within local regulations was also necessary to apply this knowledge.

The solution's initial design revealed the consequences of insufficient system understanding. Respondent L made this clear; "…you really need to understand the system you're working in because often only half is understood and then the solution is based on half of your knowledge. Then it often goes wrong". On the BwN Indonesia project, severe land subsidence was identified, influencing the solution's effectiveness in mitigating the effects of sea level rise. This issue was determined after speaking with the local community and asking contextual questions regarding past sea level inundations. In doing so, the severity of land subsidence could be determined and addressed.

Based on this understanding, the team was able to halt the execution of further coastal nourishments in other locations. Instead, separate work packages were set up to explore an action plan to reduce regional land subsidence.

L25: To secure funding, projects should have feasible and demonstratable outcomes and provide mutual benefits and objectives to actors.

On Marker Wadden, integrating multiple objectives contributed to the project's success by gathering financial donors' support. In these instances, stakeholders' financial investment adds to the commitment to ensuring the project's success. Respondent F commented that “the key factor for success was the combination of goals. If you start with the idea of a bird paradise, then people would say, you spend so much money on birds'. Showing the combination of multiple goals is a far stronger point”.

Respondent C also spoke on this dynamic:

> *In the Netherlands, the objective of flood defence is always the most important objective… that's the only goal financed by Rijkswaterstaat. Then if other organisations want other goals incorporated in the solution, most of the time, that makes it more expensive. If you want to incorporate other goals, then you have to contribute some money.* (Respondent C)

Case 2: On the BwN Indonesia project, aligning project objectives with financial donors' objectives was also a key consideration for success. In this case, local authorities initially hesitated to contribute funding as the solution was unfamiliar and untested within the context (Respondent T). A pilot project was constructed to overcome this, highlighting the value to key stakeholders for a full-scale project.

L27: Risks can be encountered at each stage of NBS realisation due to the infancy of the concept; however, they are primarily associated with maintenance and post-project monitoring requirements due to uncertainties in the future behaviour of a system.

The most considerable risk on the HPZ project largely surrounded the maintenance requirements associated with the sand dune and its safety and integrity. In this context, the client accepted these risks as the advantages of the sandy solution outweighed the disadvantages. It is believed that the successes of previous sandy projects led to the progression of the HPZ. Respondent A noted, “I doubt, if not for the [similar] sand engine, whether they would have dared to use [this solution]”.

Respondent C commented that if monitoring is not implemented at the beginning of the project, there is the risk that good research and accurate evaluations of outcomes are not possible. In this instance, post-project monitoring is vital due to the context of the solution. The concept was relatively new to the area, so the emphasis was placed on ensuring that appropriate maintenance and monitoring were implemented and upheld.

L28: Uncertainties of NBS regarding their integration with nature may present several risks. Design must consider the system and how to address these potential risks.

Case 1: On the Marconi project, the pioneer salt marsh construction occurred outside the port's protected areas, making it challenging to control implementation processes due to the sea's influence. For example, the action of mixing very watery, fine sludge with sand for the salt marsh was already problematic, and issues were exacerbated due to its location in a tidal area. In this case, the influence of natural processes, such as wave heights and the current flood stage, was critical. The planning and design had to be flexible and work within these influences' limitations to implement successfully.

Respondent I reflected:

> *We can learn a lot in nature, but we also have to take in consideration that we're working in an area where nature is always changing…It can be unpredictable. You must learn to work with it and plan operations at the right time.*

Case 2: Natural processes not only create risks for project execution but also risks for ongoing operation. The HPZ project's objective was to design a solution requiring minimal maintenance over the first 20 years to allow for the occurrence of natural processes and encourage ecological development. Planning and design had to include methods to ensure the solution could withstand nature's destructive forces whilst allowing natural development to occur.

5.1.3 Design of the NBS Implementation Process

L32: Integrated multidisciplinary teams with a diversity of skills aid the exploration of alternative processes and facilitate consideration of added benefits for a solution.

Case 1: On the BwN Indonesia project, Respondent J commented on their experience; "you have to be really open. The communities have their own knowledge which is very valuable…In that sense, a multidisciplinary team knows much more. All the members of the team are equally valuable" (Respondent J).

Within the BwN Indonesia project, the local community's knowledge was invaluable for understanding the unique characteristics of the local system. The community's contextual knowledge of the landscape enabled a better understanding of the ground subsidence, local materials, and past aquaculture practices, aiding the design of the project's various intervention strategies. For example, insight into the intensity of flooding within villages led to realising ground subsidence severity, allowing project efforts to be refocused to address this issue.

Case 2: On the Marker Wadden project, the interactions between Rijkswaterstaat and Natuurmonumenten allowed added value creation. Respondent D noted that they were able to provide complementary skills to design and deliver the optimal solution for the context. Cooperation between responsible authorities and other actors is common in the Netherlands to create added value.

In this example, the government body (Rijkswaterstaat) had experience leading large infrastructure projects and knew about Marker Wadden. Natuurmonumenten had significant experience with stakeholder involvement and communication, which provided these complementary skills necessary.

L34: The project team must be open and respectful of local knowledge within particular contexts for local support.

Case 1: On the HPZ project, contractors were allowed to interact with local stakeholders, including residents, municipalities, businesses and nature organisations, for advice on aspects of the proposed solution. This communication was noted as a pivotal contributor to local support for the solution. Collaboration through meetings allowed contractors to amend the design, optimising construction and maintenance methodology to suit the local area better.

Case 2: On the BwN Indonesia project, the team was vigilant about being open and respectful of local traditions and knowledge. As Respondent J noted, it is not only science and theory that is useful, but all knowledge streams and team members are. In this instance, multidisciplinary teams that account for local knowledge's value are critical. For the project's construction, members of local villages were consulted on locations for structures, construction methodology and their observations of existing structures.

In this project, it was also vital that everything was done under local laws and regulations. This involved training people to execute the work safely and requesting necessary permits. Respondent L commented that while this was considerable work, it was a key objective for the project.

L37: Invest resources to build a good team with active cooperation, positive dynamics, and values.

Case 1: It is possible to achieve more effective results if an investment is made in forming a good team at the beginning of a project (Respondent C). Within the HPZ project, Respondent C noted that crucially, the team must cooperate to allow them to find the best solution for safety and nature. Respondent B reinforces this, commenting that to ensure the success of project objectives, you must invest in the team. Actors must work together in a team, both within and between their organisations.

Case 2: On the Marker Wadden project, existing difficulties between members within Rijkswaterstaat and Natuurmonumenten meant it was essential to foster cooperation to manage the various corporate cultures and practices between the disciplines. To ensure this, attention was paid to forming the team, looking at people's energy and whom they can work well with (Respondent E). “I think what is very important when making a project team... is that the characters fit” (Respondent A). A successful project could be executed by fostering a team's willingness to appreciate and work alongside different corporate cultures.

L38: Management, continued nurturing, and coordination is important to maintain good relationships between teams and external partners.

Case 1: On the Marconi Project, there were multiple stakeholders, including the waterboards, the municipality and the province. Of these stakeholders, “they all had different wishes and needs” (Respondent H). To add to this, the structure of the overall project consisted of a series of separate work packages involving various actors from contractors and project teams. This set-up required management and coordination between actors to regulate and oversee the complex communication channels.

This management and coordination role was critical in keeping the actors within different organisations and packages cooperating. It was also useful in scheduling project actions reliant on subsequent processes to ensure each package's timely delivery. Allocating this role on each project can reduce the potential for disagreements as everyone begins to work as a team.

Case 2: On the BwN Indonesia project, the management and coordination role was vital due to the team composition across Indonesia and the Netherlands. Differences in languages, perspectives, and practices highlighted the importance of coordination and nurturing to maintain relationships within the project team.

This role is critical in fostering positive relationships in project teams; however, “it is framed as management, but it's actually ensuring interdisciplinary collaboration” (Respondent J). This learning shows that managing partnerships and teams is not a simple process. The role requires a significant amount of nurturing of dynamics to avoid the isolation of actors.

L39: Organisational partnerships with local institutions can provide complementary skills and create added value through established networks and resource diversity.

The Marker Wadden project was founded on a public-private partnership between Natuurmonumenten and Rijkswaterstaat. In this partnership, Natuurmonumenten handled the project's organisation, PR and ecology. As they are primarily engaged in enlarging their support base, they were well experienced in stakeholder engagement, particularly for more prominent actors. For example, in the project proposal, Natuurmonumenten was highly skilled in drawing links between the government's objectives, the province, and their objectives.

Rijkswaterstaat, on the other hand, is responsible for water-related designs and has significant experience in leading large-scale infrastructure projects. “…When you have other objectives, it's extremely beneficial to partner with an organisation who understands how democracy works and how bureaucracy can help you. This is important because you do have to follow certain procedures” (Respondent E).

Rijkswaterstaat's experience with the Markermeer and other water bodies meant they were well-positioned to handle the project's technical aspects. These included actions associated with the contracts, such as developing work packages and engaging contractors.

The partnerships developed on Marker Wadden offered complementary skills to create extra value through mutual objectives, aiding in successful project execution. Respondent F commented on their experience of this relationship: “It was very special that half the team is from Natuurmonumenten, and half of the team is from Rijkswaterstaat. We started from a very simple idea that everybody does what they are good at…So it worked very well”.

Case 2: On the BwN Indonesia project, the value of partnering with local organisations was observed through benefits in consultation, team mobilisation and established rapport. Respondent K noted “for local stakeholder involvement or engagement, we try to have a local party doing that because they are much more familiar with the locals. Involving local people and engaging with relevant actors is vital due to outsiders” difficulties in entering societies. Interaction is made more accessible by establishing relationships with local institutions and organisations connected to such actors.

Exiting relationships with the project partner Wetlands International was useful due to their "very strong local presence and connections to various ministries and local government" (Respondent K). This relationship allowed the establishment of trust and support for the delivery of the project.

5.1.4 Implementation of NBS

L46: Successful NBS implementation requires a willingness from the community while the decision-maker commitment to project outcomes.

Case 1: The Marconi project's success is attributed to the various actors' commitment, particularly decision-makers. Respondent H comments;

> *It really was about our clients, which was this consortium of different groups that were really bonded together. Often on the lower levels, you have people questioning many things, but on the decision maker's level, they had decided together that [Marconi] has to be a success.*

There must be agreement and determination by high-level players (decision-makers) to pursue the project's success. In doing so, commitments were made to the project, ensuring objectives were seen to completion by these actors.

Case 2: On the BwN project, respondents commented on the importance of willingness from relevant stakeholders. Respondent J notes, "community willingness and government willingness are key". To achieve this willingness, the BwN Indonesia project sought to work at the various stakeholder levels, including the village, district, government, provincial government, and national government. Within all these stakeholder levels were various objectives and motivators. As Respondent J commented, "you need to balance all of that to gain willingness".

L49: Adaptive management is crucial in NBS and creates constructive learning, which involves monitoring, learning by doing and knowledge sharing.

Case 1: On the Marker Wadden project, the core objective for Natuurmonumenten was creating as much nature as possible. An adaptive management approach allowed flexibility to be granted to contractors, encouraging them to submit design proposals that would develop the largest number of islands possible with the funding available.

In the construction stage of Marker Wadden, uncertainties were identified relating to the capabilities of the initially proposed building materials. In response, the contractors were permitted to adjust their work method to deliver the required project outcome. In this, adaptive management techniques were also utilised.

Case 2: On the BwN Indonesia project, monitoring processes aided in identifying physical challenges within the original design. For example, the permeable structures had incurred damage from compaction and being eaten by shipworm. Recognition of this complication early in the project allowed adaptations to be made to prevent reoccurrences. Bamboo, different woods and PVC pipes filled with concrete were all investigated as options for the final structures.

L53: Nature is constantly changing, and we must work with it. System understanding is essential to work with changing natural systems and avoid implementation issues.

Case 1: On the BwN Indonesia project, the consequences of insufficient system understanding became apparent in the solution's initial design. Respondent L made this clear "…you really need to understand the system you're working in because often only half is understood and then the solution is based on half of your knowledge. Then it often goes wrong".

The issue with land subsidence was far more severe than expected, influencing the amount of sediment required to mitigate the effects of sea level rise. When speaking with the local community and asking questions about the height of sea level rise in the past and the frequency that houses are raised, the severity of land subsidence could be determined.

Case 2: The importance of system understanding was also highlighted in the Marconi project. Laying the foundations for the salt marsh was undertaken without knowledge of the underlying geotechnical conditions. This material was dumped on top of the existing ground that was retrospectively found to be of weak composition. As a result, there was a significant settlement and collapsing of the ground in areas. The uneven surface and unexpected settlement required additional material to be used, causing an excess cost burden (Respondent I). According to Respondent I, assumptions about the geotechnical conditions disregarded the unique system characteristics, meaning additional and unnecessary efforts were required.

L54: Be aware of the project and context conditions when considering the feasibility and practicality of the implementation methodology. This includes the availability of machinery and the capability of local contractors.

Respondent I noted that "having a plan or theory of how to achieve an outcome is one thing, but physical execution is another". On the Marconi project, flexibility in implementation processes was crucial. Mixing fine sediment through the sand to construct the salt marsh proved more difficult than expected and made it more complex when working within the tidal area. The construction approach involved mixing dredged sediments from the port channel with sand using various transportation and mixing methods. This was too complicated for the contractor and beyond the capabilities of the machinery available. A different approach was required and utilised resources from the surrounding context, which was within the capability of local contractors. This involved using excess clay material from a neighbouring project and combining it with sand using an agricultural machine.

L56: Overcoming unanticipated circumstances requires a mindset of cooperation within teams.

This learning is exemplified as an outcome of actors involved in the HPZ project. On an NBS project utilised as an example for the delivery of the HPZ project, Respondent B acknowledged that unanticipated circumstances occurred. These were associated with the financial costs of the NBS, resulting in higher costs than a traditional solution. This was observed later in the planning phase with increased costs due to excluded and unforeseen scope in preliminary planning. As a result, the relevant stakeholders, including the waterboard, ministry and municipality, have to agree on the production of additional financing. This cooperation was necessary to see the project through to realisation. Respondent B noted that "to overcome unanticipated circumstances, it was always 'doing things together', 'we are in this together'. It's not about going behind closed doors and pursuing your own interests".

This jeopardised the researcher's findings and created neglect of the other project objectives of innovation and learning.

L61: Initial resistance often decreases or disappears throughout construction, mainly where opportunities are available to observe or engage with the project.

A 'learning by doing' approach can help reduce concerns over implementation periods of unfamiliar solutions. These concerns can often manifest due to a lack of observable and tangible results. For example, on the BwN Indonesia project, while restoration practices such as mixed mangrove aquaculture can encourage aquaculture productivity, they can take a significant period to show success. Further, harvest periods for aquaculture are relatively short. These timelines compete with the duration required to create established and successful practices.

Respondent J noted that a method to overcome this is "to start soon with pilots in every village to show the possibilities. Those pilots can then be used to show success while others are still testing”. In this project, coastal field schools adopted an educational, hands-on approach to exemplify and reinforce the benefits of restoration practices.

5.1.5 Stakeholder Engagement and Communication of Co-Benefits

L64: Early involvement of all stakeholders is crucial and involves communicating clear project objectives and benefits and understanding stakeholder concerns.

In developing the Marconi project, an established stakeholder program called Economy and Ecology exemplified this learning. This collaboration involved regional authorities, the province, the municipality, regional industry and nature organisations. The objective was to balance nature development and the region's protection whilst allowing economic activities. By utilising this stakeholder program, stakeholder desires could be recognised and integrated into the NBS design, which resulted in it being positively received and well supported in the early stages.

The interest of these stakeholders was an essential factor distinguished from Marconi.

> *You always have to learn and to know what the other party wants; what are their objectives, what are the do's and don'ts, and try to make your project in such a way that you are contributing to their objective*. (Respondent I)

For example, support was secured from nature organisations by communicating the benefits of constructing two salt marshes: one solely for coastal protection and nature development. This design component showcased the objective for nature preservation and revitalisation to be brought to the area.

L66: While stakeholder involvement during design can be an intensive process, it is valuable for support. Further, exploring alternative functionalities offered by stakeholder knowledge can allow primary objectives to remain while adding benefits and cost savings in design.

On the BwN Indonesia project, stakeholders, including the local community and various levels of government (district, province and national), were integrated within the project rather than just consulted. “[Local actors] can be useful in exploring alternative functionalities and involving these stakeholder opinions can lead to the most cost-effective solution” (Respondent D). During the construction of permeable structures, for example, investigations sought advice from stakeholders regarding ‘how are the current structures working?’, ‘where should we place them?’ and ‘how should we place them?’ (Respondent L). This communication was of primary importance in understanding the system to utilise successful implementation methods.

This local knowledge assisted in optimising work methodologies and ongoing objectives for the project. As mentioned in Learning 23 and 51, the project team could interpret and understand sea-level inundation behaviour with local knowledge, leading to identifying ground subsidence in the area. This allowed the reprioritisation of resources to address this problem.

L70: Showcasing the project through media, public visitation, and education helps communicate objectives, decrease resistance, and encourage funding opportunities.

Case 1: On the HPZ project, in response to how stakeholders may perceive a project, Respondent A noted "…what you learn is people are not really aware of what is happening...you should make the project a public attraction…The issue automatically disappeared because people…then saw how it looked…it looks nice, and they have a nice beach now" (Respondent A).

On the HPZ project, offering visitation to the site throughout construction reduced resistance to the outcome by allowing stakeholders to view the process and see potential benefits to the surroundings.

Case 2: This learning contributed to the project's positive perception of the Marker Wadden project. Respondent E reflected that it is extremely good for the temper of people…inviting them and welcoming them to visit the project site. Using a project ambassador to showcase design qualities such as biodiversity and recreational opportunities appeared to help inform people and get them involved. Using educational materials to communicate the project objectives highlighted essential elements of the design, stakeholder benefits, and increased enthusiasm and support.

Media platforms were another method utilised on Marker Wadden for this purpose. Natuurmonumenten undertook presentations and television appearances to discuss aspects of the project. Natuurmonumenten's connection with the media also provided a platform for researchers to communicate their purpose, informing stakeholders of the project's objective and benefits.

L72: Engaging and developing relationships with local institutions trusted within established networks is good practice. This can vastly improve local stakeholder engagement, interaction and support.

This learning is exemplified in the BwN Indonesia project, which involved a rigorous planning process, including community engagement with local actors, before the project's location was selected. This consultation involved validating and documenting local actors' commitment and support and integrating them into the project team.

Wetlands International, a partner on this project, led local stakeholder engagement due to their positive presence in the area and familiarity with the locals. Wetlands International's connections to actors at various ministries and local governments also made them an advantageous partner for this project. Through this relationship, local support, including financial and social support, was gained, which affected its successful implementation.

In Indonesia, stakeholder interaction is also crucial for planning the timing of engagement:

> *Taking half a year, or even a year to figure out how to do things is reasonable from a science point of view. But for a community member, if we start talking with them and there is no contract to engage them, after a year, they lose their interest or trust.* (Respondent J)

In these instances, a more in-depth understanding of local partnerships' social context was crucial to avoid common difficulties when outsiders enter society.

