Governance Barriers to Proactive Asset Management Implementation

For
Primary Flood Defenses in the North Sea Region

A Master's Thesis by Diana Vlad
July 2017

Utrecht University

Utrecht University
Faculty of Geosciences

Governance Barriers to Proactive Asset Management Implementation

For
Primary Flood Defenses in the North Sea Region

Dymchurch Seawall, Romney Marsh, UK (own photograph)

Master's Thesis

Diana Vlad (5616840)
Email: m.d.vlad@students.uu.nl
Mobile number: 0634037047
Address: Spinozalaan 1 II-A, 2273 XA Voorburg
Credits: 45 ECTS
Master Thesis (**GEO4-2321**)
Master of Sustainable Development
Track-Earth Systems Governance

Thesis Supervisor: Dr. H. Mees
Second Reader: Dr. D. Hegger
Utrecht University
Faculty of Geosciences

Internship Supervisor: Dr. B. Gersonius
UNESCO-IHE Delft
Department of Water Science and Engineering

Utrecht University

UNESCO-IHE
Institute for Water Education

Abstract

This thesis was inspired by the Interreg North Sea Region project called FAIR, which commenced in 2015 and is due to be completed in 2020. The main goal of the project is to optimize the lifecycle of the primary flood defenses across all the North Sea Region (NSR) countries by shifting from a traditional, reactive asset management strategy to an adaptive, proactive asset management strategy. There is a paradigm shift taking place from simply flood mitigation and prevention to flood adaptation, one embracing uncertainty and change. In this thesis the adoption of this new paradigm is investigated by examining the field of asset management for primary flood defenses. After a synthesis of relevant literature, a proactive asset management framework has been derived. It is about thinking ahead by incorporating long-term planning into short-term strategies and identifying as many measures for primary flood defenses as possible in order to increase the likelihood of selecting the most optimum one. It is also about adopting a whole-systems approach and looking at the network of assets and not only at individual primary flood defenses such as a dike. The purpose of this thesis is to investigate the governance barriers that asset owners in each of the seven North Sea Region country faces to proactive asset management implementation for primary flood defenses in the North Sea Region. The central research question that it sought to answer is: *What are the governance barriers that asset owners in the North Sea Region face to proactive asset management implementation for primary flood defenses and what are practical opportunities to overcome them.* This question was answered with the help of a governance barriers analytical framework which was derived from the literature on governance and also asset management, by selecting five categories of governance barriers that could possibly encompass a large variety of specific barriers. The analysis produced some insightful results for both theory and practice. First of all, asset owners in each North Sea Region country consider different barriers to be significant, and these differences could in part be explained by the national contexts and current asset management strategies. Countries could be compared in terms of the stages in which the identified governance barriers were presumed to occur by the asset owners and the researcher, the significance accorded to the barriers and the frequency (number of countries that identified a specific type of barrier).

Keywords: proactive asset management, governance barriers, North Sea Region, asset owners

Acknowledgements

This thesis has been written as part of the Master Sustainable Development at Utrecht University, Faculty of Geosciences. It is supported by the Interreg Project FAIR. It has been an exciting and challenging eight-month journey that also included trips to two beautiful places, and various project meetings and social gatherings with the people engaged in this project. It was an excellent learning and hands-on work opportunity, involving the reading of interesting text and lots of writing and reflection. I am proud to say that I was the only academic of a social scientist background involved directly in the research of the project, and speaking from my own experience, I utterly hope that governance will be offered a more central stage in the field of flood risk management and in water management more broadly.

First of all I would like to thank my supervisor, Dr. Heleen Mees, for the generosity of her time and knowledge. She always provided me with constructive and very insightful feedback, and encouraged me to dig deeper into the details. Also, many thanks to Professor Dries Hegger, my second reader, for taking the time to speak to me and offer feedback, despite his busy schedule.

Secondly, I would like to thank Dr. Berry Gersonius from UNESCO-IHE for pushing me to do my best work, for passing on some of his extensive knowledge of asset management to me, and especially for giving me this opportunity which I shall always cherish. In the same lines, I want to thank Professor Jeroen Rijke from Van Hall Larenstein University of Applied Sciences, for his stimulating and creative insights, and for supporting me during the data collection and writing process.

Furthermore, I would like to thank the rest of the scientific team, both in the Netherlands and abroad, for allowing me to participate in the discussions and the asset owners for accepting to participate in my interviews. It was a pleasure collaborating with them.

Lastly, I would like to show gratitude to my mother for her constant moral support during my studies, and to my beloved fiancé, who has been understanding, caring and patient, especially during my last mile of writing this thesis.

Diana Vlad,
Voorburg, the Netherlands
July 2017

List of tables:

List of figures:

Glossary and Abbreviations

Glossary:

- **Governance barriers: "**Obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritization and related shifts in resources, land uses, institutions, etc." (Ekstrom et al., 2011: pg. 10).

- **Opportunities to overcome:** "A "road map" to design strategies to circumvent, remove, or lower the barriers" (Ekstrom et al., 2011: pg. 55).

- **Asset Management:** "The systematic and coordinated activities and practices through which an asset's conditions, performance, risks and expenditures are optimally managed over the life cycle of the asset for the purpose of achieving the strategic plan" – CIRIA (2013). It is composed of the strategic management, tactical management and operational management level.

- **Asset owners:** Asset owners are responsible for the assets-investments, renewal, maintenance, etc. and operators of the operation of critical flood protection infrastructure systems and services. It may be the same stakeholder, yet can also differ.

- **Primary flood defenses:** Tangible assets such as dams, sluices and floodgates, built to protect an area from flooding (Collins English Dictionary)

Abbreviations:

NSR: North Sea Region
AM: Asset Management
ADM: Adaptive Delta Management

Organizations:
RWS: Rijkswaterstaat
HHSK: Schieland and Krimpenerwaard Dutch water board
DCA: Danish Coastal Authority
MDK: Belgian Agency for Maritime and Coastal Services
NVE: Norwegian Water Resources and Energy Directorate
EA: UK Environment Agency

Countries:
NL: the Netherlands
BE: Belgium
DE: Germany
UK: United Kingdom
DK: Denmark
SE: Sweden
NO: Norway

Table of Contents

1. Introduction and Background

Scientific views end in awe and mystery, lost at the edge in uncertainty, but they appear to be so deep and so impressive that the theory that it is all arranged as a stage for God to watch man's struggle for good and evil seems inadequate.

~ Richard P. Feynman

Following from this quote by the famous physicist, this chapter goes to introduce the area of research, one of much uncertainty. First, the context of the research project is examined. Second, the problem is explained. Subsequently, the research objective is described along with the central research question and the sub-questions. The last part contains the outline of the research.

1.1 Project Context

1.1.1 Paradigm shift

Flooding is fast becoming a major global issue, being one of the most threatening natural hazards for human societies. The last 50 years have seen an accelerated increase in economic and infrastructure damages throughout the world (Schanze, 2006).). Floods can occur in small and large river basins, in estuaries, at coasts and locally. The sources of flooding can include rainfall floods, summer convectional storm induced floods, sea surge and tidal floods and tsunamis (Schanze, 2006). Flash floods are a special type. Flooding is in part caused by climate change, which is partly responsible for sea level rise, melting glaciers, changing precipitation patterns, changing land use, among other effects (Klijn et al., 2013). Floods could lead to a diverse set of societal and ecological disruptions, among those being: traffic disruptions, material damage to buildings, economic damages, and health impacts due to molds from released contaminants or infectious diseases (Runhaar et al., 2012). It is important to mention that not all flooding is bad; for example floods occurring in natural floodplains are good for harvest. However, floods can also be induced by mankind through intensive land use, and this is something that should be kept in mind. The negative impact is evident from the increase in damages worldwide observed during the last 50 years (Runhaar et al., 2012). At the end of the 20th century, with the International Decade of Natural Disaster Reduction (IDNDR), a paradigm shift occurred, from absolute protection to risk management. It has been concluded that absolute protection is unachievable and unsustainable, due to high costs and mounting uncertainties. The flood risk management paradigm has been recommended as being more suitable and it is receiving growing attention within flood research (Schanze, 2006). Flood policies are also seeing a shift from flood prevention to adaptation, or from reactive to proactive strategies.