L76: Educational tools such as field schools and learning-by-doing help involve and educate stakeholders about project operations, benefits and co-benefits and gather local knowledge.

The beneficial use of educational tools on NBS projects is best exemplified through the BwN Indonesia project. Stakeholder engagement was done both formally and informally. Field schools run by facilitators were the primary lines of communication with the community and were crucial for public support. In this educational process, demonstration ponds were used to regularly educate and learn about more beneficial, sustainable practices through a learning-by-doing approach.

These tools were not only about involving the community but educating them on sustainable aquaculture and concepts previously misunderstood, such as coastal safety and the impacts of current practices on the environment (Respondent L). “It is not only about coastal protection but improving the livelihood of the people living there”.

Due to their familiarity with the area and its typical processes, the project was provided with invaluable knowledge.

5.1.6 Monitoring and Evaluation

L78: Good monitoring programs help validate progress towards goals and achieve multiple benefits.

On the BwN Indonesia project, Respondent K commented on the benefit of monitoring in determining success:

Ultimately you need to verify that whatever your goal was at the start, that you're moving towards it. So, monitoring, in any case, will be important. Ultimately NBS are a form of civil engineering solutions. There is a physical problem that we're trying to solve and the social components that support that. Monitoring helps to ensure these objectives are being achieved. (Respondent K)

Similarly, on the Marconi project, Respondent G noted that monitoring rounds captured learnings for the various objectives. “For this, the most important thing that you really have a very good monitoring plan”.

L80: The way the project is connected to the wider physical and social environment and how it considers and interacts with nature alongside other objectives is a key determinant of success.

On the BwN Indonesia project, Respondent J noted that the solution's success was because it was connected to and sits within the wider environment, while fitting the social environment. The solution had to be based on system understanding (Respondent J). This was exemplified in the final solution, which incorporated both physically and visually appropriate mangroves for the local context. As Respondent L noted, “people could remember that mangroves had played a role in the past and so there was a lot of willingness [for their implementation]”.

L84: Monitoring and data management should be implemented from the beginning of the project to understand project impacts and inform an accurate evaluation of outcomes.

Respondent H from the Marconi project noted the importance of ensuring decision-makers and clients understand that monitoring is an integrated part of the project, not an afterthought.

The difficult thing is often decision-makers consider the project completed once its built. But there it actually begins, because then you have the learning phase'. While this was not necessarily the case on Marconi' in other projects, it often happens; a client is happy because they have the solution and then say they no longer have any money for monitoring. (Respondent H)

The monitoring project started two years after construction had already begun on Marker Wadden, which caused issues in monitoring practices. Similarly, with the KIMA project, resulting from Marker Wadden, the timeline and scope for research and monitoring were insufficient, considering the project's complexity and uncertainties. Further, no data management system was adopted throughout the entire program. On this,' starting with a good monitoring system and data management system so [we] can learn from it and also better monitor the effect of the projects on Lake Marker would be an improvement' (Respondent D).

L86: Successful monitoring must involve planning and evaluation of monitoring goals. While some results can be seen in a short period, long-term monitoring is ideal for investigating uncertainties and effective learning.

Case 1: The HPZ project primarily encompassed a large-scale sand dune to protect surrounding areas from flood risk and increased sea-level rise. Due to the novelty and size of this solution, extensive monitoring and data collection aid its management and maintenance over the long term:

> *There are certain solutions that we already know a lot about, but [HPZ] was quite a new type of solution, building a Dune before a dike going in the direction of the sea. How would these constructed dunes develop? The same way as naturally developed dunes, or differently? The reason that we should incorporate monitoring in this type of project is because there are more uncertainties [than a more common solution type]. To know more how to maintain [it] and learn from it*. (Respondent C)

Case 2: Similarly, the Marker Wadden project was a new concept involving the construction of a series of islands using reclaimed material. The monitoring program- KIMA- was initiated to gather helpful information about the current performance and monitor and evaluate Marker Wadden's effectiveness in improving the broader ecosystem.

L87: Barriers to monitoring include lack of budget, unclear objectives, and unwillingness to invest in and utilise monitoring for knowledge development.

Case 1: On the monitoring project associated with HPZ – Hondsbossche Dunes – the availability of finances for the desired objectives was a significant barrier. At the beginning of the project, numerous areas were identified for monitoring; however, the cost of monitoring these elements vastly exceeded the allocated budget. As such, the scope for monitoring had to be reduced.

A lack of clear purpose for the results also hindered monitoring on Hondsbossche Dunes. “We struggled all the time because we wanted to learn lessons for other projects…but what projects?” (Respondent C). A similar project being constructed, Prins Hendrick Sand Dike, was identified as a possible recipient of Hondsbossche Dune's knowledge. As the project had already begun construction, indirect learnings were considered to create more complexities rather than reduce them. Without purposeful learnings developed, monitoring outcomes lacked practicality, limiting their use.

Case 2: In countries less familiar with Nature-based approaches, the uninformed allocation of a budget can cause issues for NBS projects' success. On the BwN Indonesia project, Respondent L noted that 'most of the budget is for construction, not for maintenance, and [in this project] these permeable structures need a lot of maintenance'. Ongoing processes such as maintenance and monitoring are critical to ensure the continued effectiveness of NBS. As such, project budgets must be appropriately divided to allow the execution of these vital project processes.

Acknowledging the importance of maintenance and monitoring and providing the appropriate funding for these actions is critical for the continued success of NBS. This practice of focusing finances on project construction rather than monitoring and maintenance is common within traditional 'grey' solutions. With uncertainty regarding unique NBS projects' requirements, it is difficult to gauge the funding necessary for processes beyond its construction.' That became a problem on the BwN Indonesia project because they didn't know how to get [monitoring] budget into their annual estimates' (Respondent L). As such, it is crucial to take learnings from past NBS projects to understand the resources required.

L88: A lack of pre-existing information or data availability from projects can impact monitoring success and the ability to gain system understanding, particularly if monitoring is not implemented from the beginning.

Case 1: The monitoring project began following the HPZ project, and limited monitoring created issues with results later in the project phase. On HPZ, no provision was made for stakeholder engagement, so this absence of data made analysing changes in stakeholder perceptions between pre-, and post-project, challenging.

Case 2: Experiences on the BwN Indonesia also exemplified this learning. A lack of data availability in Indonesia created difficulties in gaining system understanding (Respondent J). An issue with land subsidence was initially unknown due to a lack of existing contextual data. As such, measures could not be put in place from the beginning to take a different approach or select a different site.

5.1.7 Transfer and Upscale of NBS

L92: Local stakeholder involvement aids the translation of contextual knowledge due to their system understanding.

This learning is best exemplified by the experiences of Respondent D. Translating contextual project experience to other contexts is very difficult. It is essential to understand specific circumstances well, so involving local parties in the process is vital (Respondent D).

> *In working on international projects, you need to know a lot about the local conditions to give them some benefits. I have a lot of experience in the Netherlands and other European countries. To translate that to another context, however, often the circumstances are so different, you need to know them well. So, involving local parties is very important.* (Respondent D)

L93: Spreading awareness of NBS concepts through training and education programs is a valuable way to encourage NBS translation. This involves the development of guidelines, integrating education into university programs or government training, and community interactions. This can help create an understanding of NBS practices and benefits, increase enthusiasm about the approach and disseminate this knowledge to a broad group of actors.

Universities in the Netherlands train new generations of engineers in NBS, promoting its concepts. In Indonesia, spreading awareness of NBS is imperative as they often use traditional solutions. If practices are not within approved standards or guidelines, they are not authorised to be implemented. NBS concepts can be incorporated into these guidelines through education and awareness strategies and truly assist mainstreaming efforts (Respondent K).

Within the BwN Indonesia project, the 'training of trainer's' program was aimed at government and academic (university) actors to provide education about NBS concepts. The idea is that these people will be responsible for educating and training others by including NBS in their curriculum. This program assists in producing relevant teaching material to improve its accessibility and uptake for stakeholders. According to Respondent D, “this program can be applied and is beneficial everywhere. In the end, it is necessary that the people making the decisions and design know what [NBS] is and have been told of its benefits”. This includes methods of application, what can be learnt from the project and how to implement it in other situations.

Within the BwN Indonesia project, the training of trainer's program relies on participation as a crucial component for success, particularly from actors in high-level positions. Respondent D commented on this:' I think it is quite an active group, but [involvement in these programs] differs a bit…some people are always really active in participating, and some are less active'.

L97: NBS can often prove more economical than traditional infrastructure. To be competitive with traditional solutions, total lifecycle costs are needed, which monetise the added values and benefits that NBS provide, in addition to the cost of execution.

Respondent L from the BwN Indonesia project exemplified this learning. To mainstream NBS concepts, projects eventually require government funding, similar to typical tenders. While this method of funding NBS is observed within the Netherlands, it is not particularly common outside the Netherlands, primarily due to the common assumption that sustainability is more expensive than traditional practices. Respondent L commented that if a traditional cost-benefit analysis was to be done on a Business Case, there are few times NBS would win compared to a traditional ('grey') solution. The added (social and environmental) benefits of NBS must be monetised into the cost-benefit analysis to make the solution viable and competitive with traditional solutions. Doing so makes funding more likely to be willingly available for NBS projects.

L100: People must understand that NBS transcends the physical solution, affecting wider physical, social, and economic spheres, which requires system understanding.

Case 1: On the HPZ project, Respondent A commented on the importance of recognising the priorities of the context.

> *We should always bear [conflict between people, planet and profit] in mind. If you work in poor countries where the worry is 'do I have enough food tomorrow?', it's very difficult coming from this nice Western world and telling them what to do for nature…* (Respondent A)

As the respondent mentioned above, if problems exist surrounding necessities like food, shelter and economy, resources such as time and money are unlikely to be prioritised to improve environmental outcomes. It must be recognised that priorities extend beyond needing a physical solution, which NBS can strive to address.

Case 2: On the BwN Indonesia project, this learning was evident. The objective of reducing erosion was overshadowed by the recognition of severe ground subsidence in the area. As such, the primary solution of permeable structures and mangrove rehabilitation is insufficient to address this significant challenge. Respondent K commented:

Land subsidence is a big problem all over Indonesia, so we are cooperating to set up a roadmap so that within a couple of years we can start implementing measures or procedures to reduce land subsidence. It's a challenge because there are so many components it's very difficult to address.

Further, the influence of social systems and stakeholders external to the immediate area was recognised in this context. In Indonesia, one organisation may be responsible for the entire coast or rivers where the solution is built. However, private actors may own the downstream coastline (Respondent C). Working with these actors is vital as development that may occur without proper consideration for the risks may negate the project's positive effects.

L101: Both practical execution and research processes benefit each other by creating and sharing valuable knowledge to improve realisation processes.

The Marker Wadden project emphasised that knowledge developed from the research project (KIMA) could have been beneficial for executing the physical solution. Respondent D noted that this knowledge could help actors from the delivery project understand natural processes better, improving construction methodologies and reducing delivery time and cost.

It was suggested that the knowledge from KIMA could have been used to improve the selection of effective construction materials through a shared understanding of the material's performance in different conditions. Respondent D noted that this knowledge would have helped avoid sediment reuse for island construction due to its undesirable characteristics.

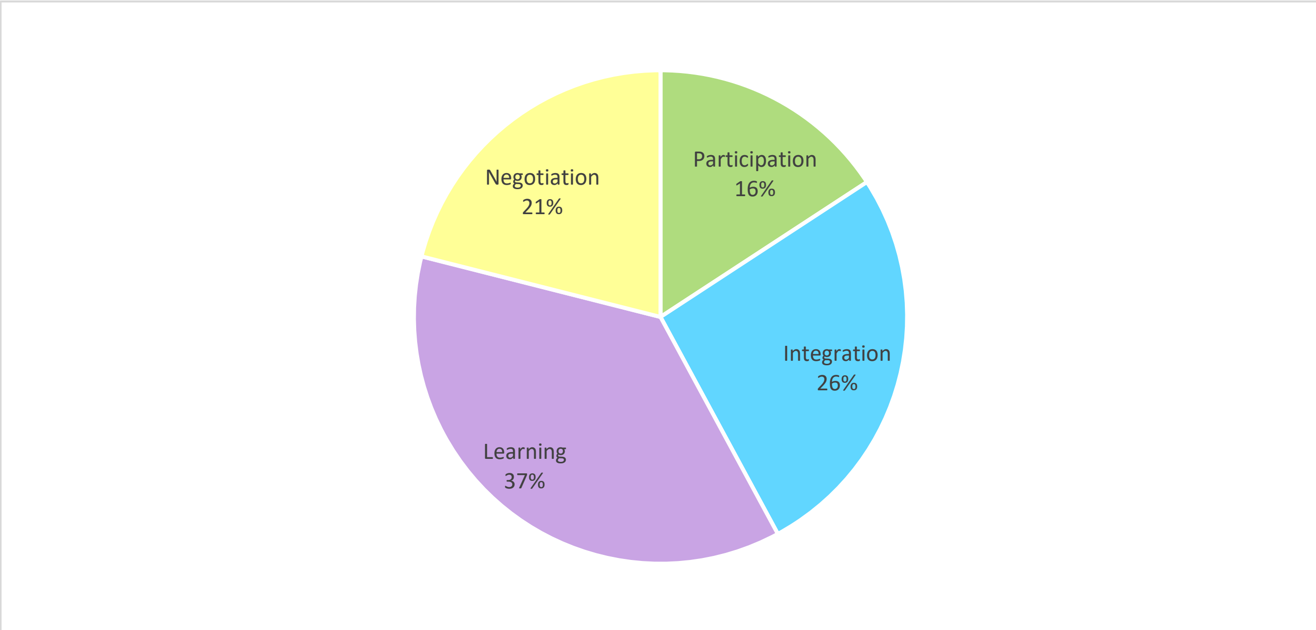
5.2 Categorisation of Lessons Learnt

To determine key lessons learnt (research question one) and how stakeholders can support the realisation of NBS (research question two), the lessons learnt were further distinguished using a SWOT analysis. Following this, the researcher used van Kerkhoff, and Lebel's (2006) approaches to overcoming boundaries between knowledge and action to categorise the learnings (see Section 2.4.1). In doing so, the results outline where the strengths, weaknesses, opportunities, and threats of NBS projects lie surrounding NBS realisation (see Table 5.1). The outcome of this categorisation can be seen in Appendix 5.3.

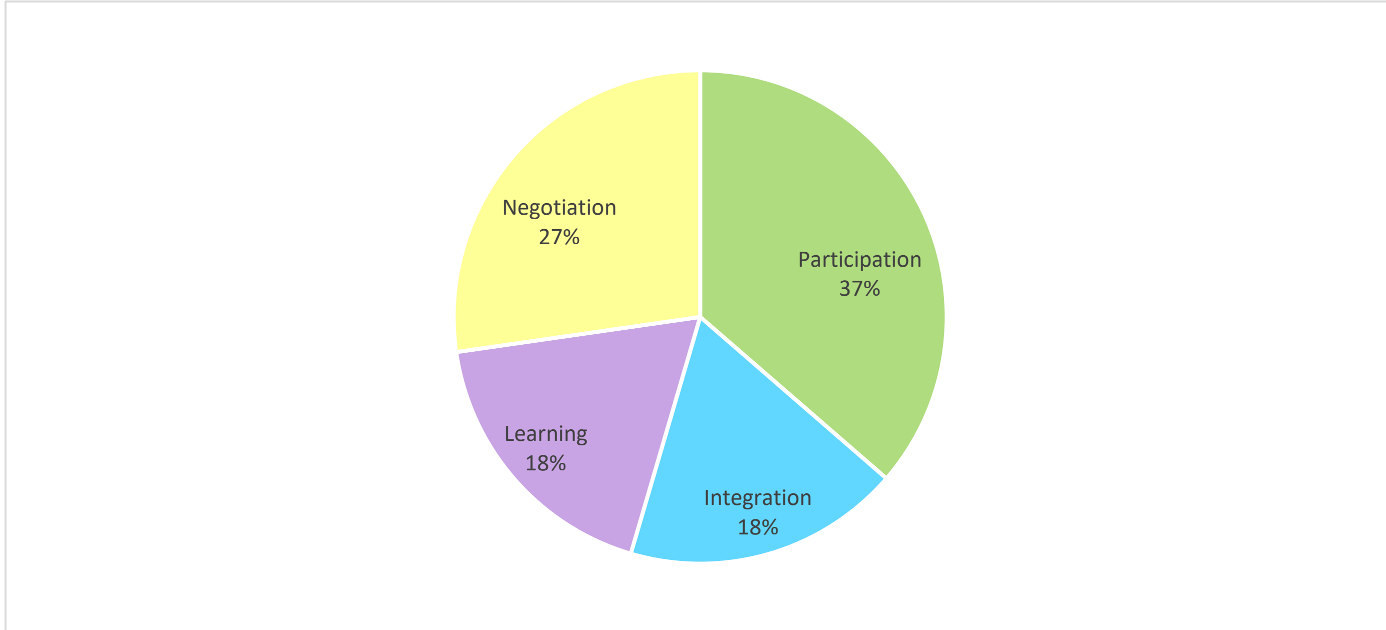
Table 5.1 clearly distinguishes the dominant categories of overcoming boundaries between knowledge and action within each of the four categories of the SWOT analysis. For strengths, 'learning' and 'integration' are the two primary themes of the lessons learnt, comprising 37% and 26% of the learnings, respectively. For opportunities, 'participation' makes up 37% of learning, with 'negotiation' comprising 27%. Within weaknesses, 'integration' and 'negotiation' are the dominant themes comprising 33% of learnings each. Finally, 50% of learnings with the threats categories are associated with 'learning', with 'integration' making up another 25%.

Table 5.1 Categorisation of Key Learnings.