Since now we are living under a different paradigm of a high level of uncertainty as a result of an increasing prognosis of climate change effects and socio-economic factors, the probability of flood risk is an important concept to keep in mind. It is equal to the flood hazard multiplied by the flood vulnerability (Klijn et al., 2013). Flood probability means that certain elements in the environment are exposed to potential damage, and a proactive attitude must be undertaken to prevent that from happening, or to plan how to deal with it in case it does happen. This new paradigm is no longer about *reacting* to flood occurrence

after it happens, which was the traditional approach, but about *adapting* to it in a *proactive* manner (Gersonius, 2012). Vulnerability refers to inherent characteristics in those elements which make them susceptible to be harmed (Klijn et al., 2013; Schanze, 2006). There is social vulnerability, referring to loss of life and health impacts; economic vulnerability referring to financial losses by damage to property; and ecological vulnerability which causes pollution in the natural environment (Schanze, 2006).

1.1.2 Asset Management

One important field of study in the flood risk management paradigm is asset management. Asset management can encompass all types of assets, both tangible and intangible. In this thesis asset management is specifically for primary flood defenses such as dikes and sluices. Asset management is interpreted as the decisions undertaken to analyze, assess and to try to reduce flood risks (Schanze, 2006). Asset management should be a 'holistic and continuous societal analysis, assessment and reduction of flood risk'. Holistic means that the flood risk system should be as comprehensive as possible, via a whole-systems approach (Van der Velde, 2013). Continuous refers to the fact that this assessment should be done continuously, as the flood risk system is under constant flux. It is important to note that asset management for primary flood defenses is one small part of adaptation to climate change, but that the same principles apply as infrastructure asset management is about continuous adaptation and it must take climate change scenarios into account for the long-term (Van der Velde, 2013).

Asset management takes place at different societal levels, from European, to national, regional and local (Van der Velde, 2013). The decision-making process varies by country depending on the politics, administration, planning and culture within those countries (Willows and Connells, 2003). In addition, they are influenced by external factors, being climate change and socio-economic factors that are inevitable but remain difficult to predict (Sayers et al., 2014). The way asset management is dealt with in each country has to be analyzed differently, depending on individual and collective perspectives, which is why governance is so important to investigate, because the way flood risk is managed depends on the institutions, on the interaction between different stakeholders and on the culture of the country, the way flood risk is perceived (Biesbroek, 2013). For this reason, governance barriers literature was searched to select several categories of barriers that could group the specific problems asset owners in the North Sea Region are facing to proactive asset management implementation in order to reduce the negative consequences of future flooding as much as possible.

Infrastructure has always played a necessary part in society, and it has evolved dramatically through time (OECD, 2015). There are different sectors in which infrastructure is important, including roads and waterways. Waterways is the focus of this thesis, specifically primary flood defenses that help defend inland and coastal communities from flooding. Primary flood defenses have historically been the predominant solution to flooding (OECD, 2015). However, it has received a lot of criticism with the emergence of sustainability and climate change uncertainties. Investment in flood defense is of course still important, but it needs to be situated within a broader context that includes both physical and social aspects, depending on what part of the overall risk system are being investigated, whether it is a close examination of the types of floods, or the progress of economic growth and key determinants of social vulnerability (Schanze, 2006). Today, no

European society can be described as completely resistant to floods, due to the risk of uncertainty that decreases the chance of coping (Schanze, 2006.). Therefore, there is increasing need for a more proactive approach (Gersonius et al., 2015; 2012; Sayers et al., 2014; Handout et al., 2012). The key to a modernizing society is accepting the possibility of defense failure (Schanze, 2006).