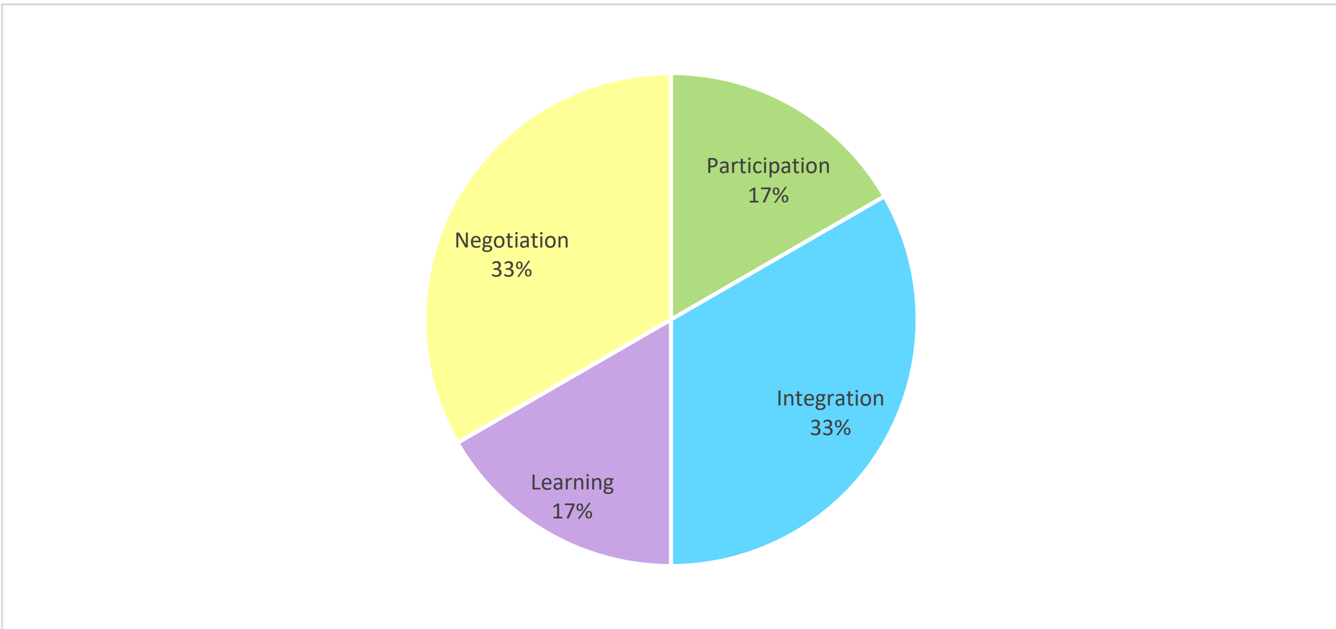
Strengths



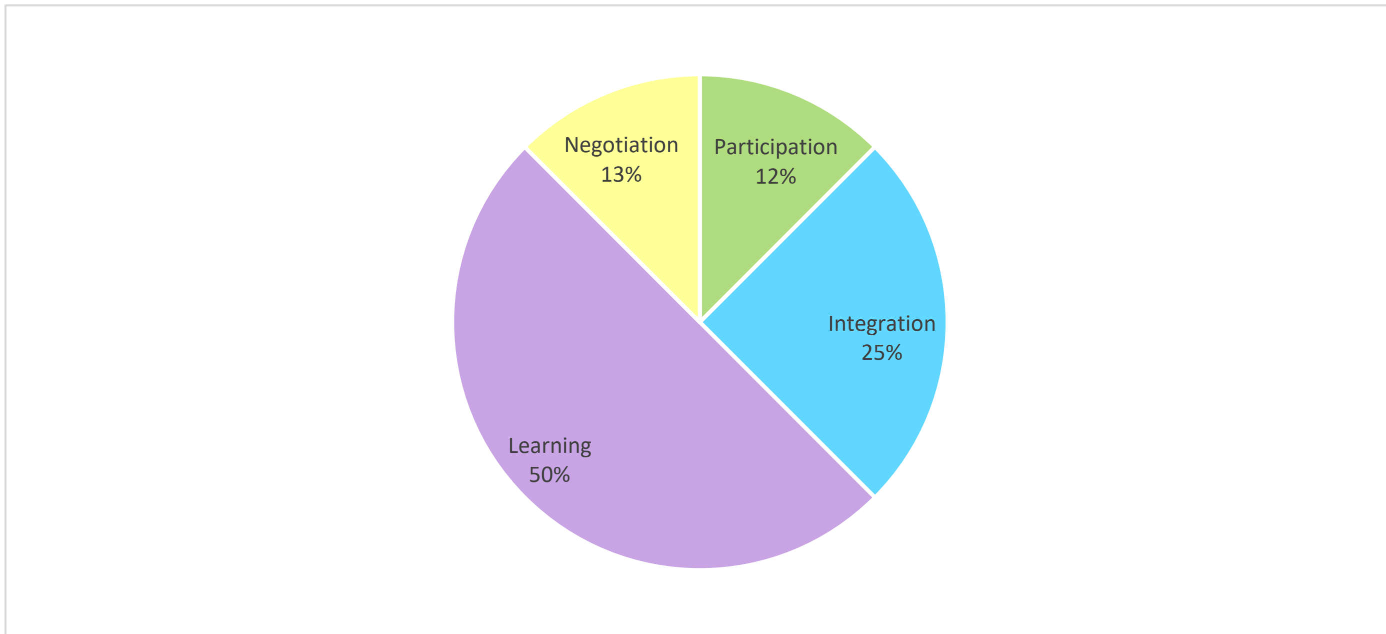
Opportunities



Weaknesses



Threats



Chapter 6. Discussion

The following chapter provides a discussion of the results extracted in this thesis. It analyses the learnings that were categorised utilising a SWOT framework. The learnings in these categories are contextualised based on their relationship to the approach explored by van Kerkhoff and Lebel to link knowledge and action. Doing so allows the researcher to discern key lessons learnt and methods that may support NBS realisation, providing answers to research questions one and two.

6.1 Key Lessons Learnt

Analysing lessons learnt in conjunction with the theoretical categories of participation, integration, learning, and negotiation enables the researcher to highlight methods that can help to overcome the challenges of relating knowledge and action. Breaking this down further through the SWOT methodology helps to pinpoint approaches to support NBS realisation, specifically through strengths and weaknesses. Strengths are targeted because they comprise internal and controllable positive factors built into NBS. Strengths can be enhanced by improving areas of NBS to which they relate, thus helping to link knowledge and action and support NBS realisation. Opportunities are also targeted. Although they are considered external and uncontrolled, opportunities refer to favourable factors that can be explored to increase links between knowledge and action to support NBS. As such, for this paper, supporting NBS realisation relies on identifying the existing areas of strength to be enhanced or opportunities for exploration and development within NBS projects.

The research conducted for this paper has highlighted dominating categories considered to be strengths, which are associated with learning and integration. Methods of integration create links across social, physical, and political contexts. Moreover, learning methods aid in developing relationships between knowledge developers and their user communities and fostering engagement between researchers and practitioners.

Conversely, lessons learnt that are considered opportunities are associated with participation and negotiation. Therefore, opportunities to be explored in NBS rely on engaging actors in NBS research or knowledge development that are not traditionally involved. Opportunities can also be sought in power-sharing and creating room for different political interests to support NBS.

6.2 Support of NBS Realisation

While this paper has established that the realisation of NBS stems from successful links between knowledge and action, the practical implication requires considering obstacles within knowledge-action systems. In doing so, building on dynamic responses to such barriers is necessary.

Integrating the SWOT analysis to examine key lessons learnt from respondents provides an interface to inform the researcher on methods of bridging knowledge and action. Responses to the dynamic and iterative nature of knowledge-action systems within NBS are then recognised within the categorisation explored by van Kerkhoff and Lebel (2006). This translates to actions that may be leveraged (strengths) and those that can be further explored as opportunities to support NBS. This strategy also helps to reveal new learnings that, while highlighted in projects, may not be reflected in literature. These learnings can be added to the existing body of NBS knowledge to support wide-scale NBS realisation.

6.2.1 Strengths

Strengths are internal and often controllable positive factors that exist and are inherently built into NBS. This means that creating beneficial outcomes between knowledge and action can be influenced by engaging strengths associated with NBS projects.

6.2.1.1 Learning

The research conducted for this paper suggests that NBS projects positively draw on learning-based methods to support research-practice interaction for NBS realisation.

As part of this approach, adaptive management is a crucial characteristic of successful NBS implementation (**Learning 49**). Van Kerkhoff and Lebel propose this in response to barriers between knowledge-action systems, which limit wide-scale NBS realisation. This strategy is an enabler for NBS as the concepts are relatively new, meaning uncertainty is typical in project outcomes, particularly in different contexts. For NBS, adaptive management emphasises flexibility and resilience in response to uncertainties, particularly pertinent within the continuously changing and adapting systems where NBS are situated.

Using a proof-of-concept approach can also help to inform and optimise the design by evaluating opportunities and addressing uncertainties (**Learning 4**). While NBS are still relatively new, providing evidence for their success remains an essential component of projects. This is not as important in traditional solutions, such as dams, as there is an already existing evidence base that is commonly accepted by the industry. Proof-of-concept approaches through observation or learning-by-doing can help to generate confidence in stakeholders surrounding outcomes and minimise perceived risk to project owners and operators. Strategies that can be adopted include leveraging the learnings of similar projects and implementing pilot or smaller concept demonstrations to integrate and engage stakeholders.

This method of promoting confidence and reducing the perceived risk of NBS is not apparent within literature around ‘learning’. **Learning 4** recognises the importance of stakeholders while offering an approach that seeks to improve the relationships between stakeholders and NBS projects. It leverages the knowledge developed in other projects to create a sense of trust, increasing the opportunities available to select an NBS in the first place. This, in turn, increases the comprehension of NBS concepts and the capabilities they present to a context. This learning, therefore, takes a literal approach, linking the knowledge from projects directly to the implementation of NBS.

Learning 4 also alludes to the importance of understanding the system context and evaluating impacts to tailor the solution accordingly (**Learning 18** and **Learning 53**). System understanding is perhaps the most critical element of NBS projects as it involves recognising the social, political and natural systems influencing and being influenced by the project. While traditional solutions require contextual knowledge, they often resemble a ‘cookie-cutter’ approach that experiences little change between locations. By contrast, the success or failure of NBS depends on the natural system of the locality and therefore requires a far more profound understanding of these characteristics. The strength of NBS lies in utilising contextual differences to tailor the solution according to the site. This increases stakeholder acceptance of the project and the likelihood of success when responding to issues within the natural system.

Similarly, strengths are identified through educational tools which help to foster social learning (**Learning 76**). While government mandates or standard approaches do not cover NBS, interactive education helps to build stakeholder understanding of the capabilities and benefits of NBS and enthusiasm towards the process. These interactions can also provide access to local knowledge, which is critical for system understanding. By facilitating the provision of education, concept understanding, and the ability to receive local knowledge, this tool can help to address the barriers between knowledge and action concerning what knowledge is needed and what is required. **Learning 76** highlights the fundamental role of stakeholders’ knowledge in typically community-integrated projects such as NBS. This aligns closely with Van Kerkhoff and Lebel (2006). They flagged the role of social-based learning in enhancing innovations and knowledge by highlighting the value of individuals’ contributions within knowledge-action systems.

A project's success depends on its objective and the intended outcome. Monitoring and management help to verify whether a project is moving towards its goals (**Learning 84** and **Learning 86**). Currently, monitoring processes are undertaken primarily for maintenance rather than learning and improving NBS knowledge pools. Engaging in these management systems from the beginning of a project encourages the documentation and recognition of knowledge for future use. This is again particularly relevant for NBS due to the number of uncertainties or new concepts involved in its implementation. However, enforcing the monitoring of learning on projects would require improved political and financial commitment from high-level actors.

6.2.1.2 Integration

According to the results, integration methods are associated with strengths relating NBS knowledge and action. These approaches support responses to fragmented relationships between knowledge developers and their user communities, positively benefiting NBS projects due to their highly contextual nature.

Strengths include the ability to develop mutual benefits and demonstratable outcomes to secure project funding (**Learning 25**). The development of mutual benefits is a characteristic that can be leveraged to gather support for project financing, enhancing the ability to fund and implement an NBS project. This concept goes beyond the financing methods of traditional solutions, which primarily seek government-only or market-only funding. Unlike traditional solutions, NBS can meet multiple objectives within a single solution, providing mutual benefits for different stakeholders within the community, market and government.

Learning 25 builds upon the existing knowledge base surrounding integration using structural, institutional and governance issues. It seeks to link knowledge and action by targeting and demonstrating the strengths of NBS to finance implementation. This approach utilises the integration of stakeholders through ‘buy-in’, relying on stakeholder perceptions to fund NBS realisation.

For NBS, the intention to expand implementation across contexts makes the concept of integration particularly relevant as it speaks to geographic scales, jurisdictions and research-user chains. To adequately address the differences between these arenas, understanding and respecting local knowledge is critical for NBS (**Learning 34**). NBS is intertwined with the local context through social and environmental systems. This makes the need for system understanding unique to this type of project. Further, the differences between these systems lend value to local stakeholders who possess comprehensive knowledge of the specific context and natural processes. Integrating local stakeholders within project processes helps gather this local knowledge and better understand the context.

As NBS remains on the outskirts of mainstream infrastructure, unforeseen circumstances are more likely to occur with more uncertainties. Stakeholder and team cooperation has been found to help overcome these occurrences (**Learning 56**). In this, working across different scales with a mindset of collaboration can appear as involving stakeholders across spatial regions or political levels in initial planning, consultation and design processes. This may help identify complexities early in conception and create a perception of mutual ownership and, thus, responsible for the project's success.

Another strength of NBS is the ability to design a solution based on system understanding, transcending the physical environment (**Learning 100**). It is critical to ensure that a solution such as NBS addresses the fundamental issue at hand; however, these may not always appear in a physical sense. Strategies involving social and economic reform may be required to assist the solution's success. NBS can combine efforts outside of a physical environment based on the need of the context. This is particularly important across geographic scales where cultures operate in contrast.

Calls for integration in research have often been initiated by people or groups who are not active researchers. As highlighted throughout this paper, practical execution and research can create mutual benefits by creating and sharing valuable knowledge to improve realisation processes (**Learning 101**). This can help to strengthen links between knowledge and action in a literal sense. In NBS, integrating research within project scopes increases the capacity to extract new knowledge and build upon existing knowledge. This is advantageous in developing more diverse and comprehensive knowledge bases to address the infancy of NBS concepts in mainstream infrastructure.

6.2.2 Opportunities

Opportunities are positive external factors that exist but are not inherently built into the process of NBS implementation. While this means the ability to directly influence outcomes may be limited, opportunities assist in understanding external factors in NBS that can be explored and utilised to relate knowledge and action.

6.2.2.1 Participation

Opportunities within NBS projects were associated with actions akin to ‘participation’. Participation refers to how stakeholders not typically involved in NBS become involved. This can be useful to enhance public participation, strengthen informed decision making and foster action towards sustainability.

Methods of participation present opportunities for the initiation of NBS through the use of expert and local knowledge (**Learning 22**). This learning recognises the benefits of stakeholder knowledge which aids in exploring alternative functionalities, adding benefits and cost savings to design. Seeking knowledge from key stakeholders early in the initiation phase of an NBS project can help reveal less readily available knowledge sources. This can also create insight into contextual systems such as governance systems, which are critical in navigating political procedures to implement new projects in different contexts. With multiple knowledge streams comprising numerous stakeholders, this opportunity can also help address issues with comprehension and acceptance of knowledge by increasing contextual input and integration into knowledge.

The participatory approach also acts to develop practices that are of interest to all parties involved. The participatory approach can apply collaboration methods such as site visits and joint meetings, which enable stakeholders to develop shared visions for the project. A diverse support base is important as community and decision-maker willingness for change and commitment to the project is critical for NBS success (**Learning 46**). Creating room for different interests within the project by working with these stakeholders helps to make stakeholders feel ‘heard’. These objectives must be balanced; however, the opportunity to gain crucial project support can reduce barriers to realisation at different project stages.

The importance of securing stakeholder support, particularly from the community and decision-makers, has not yet been emphasised in the literature surrounding participation, focusing on strategies to encourage participation instead. **Learning 46** highlights the critical preliminary element to encouraging participation within NBS projects to link knowledge and action. This concept must be secured first to create a sense of responsibility, after which participation in building partnerships and developing system understanding can begin. This could be achieved by investing more in stakeholder engagement earlier in the initiation process and regularly through to realisation.

To improve the success of this strategy, opportunities exist within NBS to engage or partner with local institutions on the project who already have an established network within the context (**Learning 72**). Utilising these partnerships improves stakeholder engagement, which is vital for system understanding, project support and the general success of the solution. This method of participation can improve integration between project goals and the desires of local communities (Short, Clarke, Carnelli, Uttley & Smith, 2019). It also helps to develop local stakeholders' trust in the project.

According to Barton & Trusting (2005), collaborative processes involved in participatory methods help to develop learning through involvement in action, communication and negotiation. This aligns with the opportunities available in local stakeholder involvement to translate contextual knowledge through their understanding of the system (**Learning 92**). Shared processes developed through participation foster regular and directed interactions with local stakeholders, which can help to address complex issues on a wide scale (Short, 2015). Once again, as NBS concepts are still in their infancy, the participation of local stakeholders, such as community members and local experts, adds depth to the knowledge base, increasing the breadth of understanding of particular contexts. This opportunity presents itself within NBS as its realisation is a collaborative, iterative process that recognises the influence of and on local stakeholders, somewhat unlike traditional solutions.

6.2.2.2 Negotiation

Within NBS, opportunities to support NBS were also highlighted under the theme of 'negotiation'. Approaches surrounding negotiation seek to relate knowledge and action through power sharing. This attempts to respond to barriers between different knowledge coalitions within NBS.

Decision makers significantly influence infrastructure implementation and thus must act as advocates for NBS (**Learning 17**). This comes in the form of both financial support and influence on policy. Within negotiation, a key factor is the existence of advocacy coalitions that bring together stakeholders, including knowledge creators. While valuable knowledge is developed within NBS projects, it cannot be disseminated without trust or a platform. This learning reflects an opportunity to encourage decision-makers' participation within advocacy coalitions. This will help to stimulate the implementation of NBS through the verification of knowledge by trusted authorities and by making the knowledge official within national policy and standards.

Despite this, it is recognised that priorities can differ between stakeholders. Particularly to foster the wide-scale realisation of NBS, different priorities between stakeholders and scales exist as barriers in NBS knowledge systems. This is relevant for NBS as opportunities to implement this solution type are highly contextual. With stakeholder support crucial for NBS implementation, developing mutual goals can foster cooperation between different stakeholders (**Learning 20**). A characteristic of NBS is integrating multiple objectives into the same solution. This advantage can be utilised to target stakeholders at different levels that may be limited in their support for the solution.

The benefit of this opportunity comes with the cooperation which results from the integration and shared responsibility of multiple stakeholders. This approach allows stakeholders with different viewpoints and interests to develop data, analyse facts, and cultivate common and informed assumptions to reach decisions together (Klijn & Edelenbos, 2007). The connections formed give specific knowledge impact within different coalitions. This responds to the barrier of miscommunication between the knowledge produced and the knowledge required, nurturing collaboration and creating shared understanding within and beyond the NBS project.

While developing mutual goals is crucial, it implies stakeholders operate in a positive environment. Management and coordination within NBS projects help maintain good relationships between team members and external partners (**Learning 38**). This strategy acts as an opportunity to create these positive environments, fostering cooperation between stakeholders. Through this approach, developing mutual goals and strengthening the overall team are critical factors for project success.

While **Learning 38** has not been defined in literature around negotiation, it relates to the idea of power-sharing through managing and coordinating stakeholder roles and responsibilities. The difference presented by this learning is that it begins from a position external to the implementation of the project. The learning highlights the importance of using a managerial and communications position to foster stakeholder negotiation and interaction. Strategies such as collaborative dialogues can facilitate communication between actors, thereby assisting in exploring this opportunity.

6.2.3 Emerging Concepts

Using literature to explore strengths and opportunities within NBS projects helps to highlight learnings that may add to the existing body of knowledge. In a practical sense, this identifies new learnings that can be used to support NBS realisation. Based on the discussion above, four learnings have been determined to suggest unique insight within participation, integration, learning and negotiation categories.

Learnings 4, 25, 38 and **46** present new knowledge that can be added to the existing knowledge base within the field of NBS, explicitly relating to NBS realisation. These learnings appear to be commonly targeted toward developing positive perceptions in stakeholders to create successful project outcomes. This is done using demonstratable results, relying on existing knowledge, providing mutual benefits, managing relationships and engaging community support and decision-maker commitment to project outcomes.

Chapter 7. Conclusion

This research paper supports the idea that a critical obstacle in the realisation of NBS is the inadequate interaction between knowledge and action. Boundaries between knowledge and action limit the availability of widespread and in-depth information, hindering the realisation of NBS. This idea considers the complexity-oriented perspective of knowledge systems, containing multi-disciplinary stakeholders who participate interchangeably between knowledge creation and application in multiple contexts.

Using the knowledge of critical stakeholders within BwN projects, this thesis sought to identify key lessons learnt in NBS projects that are driving the realisation of NBS (research question one) and approaches to support future NBS realisation (research question two). Utilising these learnings in conjunction with the theoretical categories developed by van Kerkhoff and Lebel (2006), the researcher highlighted approaches to overcome obstacles between knowledge and action and drive NBS realisation. The SWOT methodology was used to pinpoint key lessons learnt based on those identified under the themes of strengths and opportunities. Strengths comprise internal and controllable positive factors that can be built upon within NBS projects. On the other hand, opportunities are external and uncontrolled positive factors that present elements to be explored further to support their implementation.

The outcome of the research conducted for this paper has highlighted strengths that support the realisation that NBS are associated with learning and integration. Methods of integration create links across social, physical, and political contexts. Learning methods will aid in developing relationships between knowledge developers and their user communities and engagement between researchers and practitioners.

Lessons learnt that are considered opportunities are associated with actions based on integration and negotiation. This implies that NBS projects can further benefit by improving methods linking knowledge and action through integration and negotiation. Precisely, opportunities lie in facets of relationships between knowledge developers and their user communities and by creating room for different political interests.

This research explored the challenge of overcoming the obstacles between knowledge and action in the context of NBS. This paper adds to the existing knowledge that addresses these obstacles by analysing lessons learnt using literature. It categorises strengths and opportunities against strategies to overcome boundaries between knowledge and action. These enablers to NBS realisation are compared to existing literature to reveal new learnings. From this, four learnings were identified as supplementary to existing knowledge. Sitting within the categories of participation, integration, learning and negotiation, these learnings prioritise the development of positive perceptions and relationships in stakeholders to relate knowledge and action. To do this, they highlight the benefits of using demonstratable outcomes, relying on existing knowledge, providing mutual benefits, managing relationships and engaging community support and decision-maker commitment to project outcomes. To expand on this, the four learnings determined to add to the existing body of knowledge include:

4. Using past designs and pilot research as examples can be beneficial to help address uncertainties, optimise future designs, and evaluate problems or opportunities. Solutions that are trusted and demonstrated are more likely to be selected.

25. To secure funding, projects should have feasible and demonstratable outcomes and provide mutual benefits and objectives to actors.

38. Management and continued nurturing and coordination are important to maintain good relationships between teams and external partners.

46. Successful NBS implementation requires a willingness from the community while the decision-maker commitment to project outcomes.

While this research is valuable, many facets are yet to be explored. Several areas cannot be expanded in this paper to the extent necessary. Further work is needed to scope, develop and implement tools using integration, participation, learning and negotiation methods to support NBS realisation. Research opportunities include developing databases of NBS knowledge from past and active NBS projects. Understanding the quantifiable benefits of employing integration, learning and negotiation methods to link knowledge and action is another area of further investigation. Further research could explore the learnings gained from this thesis and quantify them to highlight existing relationships that may occur across the various stages of each project.

Although there are many ongoing areas from which research can be continued, it is essential to note that the outcomes have provided insight into the interactions within knowledge systems. In addition to identifying key learnings to add to the existing knowledge base, this paper has helped to identify more expansive action areas that may help support NBS realisation. In doing so, the issue becomes more approachable and NBS outcomes more attainable.

Based on these efforts, stakeholders can prioritise resources for particular approaches within NBS projects to support links between knowledge and action. Support could include funding coordination and communication roles to maintain team relationships and providing concept demonstrations to foster confidence in solutions. Additionally, this thesis identified relationship and communication management and practical demonstrations or trial areas that finances can target to support NBS realisation. At NBS conceptualisation, actors within project teams can assess the learnings developed within the SWOT table against known characteristics of the project. This process can help highlight gaps in project processes and allow resources to be directed to them before commencement. Alternatively, the comprehensive table of lessons learnt outlined in the framework established by Raymond et al. (2017) (Appendix 5.1) can be used as a list to confirm that the project elements meet these learnings. It is essential to be aware of the project processes that occur across each stage of realisation (Identifying the problems and opportunities, Selection and assessment of NBS, Design of NBS implementation process, Implementation of NBS, Stakeholder engagement and communication of co-benefits, Monitoring and evaluation and Transfer and upscale NBS). Utilising this framework will provide a logical approach to producing successful outcomes. Successful outcomes in the context of NBS are fulfilling the objectives determined for the project, which could involve effective storm surge protection, local economic stimulation and increased biodiversity. The Marker Wadden project exemplifies this with the fulfilment of its objectives and positive reception from the community, decision-makers and relevant organisations. It is intended that future efforts will benefit from these foundations to assist in the widespread realisation of NBS.

Chapter 8. Critical Reflection

The following chapter reflects the limitations and opportunities of the results analysed in this thesis. Regarding the analysis of lessons learnt, it must be noted that it was not part of the scope to explore and divulge their meaning. This project intends to gather and document lessons learnt for future NBS projects. The second intention was to discuss how this research could help contribute to stakeholders' support of NBS implementation and realisation in different contexts. This is done through the analysis of learnings based on theoretical frameworks. Further research could use this gap to compare lessons learned between different project contexts to identify disparities in intentions, perceptions, assumptions and methods of successful NBS realisation.

The success of NBS implementation relies not only on the transfer of knowledge; in fact, many factors are interwoven. Due to the complexity of this subject matter, this thesis negates the exploration of several factors within NBS that impact the success of implementation. This includes management roles, political arrangements, and financial barriers. Rather than singling out these variables, this thesis focuses on the broader subject matter of stages of implementation and allows the integration of variables to be revealed through the analysis of results.

For case studies, each project was at a different stage of realisation, and thus inconsistencies may be present in the knowledge collected. In parallel, the analysis of cases at different stages of implementation could also offer complementarities to implementing these projects. As such, this could be useful for future NBS research and implementation.

The cases studied were situated in contexts that were not examined in detail, and therefore the nuances of the political, social and physical environments were excluded in this thesis. The thesis instead focused on the ability to support NBS realisation through knowledge rather than creating a representative example of successfully transferring knowledge for NBS realisation. In excluding these variables, the research creates a more generalised overview of learnings within NBS and how realisation may be supported by knowledge and its transfer.

An opportunity for further research is presented here. An in-depth research topic may focus on the specific conditions within which these projects were based. This could examine how these contextual characteristics may influence the ability to transfer knowledge and support NBS realisation.

Finally, while using the SWOT analysis considers lessons learnt across strengths, weaknesses, opportunities and threats, only strengths and opportunities are further analysed to support NBS. Despite this, weaknesses and threats in this context highlight areas considered obstacles to NBS implementation. Future research could explore the categories and approaches to addressing them in a similar method used in this thesis to provide additional value to the objective of widescale implementation.

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Chapter 10. Appendices

Appendix 3.1

Interview Guide

Part One: Lessons Learnt	
1 **2**	How was the particular project problem evaluated, and any potential opportunities identified? How were possible alternative designs assessed, and what were some key learnings that improved the process?
	Processes for evaluation of possible solutions (transdisciplinary inclusion, management of uncertainties) *The perspective of the importance of players/actors* *Alignment of project objectives with wider community desires*
3	What factors do you consider most important in influencing the selection of a Nature-based Solution as opposed to a traditional solution?
	Risks involving natural dynamics, financing the NBS – cost-effective, maintenance considerations for future
4	In a Nature-based project, what would you consider key characteristics that would determine its success?
	Team composition, financing, long-term perspective, planning framework *Diversity of knowledge systems* *Organisation of dialogues between stakeholders/actors*
5	During the project, what were some unanticipated circumstances and how were these overcome?
	Management of difficulties, challenges related to permits/EIA, optimisation of processes/materials, adaptation to system dynamics *Negative perception of stakeholders*
6	What are some key learnings regarding stakeholder engagement and how it was conducted?
	Importance of stakeholder inclusion *Findings for increased support*
7 **8**	If the project was to take place again, what would you do differently at each stage? *(FOR MORE DETAIL: for example, project initiation, implementation or maintenance)* From your perspective, what are the best ways to ensure the success of project objectives? (monitoring)

	Monitoring *Process of evaluation and measurement of objectives* *Barriers*
9	What 'best practices' from the project could be useful in future projects?
	Communication of benefits *Role of learning on project* *Partnerships with stakeholders*
Part Two: Translating knowledge (*Perceptions of effective knowledge*)	
10	*What knowledge would you consider most relevant for someone of your profession, for an NBS project?*
11	*What characteristics would you consider to be important for credible or quality information?*
12	*For project outcomes, what characteristics ensure their legitimacy or trustworthiness?* *In your opinion, what are the best ways to ensure that views and concerns from diverse actors are respected or considered?*

Appendix 3.2

Integrated Framework

Stage	Description
1: Identification of problem/opportunity	*This stage is associated with the identification of the needs or challenge areas that the project addressed. Identify realistic alternatives that provide true win-win solutions providing services beyond mitigation and compensation, that make use of the system's potential. Valuate the NBS alternatives and compare them with traditional designs.*
2: Select NBS and related actions	*Stage 2 surrounds selecting preferred alternative strategies within a given scope. It discusses the identification of project objectives and how they were drawn. This stage links how the project actions ensure the effectiveness of the solution.*
3: Design NBS implementation process	*This stage focuses on utilising natural processes as an integral part of strategies to be developed. This stage focuses on longer-term, incremental development, and adaptive management, with financing strategies an important component.*
4: Implement NBS	*This stage discusses the approach to project execution itself. It involves careful selection of materials and optimisation of the design layout. Within this stage, experimentation and adaptive project management is encouraged. This is for the management of uncertainty in the project, management of negative perceptions from stakeholders, and actions of successful NBS projects.*
5: Stakeholder engagement	*This stage is considered as 'stakeholder engagement'. It explores how stakeholders are involved in the project and what methods are used to engage them. Involvement of stakeholders in this process helps provide project support and cooperation.*
6: Monitoring and evaluating benefits	*This stage comprises the realisation phase and ongoing monitoring and maintenance. Considering these aspects early in the implementation process can optimise the design, reduce lifecycle costs, and allow for incremental adaptation to changes in system dynamics. Evaluation refers to how project benefits and objectives can be assessed. Stage 6 explores methods and indicators of how to measure and monitor the benefits of NBS actions.*
7: Upscale and transfer	*This stage looks at processes and characteristics in implementation that may support upscaling NBS. It also discusses the value of learnings that feed into mainstream processes.*

Appendix 3.3

Code Book

Category	Themes
1: Identification of problem/opportunity	*Problem/Opportunity* *Initiation* *Comparison of proposed solutions*
2: Select NBS and related actions	*Project objectives* *Selection Criteria* *Financing* *Risks*
3: Design the NBS implementation process	*Multidisciplinary team engagement* *Team composition* *Partnerships*
4: Implement NBS	*Problems encountered* *Actions to achieve objectives* *Perceptions towards a selected solution* *Learnings through implementation*
5: Stakeholder engagement	*Stakeholder Engagement* *Community Engagement* *Communication methods*
6: Monitoring and evaluating benefits	*Confidence towards the outcome of the solution/Determining success of the solution* *Actions to amend in future projects* *Value of monitoring* *Barriers for monitoring* *Learnings for monitoring and evaluating benefits*
7: Upscale and transfer	*Best Practices – Planning and preparation, stakeholder interactions and transferring* *Mainstreaming* *Barriers for Mainstreaming* *Learnings for upscaling and mainstreaming*

Appendix 3.4

Stages of NBS	Marker Wadden, Marconi Delfzijl and Hondsbossche Dunes
Identify problem or opportunity	**Problem/Opportunities:** • The need for projects such as these is highly context-dependent. In the Netherlands, project opportunities largely surround the need for flood defence, however identifying opportunities can differ between countries. • The Marker Wadden project began due to the concern and data showing the degrading water quality and ecological quality of the Markermeer, together with the wish of an NGO to create a new nature area. It provided a win-win situation, since the hypothesis was that the islands would improve the water quality and give a boost to the lake's ecosystem. The primary issue in the area of Delfzijl are rising sea-level coupled with land subsidence due to gas extraction. The Marconi project was initiated due to a need to address flood safety, dredging issues and social livelihood issues associated with economy, recreation and nature improvement. The project allows us to investigate how to accommodate and allow for the growth of new salt marshes, using dredged sediment. • The Hondsbossche Dunes project began due to identified weaknesses in flood protection which required amendments. **Initiation:** • Investigating solutions requires many discussions and exploration from different angles. An integrative and multifunctional approach is characteristic for NBS projects. Just like other large infrastructure project, this requires a long process of involving stakeholders to identifying desires, commitments and demands of relevant parties. These insights are important for developing an integrated plan and initial designs. • In evaluating the problem or opportunities, use research, revisit past designs and include meetings to discuss ideas. It can be helpful to find a need to fit the objective. Adding further objectives such as … can bring support (examples what type of support), however when this support does not involve funding it is important to consider how to finance these extra objectives of project. • Regarding financing, it is important to invest finances on the project itself and its execution, not only on initial concept phases. Beginning as quickly as possible will aid in this: Once the project starts to take form this might stimulate other actors to finance the upcoming phases of the project. Moreover, it will add to practical knowledge. **Traditional vs NBS** • The benefit of NBS as opposed to traditional solutions is primarily associated the ability of NBS to effectively meet a number of objectives and added values within a single solution. This is particularly useful when factors of livelihood and improvement of environmental values are concerned. • Added objectives can accelerate project realisation due to added support (e.g. financial or political) for the project, in addition to being cost-effective. NBS can also function as a space for experimentation and learning for new concepts and new areas. • While traditional solutions only consider effects on nature after design (minimise negative side-effects), NBS optimises between technical solutions and uses natural dynamics and has a positive effect on nature at the beginning and throughout its lifetime. • The selection between a traditional and a nature-based solution depends largely on three factors; the project purpose, the available finances or cost, and the context. NBS is not always the best solution, nor does NBS have to be a core objective of the project. To assess the best solution, you must understand the project purpose, have good system understanding (natural, social, economic) and consider the impacts of possible solutions to the surroundings. • When solutions are proven, trusted and hold past knowledge, they are more likely to be selected. • Decision-makers have significant influence in the selection of an NBS in that they must be willing to explore alternative options and act as advocate to promote NBS towards financers and (other) policy-makers.
Select and assess NBS	**Objectives:** • Project objectives clearly differ between contexts and priorities differ between stakeholders. Acknowledging and understanding these wishes and cooperation to find win-win solutions, is important to form objectives. • The objectives of the Marconi project were: the reuse of trapped sediment; flood safety; increase livelihood of the area; and improved links between the town and sea. The project itself was developed to show the benefits of NBS which in the future may be used as a standard approach to flood safety. • The objective of the Marker Wadden was primarily to improve the ecological system of the Markermeer. Additional objectives surrounded recreation, connection between society and nature and innovation. • The objective of the Hondsbossche Dunes was to increase flood safety to meet the national safety standards, and to provide added value for nature and provide recreation opportunities. **Selection criteria:** • The selection of NBS designs largely depend on how they fit in with the local context and surroundings and how effectively they address the core objectives. Past projects often influenced this selection. • For the Marconi project, the design was selected based on the room and availability for added values and objectives. Considerations surrounded the effectiveness of solutions, the risks or complexity of design and the practicality of how it would be realised. • Regarding practicality, on Marconi, the experimental setting of NBS allowed exploration of how to address uncertainties for future designs. Attention was given to the level of variability in design, which leads to complexity and can add risk. • For Marker Wadden, the design was selected based on landscape quality, innovation, design quality, and value for money and division of responsibility. **Financing:** • In securing funding, the project team must have the right objectives, the necessary actions to reach objectives, and understand the benefits of the outcomes. An accurate calculation and estimate of the amount required, including risk is necessary to approach parties with justification for funding. Securing funding is often a one-off process; securing additional funding with the same funding institutes is more difficult and not appreciated by those parties.

	Risks: • The biggest risk on the Hondsbossche Dunes project largely surrounds the maintenance requirements associated with the sand dune and maintaining its safety and integrity. In this context, the client accepted these risks as the advantages of the sandy solution outweighed the disadvantages. It is believed that successes of previous sandy projects and that it fits in the adjacent landscape of sandy dune coasts led to the progression of the Hondsbossche Dunes. • It is important to consider all possibilities when it comes to risks. On Marker Wadden no one had considered the possibility of fire which occurred, and so were not prepared. This is possibly because there was little resistance meaning some risks were not considered • Risks can involve working in outside areas where nature and natural processes are less predictable. Lack of understanding of their influence can create problems.
Design NBS implementation process	**Multidisciplinary team engagement:** • In these projects, a multidisciplinary environment where the team cooperates and can develop and share common goals, is important. Cooperation is particularly imperative for decision-makers/authorities between different ministries to achieve mutual objectives. As such, it is useful to have someone to manage and maintain good partnership between various actors. • Success is determined by cooperation of the project team, clear objectives and consideration of the desires of all parties involved. The commitment and mentality for the pursuit of success must come from the entire team, particularly high-level players (decision-makers). • In team interactions, there must be room available for communication and discussion around potential disagreements. It can be useful during initial phases to involve team sessions to get everyone on the same page regarding project planning. Everyone should be given room to formulate their own goal which can then brought to a consensus. • Be prepared to have difficult conversations as there may not be total agreement beforehand. People will have different views, so room must be given for those discussions and facilitate cooperation to come to a solution. • It is useful to have close cooperation with organisations that understand political processes and bureaucracy. This helps to understand procedures to follow. Further, cooperation between organisations with different expertise can facilitate better the consideration of added benefits or values. • **Team composition:** It is useful, particularly in a multi-actor team, that roles are allocated based on the expertise of an organisation. Having team members with prior experience in NBS project is beneficial to shape and optimise the design and project systems. Governance experience is also valuable for the process of stakeholder engagement. • **Team dynamics:** Investing in forming a good team overall at the beginning of the project is important, both within the execution team, and between partners. A diversity of team members? must be recognised, which requires a setting that fosters cooperation between entities, not competition. There must be a good dynamic between team members, recognising and appreciating the different organisational cultures. **Partnerships** • Partnerships are beneficial to provide complementing skills or expertise to partnering organisations. Governments have experience with infrastructure projects while NGO's typically possess knowledge of the system dynamics and an understanding of stakeholder communication. • On the Hondsbossche Dunes project, the team reported to two bosses; the government and the waterboard, which was very difficult. If it is not necessary, it is not recommended. • Projects benefit when there is a singular organisation or representative with authority over the location of the project. Challenges evolve when multiple authorities are involved or private land ownership is the dominant occurrence. • Forming relationships with teams and partners is important from the beginning. Having teams (both with partners and contractors) work in the same building for portions of time and fostering empathy between partners by understanding respective business environments can help in achieving mutual goals, cooperation and understanding of each other. • In the Netherlands, cooperation or partnerships between authorities (RWS and waterboards) and other actors (public entities, NGOs), is common to aid in creating added value. Marker Wadden is a Public-Private Partnerships between NGO and Government which worked really well.
Implement NBS	**Problems:** • It is important to understand that unexpected events can occur in all projects, particularly in projects with a lot of uncertainty or experimentation such as pilot projects. To overcome problems, teams must invest in cooperating and evaluating solutions together. • NBS can be more costly than traditional solutions. Due to the nature of NBS it is important to consider each phase of the project comprehensively to avoid unforeseen costs. Financial aid can be sought from partnerships funds or charities available for these project types. The EU has a number of funds for nature-projects, while the Netherlands also has a number assigned to the revitalisation of certain areas. • On Marker Wadden, it was difficult to align the major project objectives of research and execution due to the focus on execution. Having multiple objectives could create difficulties for financing as funding of the research is completely different to the funding of the project execution. • It is important to facilitate communication between project teams to reduce potential issues/clashes. On Marker Wadden, the speed that the contractor worked at caused issues to align the research programme with the execution of the project. • It is important to understand the capacity of the contractors used. On Marconi, the contractor lacked experience in this kind of work and as numerous processes were dependent on the contractor, the project experienced some issues regarding the construction (see problems-project specific for more details). • Issues can be encountered relating to competition around knowledge sharing between private organisations working on the same project. Lack of communication can also result from these dynamics. On the Marker Wadden project, this occurred due to the separation of the research and construction contracts which lead to frustration for both groups. **Problems - Project specific** • The execution of the Marconi project was very difficult. Homogenously combining sand and watery sludge, particularly in tidal areas was too complex for the contractor. The contractor lacked experience in this kind of work and as numerous processes were dependent on the contractor, the project experienced a number of building issues. • On Marker Wadden, the objective of trapping soft sediment to use for future eislands was unsuccessful, which means resorting to other available resources to build future islands. Recreation was possibly too large of a success which caused issues with too many visitors and the waste they leave behind. • On the Marconi project, during construction, geotechnical conditions were found to have insufficient bearing capacity for the purpose. Typically, this is checked early, however, here it was taken for granted. • On the Marconi project, the execution was very difficult. Homogenously combining sand and watery sludge, particularly in tidal areas was challenging and complex, particularly beyond 20% silt. To go beyond that was nearly impossible. **Learnings:** • Constructed dunes have been proven to perform comparably to natural dunes. For future projects, dune construction can be lowered to account for natural growth.

	• It is useful for the realisation of future NBS projects, to relate and compare outcomes to natural processes. • For the construction of a new saltmarsh, silt is required to be mixed through, at a minimum of 20%. Higher percentages increase costs and complexity so use the lowest viable percentage. • Saltmarshes only help in lowering wave heights, if there is a very long foreshore. • It is important to be aware of the capabilities and skills of all involved (design and construction), including contractors, in addition to being aware of the presence of natural systems and conditions. Having a plan or theory of how to achieve an outcome is one thing, but physical execution is another. You must consider the feasibility and practicality of project actions and processes **Actions to achieve objectives:** • To achieve objectives, there must be consideration of people, planet and profit, however their order of priority varies between contexts. While there might be conflict between these concepts, the key is finding the best possible balance for the context. • Objectives must be clear and understood at the beginning of the project; determined by seeking a balance between all stakeholder intentions. The goal is to design a project which fits all desired and necessary objectives, not to fit the project within a budget. To do so, sufficient budget must be created at the beginning. • To avoid barriers for NBS implementation, such as resistance, it can be helpful to frame outcomes and objectives with respect to the priorities of the contextual environment. • While a project may have multiple objectives, it is important that there is only one overarching goal. Limitations in several areas are likely to result by not prioritising one singular goal. • It can be valuable to consider the use of existing available infrastructure in addition to collaboration with potential neighbouring projects which can help lower costs. • When designing, it is important to consider the surrounding processes and the system being working in and how to deal with these uncertainties in your design. Nature is always changing, and it must be worked with. Settings such as geotechnical conditions, wave heights and current flood stage, and their external impacts on design are all important considerations. • Having a very good monitoring plan is imperative. Decision-makers and clients must understand that monitoring is vital for project success, not an optional add-on process after the execution. • With innovation as an objective, involving universities can develop many new learnings through the project. • Adaptative management is important for BwN as there is always uncertainty. The key for ensuring safety and stability of solution is flexibility by monitoring the solution and having the ability to intervene if necessary. **Perception:** • It is common that people may be against a solution or afraid of change at the beginning of a project. Often this resistance decreases or disappears throughout construction, particularly if people are able to see what is being done. The public can often be receptive to the project when it adds value to livelihood and nature. • Reasons for possible resistance, particularly from environmental groups, often surround the particular existing state of conditions of the environment and the zoning location of the project.
Stakeholder engagement	**Stakeholder engagement:** • In stakeholder engagement, it is important to involve all relevant stakeholders for the project context in a positive way, giving them a position from the beginning preparation works. Widen fields to engage with stakeholders and take them seriously. • It is important to understand and highlight what each party wants to achieve. This way, the project can be guided in a way that contributes to these objectives, balancing what the desires are and what can be achieved. At the beginning however, an ultimate goal must be agreed upon which aids in cooperation to achieve mutual objective. A steering group enabled this communication and allowed for monthly progress updates throughout. • While not every voice can be heard, one must consider the most important voices and be wary of larger stakeholders who may drown the voices of smaller parties. • The project team must be sincere, transparent about the project purpose and honest when someone’s interests cannot be reached. It involves being open to stakeholders and being reliable by following through with promises made. By doing this, resistance will often disappear. • In stakeholder engagement, it is important to plan for future processes and provide information on a regular basis. Also be sure to keep home organisations and those responsible for maintenance, well informed. • On Marker Wadden, all relevant parties agreed at the beginning to have no official meetings, but only meet when there is something important to discuss based on identified interests and available knowledge. • Make use of available or existing community stakeholder programs, for example on the Marconi project; *Economy and Ecology in balance.* • Depending on the complexity and available budget of the project, having a separate partner to conduct stakeholder engagement and to be the spokesperson can be useful. This practice was quite successful in allowing the team to focus on other issues and reduced debate of competing agendas and interests • In stakeholder engagement, it was useful to present from the perspective of the other’s organisation. This helped to change our mindset, allowing us to view from other perspectives, more understanding, be less bias and provide more detail to stakeholders. **Stakeholder engagement - Methods of engagement** • Making the project a showcase or public attraction by investing in publicity and PR can increase project support. A way this can be done is through media platforms, project ambassadors and visitation aids in engagement and providing education materials on the process. This can increase enthusiasm about the project, communicate objectives and purposes, promote the project’s benefits and appeal, encouraging visitors and can change the attitude of resistance towards the project. **Stakeholder engagement - Interaction** • It is important to communicate and interact with stakeholders during design. This does not necessarily have to be bad or have an impact on the effectiveness of major objectives. Primary objectives can still remain while benefits may be added by exploring alternative functionalities in design, and cost-savings that stakeholder knowledge can offer. While this can be an intensive process, it is really valuable, particularly for stakeholder appreciation and support, in addition to design benefits. • In encouraging stakeholder involvement, it can be useful to frame the benefits to decision-makers, such as increased local support which is important for politicians.
Monitoring and evaluation	**Determining success:** • The success of the project is determined by the defined project objectives and the defined purpose. For an NBS project, they should be multi-functional where success typically means it using natural systems or considering nature alongside other objectives, however this varies. It is important to be curious about project outcomes to encourage success. • To determine success, a risk assessment must be done based on the main problem to be addressed and objectives of the solution. Monitoring can then be used to assess whether it is effective. I would say that it is important to assess the effectiveness of NBS the same way that traditional solutions are assessed against e.g. flood risk reduction. Of course you can add other objectives in your assessment such as the use of natural processes.

	• For salt marshes, they should be able to automatically generate while sand dunes should act as they do in nature. Solutions should use natural processes serve the intended function for e.g. flood protection. **Monitoring:** • Monitoring spanning 10-20 years with yearly updates could provide vast information. • On the Hondsbossche Dunes project, monitoring of the morphological changes was intensive with aerials and lidar done 4x per year. In addition, ecological monitoring took place. After two years, this was re-evaluated, and changes were made in cooperation with RWS and considering available budget. Further, each year, the team assessed the needs of the program to meet objectives. • On the Marconi project, monitoring captured both scientific and project specific learnings. • It is vital that a very good monitoring plan is in place. To ensure the success of the project to meet the objectives, monitoring and regular presentation and review of results is useful. While some results can be seen in a short period of time, to investigate uncertainties will take longer. On Marker Wadden, we expect the real evaluation of objectives to be over a five year period. **Monitoring - Barriers for monitoring** • Barriers for monitoring largely surround financing and lack of available budget for scope expectations. A lack of purpose or objective of the monitoring program can also limit the usefulness of monitoring outcomes. Finally, a lack of available information/data from projects can severely impact monitoring success, particularly if monitoring is not implemented from the beginning of a project. • In the Netherlands monitoring is not commonly done for lessons learned, but rather for maintenance purposes as it is considered unnecessary. As such, there must be more commitment, particularly from decision-makers, in investing and allocating finances in monitoring for learning for future projects. **Do differently:** • On NBS, it is important to recognise the possibility of the creation of new assets. In this, it is recommended to evaluate and assign responsibilities of new assets early in the process. • It is good to consider combining the construction of all project packages into one, to prevent delays to subsequent processes relying on construction (Marconi). • On the Marconi project, a different execution process for mixing sediment could have achieved a more homogenously mixed product and geotechnical information should have been obtained beforehand. • On future projects, better scope should be available which includes good monitoring systems and data management systems to begin at the start of the project to aid learning processes and understanding effects on project surrounds (Marker Wadden).
Transfer and upscale NBS	**Best practices - Planning/preparation** • In the Netherlands, it is important to prepare for procedures at State Council. If there is awareness of resistance, it is beneficial to begin creating files and preparation to face the State Council throughout the planning phase and all subsequent stages. • It is helpful to begin by looking at how to serve multiple objectives and finding a common goal or solution, particularly in places battling economic activities versus ecology • It is important to remember that each project has its own challenges and each area has its own specifications to abide by. Construct a solid plan for the project and acknowledge that in the case of pilots, they could fail. **Best practices - Interactions** • Success begins with stakeholder commitments. Having the involvement and support of decision-makers within the project is beneficial. Project resistance can consume time and money and lead to multiple re-designs. • Be aware of all potential risks, regardless of project. Resistance to a project often results in better risks assessment and preparation, while better support can lead to complacency. It would be beneficial on these projects to have an independent reviewer to explore risks. **Best practices - Translating** • Monitoring is knowledge. It is not only useful for maintenance, but also for future project learnings. Intensive monitoring is however, not necessary for all projects, but is beneficial for those with uncertainties or new processes/functions. In this it is important to consider both the context and the purpose for monitoring. • Translating contextual project experience and learnings to other contexts is very difficult. It is important to understand specific circumstances really well, so involving local parties in the process is vital. As such, it can be beneficial to frame and present the project based on value to the particular region and the multiple objectives. • A lot was learnt from the pilot research. It is important to understand that all lessons, both positive and negative, are good lessons that help future implementation. **Learning:** • Understand that both practical implementation/execution and research projects can benefit each other by gathering valuable knowledge to improve processes. • When a project has uncertainties or involves new concepts, where possible all knowledge about operation should be captured for future use. As such, the project must be designed to involve research efforts to gather as much knowledge as possible which should begin immediately at the start of the project.

Appendix 3.5

Stages of NBS	BwN Indonesia
Identify problem or opportunity	**Initiation:** • The initial project - the implementation of permeable structures – was initiated through a fund granted for Demak. This project highlighted value through improving accessibility and applicability throughout Indonesia, and as such the subsequent mainstreaming project was initiated. • A pilot project identified the problem of coastal erosion along the coast of Java. The solution concept was translated based on a similar solutions within the Netherlands using permeable structures. • With the aid of an EU grant, the BwN Indonesia project was able to be implemented. As a result, value was identified in improving the accessibility and applicability throughout of the project, a subsequent mainstreaming project was initiated. This involved processes to navigate institutional limitations. **Location:** • Together with the government, the location was selected primarily for the established presence of a partner NGO in the area. Considerations also included complexity of land tenure and social coherence in the area. **Traditional vs. NBS:** • To evaluate the need for NBS vs. Traditional solution, selection should regard the amount of energy in the system versus the space available. For example, for coastal erosion, high energy systems often require more traditional hard solutions. • The selection of a solution type is somewhat dependent on the implementing organisation and decision-makers. It must suit their mission. • Often NBS are new, so are not yet proven. Solutions that are proven through past experience and knowledge can improve trust and are more likely to be selected. Willingness to consider alternative approaches is paramount. • The financial aspect is an important factor in selecting nature-based approaches. The common assumption is that sustainability is more expensive. Providing comprehensive life-cycle costs is therefore critical to pull away from this assumption, which must include a valuation of the added benefits. • It is important to consider the benefits available in synergies between traditional and NBS solutions. Availability of space and pure execution costs mean that it is often difficult to use purely natural solutions. NBS can act as complementary to traditional infrastructure due to their functions, added values and benefits. They can in some instances replace or collaborate with traditional solutions, but not always. It is almost always necessary to have traditional components to the design.
Select and assess NBS	**Objectives:** • This program is set up in two phases; implementation and mainstreaming, of which are two separate projects with similar components and different donors. • The original goal for the BwN Indonesia was in creating new land, allowing sedimentation for mangrove recolonization. Objectives also involved the revitalisation of farming grounds, including livelihood, education about sustainable aquaculture and coastal protection. Progressing from this, the core objective is in getting BwN/NBS concepts institutionalised and accepted by the ministries in Indonesia as an applicable approach. • As we do this project with Dutch and German funds, it is important to do everything according to local laws and regulation, including health and safety. This involves training people how to execute the work safely, requesting necessary permits, etc. While this is extra work, which is not necessarily done by local institutions, it was a key objective for this project. • There is often flexibility in the priority of objectives to suit the project processes. **Selection:** • The design was selected based on a previous project within the Netherlands. Through experimentation and observation of local systems, the final design was optimised to consider the location, the practicality of the solution and previously unsuccessful practices. • Finding a balance or a hybrid between hard and soft infrastructure can fit well with the setting, may be less costly than traditional infrastructure, and have more benefits than pure traditional infrastructure. **Financing:** • Initially funding was not awarded for a full-scale project, so a pilot was instead initiated due to the critical nature of the circumstances. Being able to observe the success through this process, led to trust in the concept and aided in securing funding. • Multiple funds were utilised within the EU. The Dutch fund focussed on implementation and initiating trainings on a local level and the German fund focussed on the institutionalisation of processes. These funds were both geared towards sustainability projects. • Funding the project in its initial stages can often be an issue with NBS, as it requires the initial investment of organisations that have value in the added benefits. **Risks:** • In Indonesia, practices must be within regulation otherwise risk falls to the owner. In selecting designs or processes, if something is not government regulated, there may be resistance to its use. It is important in these instances to stick to regulation in design, wherever possible or become responsible for the effect.
Design NBS implementation process	**Multidisciplinary Team Engagement:** • Within particular contexts, the project team must be very open and respectful of local customs and knowledge. It is not only science and theory that is useful; all knowledge streams and team members are valuable. To foster this need for diverse knowledge sources, a multidisciplinary team is key. • Multidisciplinary teams require coordination however, as each actor can have their own ideas and perspectives. It can be very difficult not only to foster dialogue between them, but to get them to see the wider picture, the importance of a landscape approach. • Due to the differing locations between the project team, coordination and ensuring cohesiveness required regular visitation to Indonesia and facilitation of entire team meetings. Monthly or fortnightly skype meetings were also conducted. The multidisciplinary nature of the team and partnerships requires continued nurturing and coordination. • The management and coordination role is highly underestimated. Donors are often hesitant to fund them and perhaps this requires a re-framing into interdisciplinary coordination. In order to make the project work, this is a vital process. **Team Composition:** • On these projects, project teams are replicated (including NGOs, private organisations and research institutes) from the previous project such as the initial pilot design. These are built in collaboration with local communities and government. **Partnerships:**

	• In seeking engagement with local stakeholders, it is useful to partner with local institutions or companies. They're often much more familiar with the locals and the dynamics and will have more success in this process. • Due to the established presence of several partners and existing offices within the local area, the project was mobilised easier. It was faster and cheaper to get a team on the field for execution.
Implement NBS	**Unexpected problems:** • On the BwN Indonesia project, the rate of land subsidence was much higher than anticipated and was faster than the rate of sediment accumulation and compaction. Groundwater extraction is a major problem, which is still being pushed to get it on the agenda. Despite this, local operations and processes associated with making this problem worse, makes solving it difficult. • In practical implementation, gaining understanding of execution processes was initially difficult. A pilot was conducted, however added objectives were not involved in this experimentation. A learning by doing approach was therefore adopted for functions such as sustainable aquaculture, mixed mangrove aquaculture and promoting ecological mangrove restoration. • Without full system understanding, we encountered problems with the design. The wooden material of the structures was compacted and eaten by shipworm. The damage resulting and the level of maintenance required was also unexpected due to the nature of the materials used. Through these learnings however, the design was able to be adapted. • Site selection for aquaculture ponds in Indonesia was not conducted in a strategic way. Initially, volunteers were sought which resulted in scattered sites. To achieve the objective of restoring the greenbelt, it would have been more useful to target specific people, not just those willing to participate. **Actions to achieve objectives:** • The social component is the most important, aside from technical aspects, and is fundamental throughout the entire project. The local community was utilised a lot, not only for ensuring the integrity and safety of the project components, but for maintenance. In this, they became part of the project team. • An extensive monitoring program is important. In this instance, a local supervisor was also useful in the field, responsible for data collection and monitoring. • An integrated team of not only scientists, but NGOs, engineering companies, government and communities is vital to achieve objectives. There must be willingness from the community and government, and support at all levels. Donors must be aligned with the project objectives and outcomes and must have a mutual goal. • Having support and commitment from high-level local actors is really important for the project's success. • Balancing desires of stakeholders requires having a clear solution to the problem and to raise and spread awareness through training and education. • Systems understanding is key. Without it, the solution is cannot be fully informed which often leads to problems. This requires beginning with knowledge of the experts and the local community. Not only technical or ecological, but social, economic, and also regulations. • If the local community or governments are not open to change or in support of the project, it will not proceed. Both society and economy are key for success. **Perception:** • The situation in Indonesia is becoming desperate, so the community was supportive in what was being done. In general, stakeholders were quite open, particularly to trainings and education. • This state of desperation at some point can also cause issues. They begin to implement measures that counteract our solutions; not out of mistrust, but simply desperation. This comes from a lack of alternative options and approaching a point of no return. **Learnings:** • The processes adopted for habitat creation and mixed mangrove aquaculture were very beneficial. Despite this, these restoration methods often take more than a year, while communities operate on far shorter time periods. To offset this, pilots can be used to show possibility for success, while other projects are in operation. • The realisation of severe land subsidence led to the reallocation of resources to new work packages. This worked at accumulating existing knowledge and solutions from the local context into a single approach or roadmap with an intent for measures to be implemented to reduce land subsidence. • The project was successful in that it halted erosion to some extent and was able to facilitate and initiate a national dialogue and roadmap to begin to address subsidence. • The permeable structures were adapted based on learning by doing. Different materials were tested every construction cycle and the lifetime has improved and the maintenance reduced.
Stakeholder engagement	**Community engagement:** • Bio-rights contracts were established to engage with the community and involve them in the project. This relationship provided support through education or finances in exchange for land, insurance of protection of structures, maintenance, etc. • For the involvement of the local community, financial incentives can be vital to enable implementation at scale. • As not all community members could be involved, representatives sometimes got more benefit out of the development than other members. In some cases, this led to disagreements within the communities. To potentially overcome this issue, there could be a stipulation in community contracts in which they must ensure all profits and knowledge gain is distributed among the entire village • In Indonesia, agreements are mostly based on trust and you must engage in local practices to ensure they are respected. **Stakeholder engagement:** • Early involvement of all stakeholders; local community and the various levels of governments (district, province, national) is critical, because @@@. • Existing relationships made initial engagement with local stakeholders easier. Partnerships were also useful in this. Wetlands International, Witteveen+Bos and Deltares have an established presence and connections to actors at various ministries and the local government. • Initial engagement is very intensive, including introductory meetings with village leaders, dialogue at village meetings, explaining the process, the purpose, facilitating field schools for training and setting up bio-rights programs for ongoing participation/involvement. • The timing of initial engagement is crucial. Consider that communities may operate on different timeline. From a science perspective, half a year or a year is reasonable, while if community members are engaged and nothing happens, they may lose interest and even trust. It is a balancing act between being prepared, but also gaining valuable insight from communities. • Field facilitators were the primary lines of communication for the community and were crucial for getting the public support. Community meetings also allowed discussion of proposed plans and when necessary, experts were introduced to answer questions and explain plans. Formalised interactions were more for education or information. • Due to the size of the community, village representatives were established. These advocated BwN/ NBS within their village and ensured work was completed, amongst other things. • Involving local people and engaging with relevant actors is vital due to the difficulty's outsiders may encounter in entering societies. Interaction is made easier by establishing relationships with local institutions and organisations who are connected to such actors. • To ensure their involvement in the project, the construction contract stipulated the majority of work was to be done by the local community.
Monitoring and evaluation	**Determining success** • To determine the success of objectives, you must verify that you are moving towards the original goal. Monitoring is useful in determining success of both the physical and social components. • Different solutions require different levels of management, involvement and monitoring depending on their scale or size.

	• Education and spreading awareness about BwN/ NBS, particularly in universities and governments, is key for its continued success. It is often positively received, success depends on whether actions take up and use the knowledge provided. Monitoring can help understand what is being done with training. • The strength of NBS is the fact that it combines multiple uses, multiple functionalities and has multiple benefits. Further, being somewhat self-sufficient or self-supporting is useful in determining its success. This is not always possible though. • The project must be based on system understanding. How it is connected to the wider physical and social environment and how it interacts in it is an indicator to determine success. • System understanding is the key priority to ensure continued success after the project completion. Its related to the biophysical conditions in the project area; often the problem is not only in the specific location, but much broader. It's also socio-economic processes that are important. • You must understand the priorities within the context of the project. In Demak, participants received not only social and environmental benefits, but also economic incentive. If there is no longer financial incentive for them to continue, the project will stop. **Do differently** • Gaining full system understanding is difficult in countries like Indonesia due to the lack of data availability. For example, the subsidence problem and the boundaries of permeable structures were underestimated. These issues should have been monitored from the beginning of the project, allowing for earlier identification and intervention to solve it. Knowing this, the project may have taken a different approach, or a different site would have been selected. **Monitoring:** • In Indonesia, monitoring was conducted with the objective of handing over responsibilities in mind. It was done in a simple, low tech way to involve the local community and ensure practicality once processes were handed over. For this reason, the monitoring of land subsidence was initially considered too complex. For this reason, the monitoring of land subsidence was initially considered too complex. • Research was also done by PhDs and master students which helped. **Barriers for monitoring:** • In Indonesia, funding is a key factor for the ministries. However, annual budgets are typically reserved in majority for construction costs, not maintenance. NBS, and these structures particularly, require a lot of maintenance, which creates problems.
Transfer and upscale NBS	**Best practices:** • Best practices tie back to the level of local involvement and community participation. Making this a part of project objectives has a lot of added value. It allowed for the transfer of responsibility and maintenance of the project, allowing a deeper understanding of practices and encouraging ownership. This is particularly useful in projects with significant ongoing work and maintenance. • Ensuring the project is accepted by the community is crucial. • Having supervisors to monitor progress can also aid in success. • There must be understanding of the context and the cultures represented in particular situations. Project processes must consider and conform to the practices within the context. In Indonesia, there is a stronger social culture when compared to the Netherlands for example. • The ecological restoration method adopted was advantageous. It offers a lot of potential for mangrove restoration. It is difficult to move people away from traditional approaches, such as planting, which seems to work but later fails. Despite this, we succeeded through learning by doing, giving freedom to test and compare methodologies to prove success. • Adaptive management is also a key practice; monitoring, learning by doing and sharing knowledge are all necessary components of this. **Mainstreaming:** • Education is useful for upscaling the concept. In Indonesia, a training of trainer's program aimed at governments and universities educate about BwN/ NBS concepts, methods of application and upscaling. These people, teachers themselves, will be responsible for educating and training others through inclusion of NBS in their curriculum. Facilitating and assisting in the production of education programs can improve its accessibility and therefore its uptake. • Demonstration ponds were used to regularly educate about more beneficial, sustainable practices of aquaculture. This was done primarily by local NGOs – Blue Forests and Wetlands International. For this purpose, local parties are ideal for their familiarity with the area and its processes. • In Indonesia, signing contracts and engaging in local ceremonies which represent their commitment and make them relevant is also useful. • Spreading awareness is particularly vital in areas where traditional solutions dominate practice. If NBS are not contained within guidelines and are neither well known nor trusted, it is extremely difficult for them to be implemented. Writing guidelines that the government and other institutions can use to develop similar types of solutions elsewhere helps in ensuring continued success of NBS. • Working with high-level actors, including governments to create understanding in NBS processes, and increasing enthusiasm about the approach and its benefits, is crucial for mainstreaming. This can be done through pilot projects. • Involving local parties is key in translating knowledge. Often the circumstances are very different, and one must have a deep system understanding in order to produce some benefits. • Mainstreaming requires commitment from all parties involved (partners, stakeholders, team). Success of practices can be observed through the replication of solutions by local institutions, creating other examples of BwN/ NBS that can be applied elsewhere. • In order to be competitive with traditional solutions, the added values and benefits that NBS provide must be monetarised in addition to cost of execution. If the social and environmental aspect is included in cost-benefit analysis, NBS become sustainable. • Involving objectives for future mainstreaming helps it to become sustainable beyond project lifetime. For example, teaching communities how to perform maintenance roles and securing budget from local institutions to continue these practices aids in this. **Barriers for mainstreaming:** • Formal procedures and rules, particularly in educating and disseminating NBS knowledge, can cause complexity. • Often, the level of participation in mainstreaming practices (education, trainings) differs across relevant institutions – some are more active, some are less so. This creates knowledge gaps, leading to these difficulties. • Financing models are key in understanding the success of mainstreaming NBS. In this context, often they begin with philanthropy, moving to public or overseas development aid. Eventually, in order to mainstream, it must become funded by governments like normal tenders are. This is not so common outside the Netherlands. • Understanding the need for system understanding and that NBS goes beyond the physical solution is important. The scale at which things happen, the particular environmental context and conditions that make a solution suitable; all this information is crucial and requires involvement of all relevant stakeholders; local community, governments, experts and NGOs.

Appendix 3.6

Coding Journal

26/05

I began coding the lessons learnt for RQ1.

Initially went through the transcripts and noted the contents of what each interviewee was talking about. This was a pure description of the events that happened within each portion of text.

I also made sure to highlight each question in order to identify them correctly within the seven key stages of NBS. Within these stages, I intend to sort responses to identify common lessons learnt for each participant.

28/05

I have been coding lessons beginning with the projects within the Netherlands. This is because the interviews for Indonesian project BwN Indonesia have not been conducted.

29/05

I have continued through each interviewee, analysing the contents of what they are discussing in terms of lessons learnt throughout the interview.

2/06

What I have recognised, is that based on the way I have been coding, it will be difficult to collate the data into groups or themes. My plan was to be able to divide the data into the 7 stages identified for NBS projects. To do so, I was going to define the answers to questions pertaining to each of the 7 stages.

Despite this, it is clear that the responses given are not always associated with the subject of a particular stage of NBS.

I have looked back into the indicators I have outlined within each of the 7 stages of NBS and used those to identify subjects or topics which are outlined within a response.

Using the subjects, for example 'traditional vs. NBS', 'reason for project', 'mainstreaming', 'methods for stakeholder engagement', I expect I will be better able to sort the responses or data into the 7 key stages of NBS in later processes.

As such, I have been going back through and re-coding to a degree to assign subjects to each of the relevant responses.

8/06

Coded information is now being transferred to an 'analysis' document that will allow me to identify similar learnings and collate the data.

To be able to distinguish between projects and participants, I have created a separate document for each and detailed a single column for each respondent. These are also divided into the 7 stages of NBS.

The data is placed into the separate columns and initials have also been noted on each response to be able to distinguish between respondents once data has been further combined.

11/06

The responses are being summarised for each relevant response into a more succinct learning or to identify the key meanings which were outlined in the response.

Once this is done, the learnings are transferred into a summary table which collates all responses from each participant within a project. These are divided by the 7 key stages, and further sub-divided into their key subject. Key words have been added at the end of each learning to describe the content/theme of the subject discussed

15/06

Using these responses which are now summarised, this gives me the opportunity to identify similarities. A code has been assigned to each of the responses. Codes consist of subjects such as 'project design - cooperation', 'objectives - multifunctional'.

Common codes have been grouped together.

Themes under each of the 7 stages have been identified and responses have been sorted under a related theme. For example, under the subject 'traditional vs NBS', themes or contents could be “benefits” or “selection criteria” which can be further identified by their type of benefit for example (i.e., cost-effectiveness, multi-functionality, etc.)

23/06

Once the process above is finalised for each project, the common lessons that discuss very similar subject matter are summarised into a single learning.

Where there are no associated lessons, they were kept separate. Learnings were also rated based on their universality - this is defined when learnings are repeated a number of times or are quite broad in their nature.

These will be done in two formats - summarised learnings for each project, and summarised learnings combined from all four projects

25/06

Learnings are to be verified by an external source/expert to ensure their validity/representativeness

3/07

Coding began for RQ2. This will take a different approach as the RQ surrounds the relationships between lessons learnt or perceptions of effective knowledge, and the role of the actor within the context.

As such, for RQ2a (relationship to lessons learnt), coding will not be divided into the 7 stages of NBS. It will be defined based on their subject matter. Codes are expected to surround ideas of 'project operation', 'organisation', 'stakeholder', 'governance',

The lessons are divided into decision-maker and practitioner within each project.

It is important that although the data for RQ1 was coded based on lessons learnt for NBS implementation, the data for RQ2 must originate also from these learnings identified. Essentially, the initial process of coding for RQ1, also formed the initial phase of coding for RQ2a also.

This is important if we are to distinguish the relationship between lessons learnt and the variables of actor role and context, and not simply the contents of discussions.

It appears as though the sub-topics or themes identified within the 7 key stages of NBS are becoming key codes for this phase of coding.

5/07

I have tried a different method in coding to see if there any better results.

Using the previous method, I was struggling to identify codes, perhaps as they had already been interpreted based on extraction of lessons learnt.

This time, I have reverted back to the actual responses that were originally extracted from the transcript. Using that data, I have coded the responses based on their subject matter.

I have done this for MW and now doing it for HPZ.

Based on the results, and whether there are any observable similarities or differences, I may have to try a new method.

The new method will be coding the physical transcripts based on language used/topics discussed to identify relationships between actor roles and lessons learnt.

17/07

The process for RQ2 is being re-thought. Due to time restrictions, RQ2 will comprise a thought experiment. As such, additional coding is no longer needed.

The second phase of the interview, however, is being looked at today. Depending on their content, responses have been sorted into three sections of salience, credibility and legitimacy. From this, the responses have been simplified and summarised. Using the summaries, the key factors have been noted in order to allow for a comparison or summary between different responses. These have then been collated in a separate table for ease.

Key factors are sorted into themes to distinguish them from each other.

This process is somewhat similar to what was done for the first phase of the interviews.

Appendix 3.7

Overview Of Project Cases

Case One: Hondsbossche Dunes (HPZ)

Figure 10.1 : Hondsbossche Dunes (EcoShape, 2018)

The original sea defence for flood protection was comprised of the Hondsbossche and Pettemer sea dike, which was considered "the final 'weak link' along the North Sea coast" (Van Oord, 2019). Consisting of an asphalt dike, it was the only 'non-sandy' solution remaining along this coastline.

Inspections in 2003 revealed the Hondsbossche and Pettemer sea dike no longer met current safety standards and would thus require reinforcement (EcoShape, n.d.b). Rather than employ traditional 'grey' methods of reinforcement, the dike's seaside was reinforced with a natural barrier of 35 million cubic meters of sand along 8km of coastline. Alternative design methods introduced added value to a typically single-purpose system (EcoShape, n.d.b).

The primary objectives of this project were safeguarding against flooding and ensuring spatial quality. Using the Best Price-Quality (BPQ) ratio criteria in the project's procurement process, Rijkswaterstaat created incentives for market adoption of alternative thinking and multi-functionalities in design, such as NBS. This encouraged design options that are not typically possible in market competition from a cost perspective. The BPQ ratio assigns certain qualities with a fictional price, allowing a bidder that scores on that quality to receive a discount on the actual tender price. This process increases the chances of winning a contract not solely based on price (House of Tenders, n.d.). On the HPZ project, quality values of €10 million were assigned for nature development and maintenance efficiency, and €5 million for recreation. It was possible to obtain such values by applying an NBS approach.

The project, then known as HPZ (Hondsbossche Zeewering), located on the coastline between Camperduin and Petten in the Netherlands, began construction in 2014 (completed in 2015). Parties involved in the HPZ were Waterboard Hollands Noorderkwatier and Rijkswaterstaat, the project's initiators, and contractors Boskalis and Van Oord who were primarily responsible for the design, construction and maintenance processes. The contract incorporated necessary finances with the requirements to fulfil a maintenance period of 20 years (to end in 2036) (EcoShape, n.d.b).

After the construction of the reinforcement project, a monitoring and innovation research project were initiated, in which the area was renamed Hondsbossche Dunes. EcoShape undertook this project until its completion in 2018 (IJff & van Zelst, 2018). EcoShape partners HKV, Witteveen+Bos, WUR, Arcadis and Deltares, were responsible for executing the Hondsbossche Dune research project. Research themes involved improving the predictability of engineering habitat development, design optimisation, and community and visitor perception of coastline defences (IJff & van Zelst, 2018). The resulting research opportunities sought to develop knowledge about the added value of NBS approaches compared to ‘grey' solutions. Through this phase, significant concerns (such as sand transport) could be abated through design adjustments. Examples of such adjustments included vegetation and artificial relief features (ARF) to capture the sand and reduce sand transport.

Case Two: Marker Wadden

Figure 10.2 : Marker Wadden (Natuurmonumenten, 2018)

The Markermeer is one of the largest freshwater lakes in Western Europe, located in the centre of the Netherlands. Since its closure from Lake Ijssel, its ecological situation has severely deteriorated (EcoShape, n.d.a). The bottom of the lake now contains a thick blanket of mud which impacts the lives of plants, fish and shellfish. This result is primarily due to a lack of soft, vegetated shore and high turbidity caused by fine sediments. The declining environmental condition of the Markermeer, particularly in the water quality and ecology, signified the need for a solution in this area.

The nature conservation organisation Natuurmonumenten and the Dutch government collaborated intending to improve the natural environment in Lake Marker (EcoShape, n.d.a). Natuurmonumenten secured a portion of funding for the project through the postcode lottery and subsequently approached Rijkswaterstaat to develop a potential solution. The project attempted to capture silt from the lake and use it as a building material for an archipelago of marsh islands called Marker Wadden. With design and construction conducted by Boskalis, the project began with a trial island of ten hectares completed in 2014. Upon its success, the construction of a 600-hectare island began in 2016 and was partially opened to the public in 2018 (International Association of Dredging Companies, n.d.). The project comprises an enclosure of sandy ridges within which silt, supplemented with sand and clay (all from the Markermeer) are used in the Marker Wadden to establish a productive marsh landscape

(EcoShape, n.d.a). These islands are expected to create an attractive location for enhancing biodiversity, providing leisure opportunities, and enhancing water quality.

Two years after the first phase of Marker Wadden's construction began, KIMA was launched (EcoShape, n.d.a). KIMA is divided into three layers: Fundamental research (various Universities), Monitoring and evaluation (Deltares, RWS) and Applied Research (Led by EcoShape, executed by EcoShape partners including Witteveen+Bos, Arcadis, WUR, Deltares).

The KIMA project intends to contribute to the efficient and effective construction of all Marker Wadden phases, connecting fundamental research to applied research, coordinating collaboration between sectors and disciplines, and stimulating innovation (Rijkswaterstaat, Deltares, EcoShape & Natuurmonumenten, n.d.). It does this by exploring scaling up the practical applications of this research, in addition to monitoring efforts to strengthen knowledge bases. In doing so, the project aims to generate and present knowledge about building with fine sediment, sand and clay and about ecology and governance (Allewijn, Nieboer, Smits & Wams, 2018).

Using the information developed, Marker Wadden is intended to improve the environmental quality of Lake Marker. With the KIMA project, the program will demonstrate that the sediments studied can be used as a construction material for land reclamation, dike reinforcement and soil improvement (International Association of Dredging Companies, n.d.). The knowledge acquired regarding building with mud in freshwater systems is intended to aid in similar projects in saltwater environments in the Netherlands and other parts of the world (van Eekelen et al., 2017).

Case Three: Marconi Delfzijl

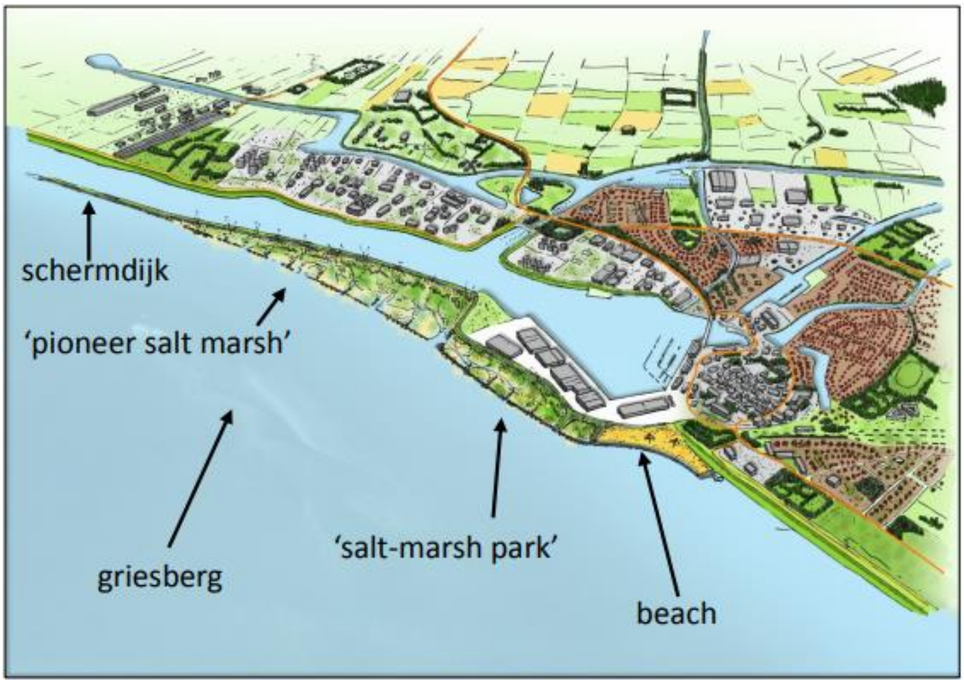

Figure 10.3 : Marconi Delfzijl (Ecoshape, n.d.)

The Marconi Delfzijl project is located on the far northeast coast of the Netherlands where salt marshes were developed with sediment from the port of Delfzijl and the Eems-Dollard Estuary (EcoShape, 2019a). In response to a study detailing promising solutions involving NBS, the municipality of Delfzijl commissioned the project. It forms part of the 'Marconi Buitendijks' regional development effort, which addresses several significant issues faced by the municipality (shrinking population, seal level rise combined with subsidence and the poor ecological condition of the Ems-Dollard) (EcoShape, 2019a).

In 2012, the focus was decidedly directed to constructing a beach and salt marsh along the current dike and harbour jetty (Groot & Duin, 2013). Two salt marshes were created for recreation and coastal protection and nature (Groot & Duin, 2013). Salt marshes are ideal as they can make use of available dredged material and have the potential to improve nature values, recreation and spatial quality. Additionally, they can also dampen waves and trap silt, reducing the load on the dikes behind the marsh (Groot & Duin, 2013).

Salt marshes provide valuable ecosystems in the transitional zones between land and water with high levels of biodiversity. Unique plants can grow, birds feed, rest and breed, and silt captured by plants on the salt marsh generates water quality benefits. These factors add further to the coast's appeal to residents and visitors (EcoShape, 2019a).

The municipality of Delfzijl appointed EcoShape to study this salt-marsh development. The project was intended to generate knowledge about how salt marshes can be created, developed or restored with local material, under different circumstances (EcoShape, 2019a). Experimentation investigated the best way to restore salt marshes by reusing sediment while developing nature that contributes to the water quality, ecology, and coastal defences coastal appearance (Baptist, 2017).

The project involved cooperation between multiple stakeholders, including the municipality, the Province of Groningen, water boards and Rijkswaterstaat (Groot & Duin, 2013). The Wadden Fund provided financial support for knowledge development relating to salt-marsh construction with the remaining amounts financed by EcoShape partners (EcoShape, 2019a).

Case Four: Building with Nature Indonesia

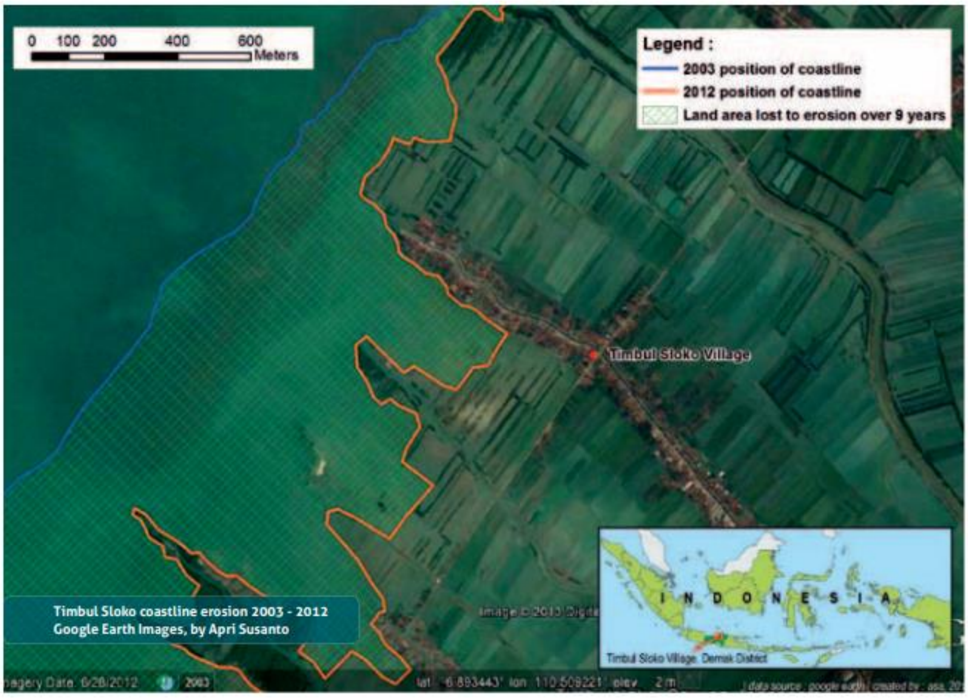

Figure 10.4 : BwN Indonesia (EcoShape, n.d.)

In 2012, the Indonesian government sought aid to address the severe coastal erosion occurring on the northern coast of Java, Indonesia. Removal of mangrove belts for intensive aquaculture farming, coastal infrastructure disturbing sediment build-up, and groundwater extraction, has resulted in land subsidence and river canalisation (EcoShape, 2017). The removal of the mangrove belts has also increased the severity of erosion and caused complications for measures aiming to reduce risks (IJff & van Raalte, n.d.). Due to these actions, approximately 3km of land and entire villages have been inundated thus far (EcoShape, 2017). It is estimated that by 2100, 6km inland will be flooded, impacting 70,000 people and 6000 hectares of aquaculture ponds (EcoShape, 2018).

The original mitigative solutions to these problems (concrete barriers) were ineffective along this rural mud-coast of Java. Not only were they unstable and expensive, but they exacerbated coastal erosion. Such measures also failed to deliver the necessary economic, environmental and social services that the original natural coastal protection provided (EcoShape, 2018).

The research institutes, Deltares and Wetlands International, initiated the BwN Indonesia project by approaching the local government to address the observed coastal erosion. The initial solution was based on a similar project implemented along the Dutch coast, using permeable structures to increase sedimentation. From this, a pilot project was initiated to demonstrate possible concepts. As a consequence of this project's success, the Ministry of Marine Affairs and Fishers co-invested in a full-scale replication of the project alongside a Dutch fund *The Sustainable Water Fund*. As a result, BwN Indonesia became a public-private partnership project between EcoShape, Dutch and Indonesian governments, universities, and local communities.

The primary project began construction in 2015, set for completion in 2020 (IJff & van Raalte, n.d.). A subsequent phase also began involving the mainstreaming of BwN, institutionalising these concepts within Indonesia. This second phase is in part funded by a German fund for climate adaptation, IKI.

The BwN Indonesia program was initiated with several broader objectives (see Figure 10.5):

1. Implementing measures on the ground in Demak (physical, ecological, socio-economic) and monitoring to address the root causes of erosion
2. Fundamental research on mangrove restoration (BioManco) and sustainable aquaculture (PASMI) (both supported by PhD research), and addressing subsidence problems
3. The results from these objectives are intended to assist in upscaling the concept tested in Demak and mainstreaming the BwN concept at a national level

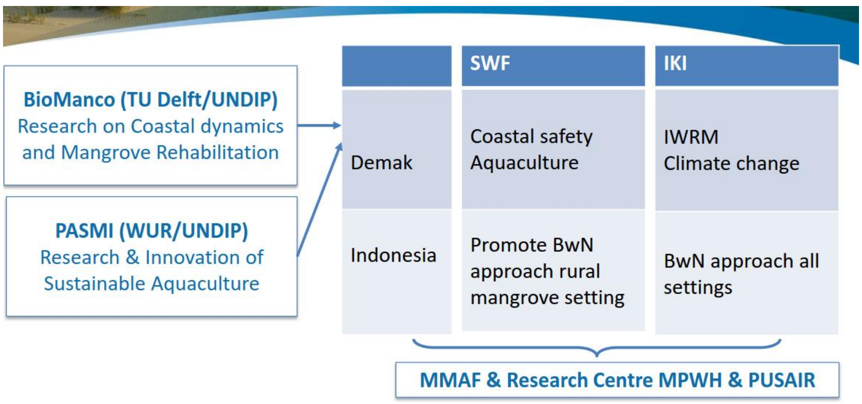

Figure 10.5 : BwN Indonesia Project

The restoration of the mangrove coastline was a significant component of the project, intended to reduce flood risk, erosion and saline intrusion to adapt to sea-level rise (EcoShape, 2018). These objectives were achieved by constructing a series of permeable structures that encouraged sedimentation, promoting mangrove regrowth. Once the coastline began to stabilise, existing aquaculture ponds were revitalised, and new ones were created.

Project objectives also aim to foster local ownership of the project to achieve project goals and maintain solutions. Community groups and bio-rights mechanisms were developed to financially support locals participating in this renewed approach in return for their active engagement in environmental conservation and restoration (BwN Indonesia & EcoShape, 2016). Further, involving local stakeholders throughout the implementation process and introducing sustainable, multi-functional land uses, was critical to enable inclusive economic growth once the coastline is stable (EcoShape, 2017). This involvement was achieved using education and training programs on sustainable aquaculture and alternative livelihoods. These programs provide opportunities for mangrove restoration and enhance local communities' prosperity through the continued maintenance of the mangrove greenbelt.

BwN training programs, development of guidelines, and knowledge-sharing strategies were regularly employed to realise long-term project success (BwN Indonesia & EcoShape, 2016). Through its policy trajectories in becoming mainstreamed on a National level, the BwN measures are supported by village development plans and land use rights regulations. Demak district and Central Java Provincial policies on protected areas and coastal zone management, in addition to adaptation and disaster risk management, also add to this protection (IJff & van Raalte, n.d.).

Appendix 5.1

Lessons Learnt – Complete List

	Theme	Total	Hondsbossche Dunes	Marker Wadden	Marconi Delfzijl	BwN Indonesia
	Identifying the problems and opportunities					
	Initiation of potential solutions:					
1	Opportunities to harness NBS are highly context-dependent and often depend on the environmental and social quality and potential risks.	5	x	x	x	
2	NBS provides numerous co-benefits beyond the practical use of mitigating climate risks	2		x		
3	Investigating possible solutions can be time-consuming and requires exploration and investigation from different angles to find the right fit. Stakeholders must be involved to develop an integrated plan	1		x		
4	Using past designs and pilot research as examples can be beneficial to help address uncertainties, optimise future designs, and evaluate problems or opportunities. Solutions that are trusted and demonstrated are more likely to be selected	7	x	x	x	x
5	Stakeholders must be willing to explore alternative options during this stage	1		x		
6	Due to their flexibility, NBS provides good opportunities to deliver multiple objectives in one project.	2		x		
7	In the initial stages, it is important to focus effort and finances on project execution to reduce delays and develop practical lessons.	2			x	
8	In different contexts, collaboration with local authorities and stakeholders is critical to establishing locations for implementation	2				x
9	It is possible to begin by looking at how to serve multiple objectives and find a solution to meet these goals. This can be effective in places battling economic growth versus ecological preservation.	2		x	x	
	Traditional vs NBS					
10	Unlike traditional infrastructure, NBS can effectively meet multiple objectives and create multiple benefits within a single solution.	8	x	x	x	
11	NBS can often prove more economical than traditional infrastructure. To demonstrate this, comprehensive life-cycle costs which include co-benefits, are critical	3				x
12	The ability to incorporate other values such as nature development and recreation can accelerate realisation due to increased political and financial support from stakeholders invested in added opportunities	2	x			x
13	NBS can provide useful spaces for experimentation and learning of new concepts	1		x		
14	Unlike traditional solutions that typically consider effects on nature after design, NBS optimise between technical solutions and effects on nature throughout all stages to have the best possible result for nature	2	x			
15	Selection between traditional and NBS projects depend on a number of factors such as the project objectives, available finances or cost, maintenance requirements and potential impacts to surroundings.	3	x	x		x
16	Selection between NBS and traditional solutions should regard the energy of the system versus available space. For high energy systems, more traditional solutions or combined hard and soft solutions are effective, while smaller-scale contexts with lower energy can accommodate NBS.	1				x
17	Decision-makers have significant influence over NBS and therefore must be advocates for financing and changes to policy	3	x			x
18	Understanding the system and evaluating project impacts is necessary to assess project opportunities and tailor the solution accordingly	4	x		x	x
19	NBS can act as complementary to the traditional infrastructure where space and costs are minimal. A balance between hard and soft infrastructure can optimise the integration with the setting, reduce costs and create added benefits.	2				x
	Selection and assessment of NBS					
	Objectives:					
20	Project priorities differ between contexts, and so combining objectives to develop mutual goals can encourage cooperation, however one overarching goal is critical for success	3	x	x		x
	Selection criteria:					
21	Solutions are selected based on effectiveness in addressing objectives, in addition to opportunities for added benefits	2	x	x		
22	System understanding requires expert and local knowledge and understanding of governance systems which is critical to inform the initiation and type of NBS.	4		x	x	x
23	The selection of NBS must consider funds, project cost, the complexity of design and stakeholder responsibilities	2	x		x	
24	While experimenting with alternative designs can be good, it places more variables in the project, adding complexity and risk.	1		x		
	Financing:					
25	To secure funding, projects should have feasible and demonstratable outcomes, and provide mutual benefits and objectives to actors.	3		x		x
26	Financing pursuits should target funds aligned to project objectives with mutual goals for buy-in, i.e., climate change, water management, education.	2		x		x
	Risks:					
27	Risks can be encountered at each stage of NBS realisation due to the infancy of the concept, however, are largely associated with maintenance and post-project monitoring requirements due to uncertainties in future behaviour of a system.	3	x		x	
28	Uncertainties of NBS regarding their integration with nature, may present a number of risks. Design must consider the system and how to address these potential risks.	3	x	x	x	
	Design of NBS implementation process					
	Multidisciplinary team engagement:					

29	Multidisciplinary environments of cooperation and negotiation are an important asset in sharing opinions and coming to the best solution	2		x		x
30	Negotiation is crucial in multidisciplinary teams	2	x		x	
31	Difficulties can arise due to a lack of communication and dialogue between different organisations and teams. Similarly, NBS may fail if the importance of a landscape/big picture approach is not emphasized.	2			x	x
32	Integrated multidisciplinary teams with a diversity of skills aid the exploration of alternative processes and facilitate consideration of added benefits for a solution.	6		x	x	x
33	Close cooperation with organisations that understand political processes and bureaucracy can inform teams of the correct procedures to follow.	2			x	
34	The project team must be open and respectful of local knowledge and traditions within particular contexts for local support	3				x
35	In projects implemented remotely, regular visitation (e.g., 4 visits/year) to the project site is critical in addition to regular team meetings	1				x
	Team Composition:					
36	Teams with prior NBS experience can be useful for shaping and optimising implementation and operational processes.	2	x			x
37	Invest resources to build a good team with the active cooperation and positive dynamics and values.	5	x		x	
	Partnerships					
38	Management, continued nurturing, and coordination is important to maintain good relationships between teams and external partners.	3		x		x
39	Organisational partnerships with local institutions can provide complementary skills and create added value through established networks and resource diversity.	4			x	
40	Having teams work alongside each other can help to develop relationships, aiding in achieving mutual goals, cooperation and understanding of different dynamics.	2	x		x	
41	It can be easier for reporting authorities if there is a single entity with ownership over the entire project implementation.	2	x			x
42	Developing public-private partnerships with governmental organisations can help with implementation due to political support for solutions.	1			x	
43	Commitment and mentality towards success must come from the entire team for the success of the project	2	x		x	
	Implementation of NBS					
	Actions to achieve objectives:					
44	Demonstrating concept success can aid in securing funding. This may lead to increased trust and adds to practical knowledge and understanding of the concept and the actions necessary for success	1			x	
45	Funding is necessary to create good outcomes for implementation, however, access to financial resources differs between contexts	2	x	x		
46	Successful NBS implementation requires a willingness from the community while decision-maker commitment to project outcomes.	6	x	x	x	x
47	Framing project objectives concerning the priorities of the context can help in seeking support from stakeholders such as political actors and local organisations	1			x	
48	Involving universities throughout the project can develop new learnings and aid innovation in implementation.	1			x	
49	Adaptive management is crucial in NBS and creates constructive learning which involves monitoring, learning by doing and knowledge sharing.	6		x	x	x
50	The success of objectives relies on the ability to engage with the society and balance concern for people, the planet and profit depending on the priorities of the context	2	x			
51	Success can be determined by stakeholders' abilities to cooperate and their mentality for success	2		x	x	
	Success for implementation:					
52	If the local community or governments are not open to change or in support of the project, it will not proceed. Both society and the economy are key to success.	3				x
53	Nature is always changing, and we must work with it. System understanding is important to work with changing natural systems and to avoid issues in implementation	3		x		x
54	Be aware of the project and context conditions when considering the feasibility and practicality of the implementation methodology. This includes the availability of machinery and the capability of local contractors.	4		x	x	
55	Projects must consider the periods in which solutions can demonstrate outcomes. Quick results are often desired, so to offset longer periods, pilots can be implemented ahead of time to set precedent.	1				x
56	Overcoming unanticipated circumstances requires a mindset of cooperation within teams.	3	x	x		x
	Overcoming Problems:					
57	Planning for NBS implementation requires meticulous consideration of processes required in each phase of the project to avoid unforeseen costs. This is due to the probability of uncertainties due to its integration in nature.	2			x	x
58	Too much focus on execution may jeopardise objectives associated with long-term learning due to conflicting actions, goals, or insufficient finances.	2			x	
59	In multi-organisation teams, competition may arise regarding knowledge sharing. This can create a lack of communication causing follow on problems. If these can be overcome, benefits from sharing and developing knowledge can outweigh these difficulties.	1			x	
60	It is important to consider systems beyond the immediate context. Particularly when working in nature, projects can influence or be influenced by factors elsewhere, and so it is important to consider systems beyond the immediate context.	2			x	x
	Stakeholder engagement and communication of co-benefits					
	Perception:					
61	Initial resistance often decreases or disappears throughout construction, particularly where opportunities are available to observe or engage with the project.	3	x		x	

62	The public can often be receptive to the project when it adds value to livelihood and nature	2		x		
63	Resistance from environmental groups often surrounds the environmental conditions and zoning of the project. Understanding their objectives and working towards a mutual outcome can reduce this pressure.	1		x		
	Stakeholder engagement:					
64	Early involvement of all stakeholders is crucial and involves communicating clear project objectives and benefits and understanding stakeholder concerns.	4		x	x	x
65	The team must be transparent, reliable and honest about the main purpose of the project, what will be done to achieve it and what interests may be compromised	2	x			
66	While stakeholder involvement during design can be an intensive process, it is valuable for support. Further, exploring alternative functionalities offered by stakeholder knowledge can allow primary objectives to remain, while adding benefits and cost-savings in design	8	x	x	x	x
67	Within Stakeholder interaction, it is important to understand the objectives of each party to guide the project in a way that contributes to these objectives.	2	x	x		
	Methods of stakeholder engagement:					
68	A Steering group can be useful for stakeholder communication to guide the practical objectives of the project	2		x		x
69	Utilising a key actor to conduct stakeholder engagement can be useful depending on the project complexity and available budget. It may reduce debates about competing interests and agendas	2		x		
70	Showcasing the project through media, public visitation and education helps communicate objectives, increase enthusiasm for the project, decrease resistance, and provide funding opportunities	4	x		x	
71	Field facilitators and community meetings can be useful lines of informal communication between projects and local communities.	1				x
72	Engaging and developing relationships with local institutions trusted within established networks is good practice. This can vastly improve local stakeholder engagement, interaction and support.	3		x		x
	Stakeholder engagement in external contexts:					
73	Stakeholder interaction must consider the particular social context to utilise successful engagement techniques. This may require different combinations of formal or informal engagement depending on the context	1				x
74	The involvement of the local communities can be very useful for gathering local knowledge, ensuring the integrity of the project and producing design benefits	1				x
75	Timing initial contact is a balancing act between being prepared but also gaining valuable insight from communities. If the community members are engaged without action, they may lose interest or even trust.	2				x
76	Educational tool such as field schools and learning-by-doing help involve and educate stakeholders about project operations, benefits and co-benefits and to gather local knowledge.	3				x
77	Incentives for local stakeholders such as community members to participate, maintain or protect NBS such as financial encouragement can be utilised where necessary.	2				x
	Monitoring and evaluation					
	Evaluating success:					
78	Good monitoring programs help validate progress towards goals and the achievement of multiple benefits.	8		x	x	x
79	To ensure the safety and stability of a solution, flexibility is critical through monitoring the project and having the ability to intervene if necessary	1			x	
80	The way the project is connected to the wider physical and social environment and how it considers and interacts with nature alongside other objectives, is a key determinant of success.	4	x	x		x
81	Although not always possible, being somewhat self-sufficient or self-supporting is useful in determining its success.	1				x
82	Different solutions require different levels of management, involvement and monitoring depending on their scale, their complexity, and their objectives.	1				x
83	Providing education and awareness on NBS concepts throughout implementation is an important determinant for future success. In this regard, its success depends on whether actions take up and use the knowledge provided.	2		x		x
	Monitoring:					
84	Monitoring and data management should be implemented from the beginning of the project to understand project impacts and inform an accurate evaluation of outcomes.	7	x	x	x	x
85	Decision-makers and clients must understand that monitoring is vital for project success, not an optional add-on process after the execution.	1		x		
86	Successful monitoring must involve planning and evaluation of monitoring goals. While some results can be seen in a short period of time, to investigate uncertainties and for effective learnings, long-term monitoring is ideal.	3	x		x	
	Barriers to monitoring:					
87	Barriers to monitoring include lack of budget, unclear objectives, and unwillingness to invest in and utilise monitoring for knowledge development.	4	x	x		
88	A lack of pre-existing information or data availability from projects can impact monitoring success and the ability to gain system understanding, particularly if monitoring is not implemented from the beginning.	4	x		x	x
89	Funding can often be reserved in the majority for construction, not monitoring and maintenance. This can create issues as NBS often require ongoing maintenance	2				x
	Transfer and upscale NBS					
	Best practices					
90	Monitoring is knowledge. Research and monitoring are useful not only for maintenance purposes, but also for construction, operation, and the development of knowledge for future projects, particularly those with uncertainties or without precedent.	2	x		x	
91	To achieve common goals, you must be empathic in your actions and behaviour towards team and partners	2	x	x		

	Translating NBS knowledge						
92	Local stakeholder involvement aids the translation of contextual knowledge due to their system understanding.	4			x	x
93	Spreading awareness of NBS concepts through training and education programs is a useful way to encourage NBS translation. This can help create understanding of NBS practices and benefits, increase enthusiasm about the approach and disseminate this knowledge to a broad group of actors. This involves the development of guidelines, integrating education into university programs or government trainings, and community interactions	4	x			x
94	NBS realisation can be difficult if practices are not contained within standards or guidelines and are neither well known nor trusted. Recognition of current standards is vital to achieving realisation and requires commitment from all parties involved (partners, stakeholders, team).	1				x
95	Setting objectives for future mainstreaming helps it to become sustainable beyond the project lifetime.	1	x			
96	Translating NBS knowledge is beneficial for creating other examples of NBS that can be applied elsewhere. Pilots can help to demonstrate benefits and contribute to learnings for mainstreaming	4			x	x
	Barriers to mainstreaming:					
97	NBS can often prove more economical than traditional infrastructure. To be competitive with traditional solutions, total lifecycle costs are needed, which monetise the added values and benefits that NBS provide, in addition to the cost of execution.	4		x		x
98	Barriers to translating NBS knowledge include formal procedures and politics and participation levels in training and education amongst different stakeholders which creates knowledge gaps.	3				x
99	Financing models are a major consideration in successfully mainstreaming NBS. To the mainstream, projects must eventually become funded by governments like normal tenders are	2				x
100	People must understand that NBS transcends the physical solution, affecting social, economic, and wider environmental spheres as well, which requires system understanding.	3				x
	Learning:					
101	Both practical execution and research processes benefit each other by creating and sharing valuable knowledge to improve realisation processes	3	x		x	
102	Designing the project to involve research efforts at the beginning of the project is vital in a project with uncertainties or without precedent to gather as much knowledge as possible.	2			x	
103	It is important to understand that all lessons, both positive and negative, are good lessons that help future implementation.	2		x	x	

Appendix 5.2

No.	Key Lessons Learnt
Identifying the problems and opportunities	
Initiation of potential solutions	
1	Opportunities to harness NBS are highly context-dependent and often depend on the environmental and social quality and potential risks
4	Using past designs and pilot research as examples can be beneficial to help address uncertainties, optimise future designs, and evaluate problems or opportunities. Solutions that are trusted and demonstrated are more likely to be selected.
Traditional vs NBS	
10	Unlike traditional infrastructure, NBS can effectively meet multiple objectives and create multiple benefits within a single solution.
15	Selection between traditional and NBS projects depends on several factors such as the project objectives, available finances or cost, maintenance requirements and potential impacts on surroundings.
17	Decision-makers have significant influence over NBS and, therefore, must be advocates for financing and changes to the policy.
18	Understanding the system and evaluating project impacts is necessary to assess project opportunities and tailor the solution accordingly.
Selection and assessment of NBS	
Objectives	
20	Project priorities differ between contexts, so combining objectives to develop mutual goals can encourage cooperation; however, one overarching goal is critical for success.
Selection criteria	
22	System understanding requires expert and local knowledge and understanding of governance systems which is critical to inform the initiation and type of NBS.
Financing	
25	To secure funding, projects should have feasible and demonstratable outcomes, and provide mutual benefits and objectives to actors.
Risks	
27	Risks can be encountered at each stage of NBS realisation due to the infancy of the concept; however, they are primarily associated with maintenance and post-project monitoring requirements due to uncertainties in the future behaviour of a system.
28	Uncertainties of NBS regarding their integration with nature may present several risks. Design must consider the system and how to address these potential risks.
Design of NBS implementation process	
Multidisciplinary team engagement	
32	Integrated multidisciplinary teams with a diversity of skills aid the exploration of alternative processes and facilitate consideration of added benefits for a solution.
34	The project team must be open and respectful of local knowledge and traditions within particular contexts for local support.
Team Composition	
37	Invest resources to build a good team with active cooperation, positive dynamics, and values.
Partnerships	
38	Management, continued nurturing, and coordination is important to maintain good relationships between teams and external partners.
39	Organisational partnerships with local institutions can provide complementary skills and create added value through established networks and resource diversity.
Implementation of NBS	
Actions to achieve objectives	
46	Successful NBS implementation requires a willingness from the community while the decision-maker commitment to project outcomes.
49	Adaptive management is crucial in NBS and creates constructive learning, which involves monitoring, learning by doing and knowledge sharing.
Success for implementation	
53	Nature is constantly changing, and we must work with it. System understanding is essential to work with changing natural systems and avoid implementation issues.
54	Be aware of the project and context conditions when considering the feasibility and practicality of the implementation methodology. This includes the availability of machinery and the capability of local contractors.
56	Overcoming unanticipated circumstances requires a mindset of cooperation within teams.
Overcoming Problems	
58	Too much focus on execution may jeopardise objectives associated with long-term learning due to conflicting actions, goals, or insufficient finances.

Stakeholder engagement and communication of co-benefits	
Perception	
61	Initial resistance often decreases or disappears throughout construction, mainly where opportunities are available to observe or engage with the project.
Stakeholder engagement	
64	Early involvement of all stakeholders is crucial and involves communicating clear project objectives and benefits and understanding stakeholder concerns.
66	While stakeholder involvement during design can be an intensive process, it is valuable for support. Further, exploring alternative functionalities offered by stakeholder knowledge can allow primary objectives to remain while adding benefits and cost savings in design.
Methods of stakeholder engagement	
70	Showcasing the project through media, public visitation, and education helps communicate objectives, decrease resistance, and encourage funding opportunities.
72	Engaging and developing relationships with local institutions trusted within established networks is good practice. This can vastly improve local stakeholder engagement, interaction and support.
Stakeholder engagement in external contexts	
76	Educational tools such as field schools and learning-by-doing help involve and educate stakeholders about project operations, benefits and co-benefits and gather local knowledge.
Monitoring and evaluation	
Evaluating success	
78	Good monitoring programs help validate progress towards goals and achieve multiple benefits.
80	The way the project is connected to the wider physical and social environment and how it considers and interacts with nature alongside other objectives is a key determinant of success.
Monitoring	
84	Monitoring and data management should be implemented from the beginning of the project to understand project impacts and inform an accurate evaluation of outcomes.
86	Successful monitoring must involve planning and evaluation of monitoring goals. While some results can be seen in a short period, long-term monitoring is ideal for investigating uncertainties and effective learning.
Barriers for monitoring	
87	Barriers to monitoring include lack of budget, unclear objectives, and unwillingness to invest in and utilise monitoring for knowledge development.
88	A lack of pre-existing information or data availability from projects can impact monitoring success and the ability to gain system understanding, particularly if monitoring is not implemented from the beginning.
Transfer and upscale NBS	
Translating NBS knowledge	
92	Local stakeholder involvement aids the translation of contextual knowledge due to their system understanding.
93	Spreading awareness of NBS concepts through training and education programs is a valuable way to encourage NBS translation. This involves the development of guidelines, integrating education into university programs or government training, and community interactions. This can help create an understanding of NBS practices and benefits, increase enthusiasm about the approach and disseminate this knowledge to a broad group of actors.
Barriers for mainstreaming	
97	NBS can often prove more economical than traditional infrastructure. To be competitive with traditional solutions, total lifecycle costs are needed, which monetise the added values and benefits that NBS provide, in addition to the cost of execution.
100	People must understand that NBS transcends the physical solution, affecting wider physical, social, and economic spheres, which requires system understanding.
Learning	
101	Both practical execution and research processes benefit each other by creating and sharing valuable knowledge to improve realisation processes.

Appendix 5.3

SWOT Analysis and Categorisation of Lessons Learnt

Key: Participation, Integration, Learning and Negotiation

Strengths	Opportunities
4. Using past designs and pilot research as examples can be beneficial to help address uncertainties, optimise future designs, and evaluate problems or opportunities. Solutions that are trusted and demonstrated are more likely to be selected. 10. Unlike traditional infrastructure, NBS can effectively meet multiple objectives simultaneously 18. Understanding the system and evaluating project impacts is necessary to assess project opportunities and tailor the solution accordingly. 25. To secure funding, projects should have feasible and demonstratable outcomes, and provide mutual benefits and objectives to actors. 32. Integrated multidisciplinary teams with a diversity of skills aid the exploration of alternative processes and facilitate consideration of added benefits for a solution. 34. The project team must be open and respectful of local knowledge and traditions within particular contexts for local support. 37. Invest resources to build a good team with active cooperation and positive dynamics and values. 49. Adaptive management is crucial in NBS and creates constructive learning, which involves monitoring, learning by doing and knowledge sharing. 53. Nature is constantly changing, and we must work with it. System understanding is essential to work with changing natural systems and avoid implementation issues. 56. Overcoming unanticipated circumstances requires a mindset of cooperation within teams. 61. Initial resistance often decreases or disappears throughout construction, mainly where opportunities are available to observe or engage with the project. 64. Early involvement of all stakeholders is crucial and involves communicating clear project objectives and benefits and understanding stakeholder concerns. 70. Showcasing the project through media, public visitation, and education helps communicate objectives, decrease resistance, and encourage funding opportunities. 76. Educational tools such as field schools and learning-by-doing help involve and educate stakeholders about project operations, benefits and co-benefits and gather local knowledge. 78. Good monitoring programs help validate progress towards goals and the achievement of multiple benefits. 84. Monitoring and data management should be implemented from the beginning of the project to understand project impacts and inform an accurate evaluation of outcomes. 86. Successful monitoring must involve planning and evaluation of monitoring goals. While some results can be seen in a short period, long-term monitoring is ideal for investigating uncertainties and effective learning. 97. NBS can often prove more economical than traditional infrastructure. To be competitive with traditional solutions, total lifecycle costs are needed, which monetise the added values and benefits that NBS provide, in addition to the cost of execution. 100. People must understand that NBS transcends the physical solution, affecting wider physical, social, and economic spheres, which requires system understanding. 101. Both practical execution and research processes benefit each other by creating and sharing valuable knowledge to improve realisation processes.	17. Decision-makers have significant influence over NBS and therefore must be advocates for financing and changes to policy. 20. Project priorities differ between contexts, so combining objectives to develop mutual goals can encourage cooperation; however, one overarching goal is critical for success. 22. System understanding requires expert and local knowledge and understanding of governance systems which is critical to inform the initiation and type of NBS. 38. Management, continued nurturing, and coordination is important to maintain good relationships between teams and external partners. 39. Organisational partnerships with local institutions can provide complementary skills and create added value through established networks and resource diversity. 46. Successful NBS implementation requires a willingness from the community while the decision-maker commitment to project outcomes. 66. While stakeholder involvement during design can be an intensive process, it is valuable for support. Further, exploring alternative functionalities offered by stakeholder knowledge can allow primary objectives to remain while adding benefits and cost savings in design. 72. Engaging and developing relationships with local institutions trusted within established networks is good practice. This can vastly improve local stakeholder engagement, interaction and support. 80. The way the project is connected to the wider physical and social environment and how it considers and interacts with nature alongside other objectives is a key determinant of success. 92. Local stakeholder involvement aids the translation of contextual knowledge due to their system understanding. 93. Spreading awareness of NBS concepts through training and education programs is a valuable way to encourage NBS translation. This involves the development of guidelines, integrating education into university programs or government training, and community interactions. This can help create an understanding of NBS practices and benefits, increase enthusiasm about the approach and disseminate this knowledge to a broad group of actors.
Weaknesses	**Threats**
15. Selection between traditional and NBS projects depends on several factors such as the project objectives, available finances or cost, maintenance requirements and potential impacts on surroundings. 18. Understanding the system and evaluating project impacts is necessary to assess project opportunities and tailor the solution accordingly. 22. System understanding requires expert and local knowledge and understanding of governance systems which is critical to inform the initiation and type of NBS. 28. Uncertainties of NBS regarding their integration with nature may present several risks. Design must consider the system and how to address these potential risks.	1. Opportunities to harness NBS are highly context-dependent and often depend on the environmental and social quality and potential risks. 17. Decision-makers have significant influence over NBS and therefore must be advocates for financing and changes to policy. 27. Risks can be encountered at each stage of NBS realisation due to the infancy of the concept; however, they are primarily associated with maintenance and post-project monitoring requirements due to uncertainties in the future behaviour of a system. 46. Successful NBS implementation requires a willingness from the community while the decision-maker commitment to project outcomes.

34. The project team must be open and respectful of local knowledge and traditions within particular contexts for local support. 38. Management, continued nurturing, and coordination is important to maintain good relationships between teams and external partners. 56. Overcoming unanticipated circumstances requires a mindset of cooperation within teams. 84. Monitoring and data management should be implemented from the beginning of the project to understand project impacts and inform an accurate evaluation of outcomes. 87. Barriers to monitoring include lack of budget, unclear objectives, and unwillingness to invest in and utilise monitoring for knowledge development. 97. NBS can often prove more economical than traditional infrastructure. To be competitive with traditional solutions, total lifecycle costs are needed, which monetise the added values and benefits that NBS provide, in addition to the cost of execution. 100. People must understand that NBS transcends the physical solution, affecting wider physical, social, and economic spheres, which requires system understanding.	54. Be aware of the project and context conditions when considering the feasibility and practicality of the implementation methodology. This includes the availability of machinery and the capability of local contractors. 88. A lack of pre-existing information or data availability from projects can impact monitoring success and the ability to gain system understanding, particularly if monitoring is not implemented from the beginning.