1.1.3 The 'FAIR' Project

In 1953, the worst flooding disaster of the 20th century in the North Sea Region (NSR) took place. The Netherlands, Belgium, and the United Kingdom were affected. Some 2,400-people lost their lives (Sayers et al., 2014). Since then, every NSR country has invested billions in primary flood defense infrastructure (e.g. Delta works in the Netherlands). However, today, infrastructure assets that are supposed to protect us from flooding in the North Sea Region (NSR) (e.g. dikes, sluices, dams) are aging fast and their performance is often no longer at the desired level, leading to loss of investments, since overall the assets are worth more than 100 bn euros (Oonk-Abrahams, 2015). The NSR has among the busiest transport and economic activity in the world, and its expected annual costs due to flood damage are extremely high, unless strong prevention and adaptation policies are implemented in case of a flood hazard (Schanze, 2006). A large part of the NSR economic sector depends heavily on good quality flood protection infrastructure, but it is currently not meeting the sufficient requirement levels because of poor maintenance and aging (Oonk-Abrahams, 2015).

The Interreg North Sea Region Programme has launched a project in 2015 involving all the North Sea Region countries to take part in implementing proactive asset management in the strategic, tactical and operational management levels in their countries. The **strategic management level** refers to the component of asset management where strategic planning for the maintenance of the asset takes place. The **tactical handshake** serves to strengthen communication between the strategic and operational management levels. The **operational management level** is about how the infrastructure is monitored, maintained, and repaired. All levels combined make up asset management. One cannot be studied without the other. Research shows that there is insufficient consideration of long-term planning for the maintenance of assets, as most emphasis is placed on asset reinforcement (Sayers et al., 2014). The aim is to engage all relevant asset owners of flood protection infrastructure to effectively and efficiently reach the goal of overcoming barriers to a proactive approach to asset management by 2020. Asset owners are those public authorities responsible for the operational management of the infrastructure, such as Rijkswaterstaat in the Netherlands. For a proactive asset management framework to be adopted by all asset owners across the North Sea Region, the current frameworks to asset management must be investigated to derive a more proactive strategy for both the strategic and operational levels that can be both flexible and robust to any situation or asset.

Currently, all NSR countries aim to improve the maintenance of existing flood defense infrastructure. This is a great challenge. In the Netherlands for example, all asset owners combined spend an estimated 2-5 bn euros/year on maintenance and renovation. Large-scale investments are being made in the Netherlands, UK, Germany, and Belgium. In Denmark, Sweden, and Norway governmental authorities aim to provide guidance to local and sometimes private asset owners for adopting appropriate solutions (Oonk-Abrahams, 2015). A further shift is needed towards an adaptive asset management approach, which,

from now on, will be explicitly mentioned in this research as *proactive* asset management, as far as it concerns the management of infrastructure assets. Proactive asset management refers to adaptation rather than merely reacting to deterioration after it has already occurred, and adopting a more strategic approach for the long term as opposed to just focusing on short-term impact. The proactive asset management framework derived in this research is an ideal type, and will be used as a benchmark against which the current asset management approaches of the asset owners of the NSR will be evaluated. Figure 1 shows the current challenges that infrastructure asset management faces.

1.1.4 Governance for Implementation

In a broad context, governance can be understood as a way of steering and managing parts of society in response to the emergence of societal problems. Mono-centric type governance is a process in which the state as a functional unit is dominant in a hierarchical and steering society. The type of governance at work in the current thesis is polycentric type governance, with many centers of decision-making. However, there comes a price with this type of governance: interdependency of decisions across levels of governance, and unclear division of tasks and responsibilities between actors (Biesbroek, 2014). The total operation of infrastructure not only depends on the physical assets themselves, but also other intangible elements such as information, data, standards, employees and culture (Wijnia and Herder, 2010). This is where governance takes central stage.

With the governance of infrastructure is meant the processes, tools, and norms of interaction, decision-making, and monitoring used by governmental organizations and companies in order to make infrastructure available to the public. It relates to the interaction between governmental institutions internally and their interaction with the private sector and citizens (OECD, 2015). The whole life-cycle of the asset is covered, but the greatest focus is typically paid to the planning and decision-making phases for most assets. Those are the most resource-intensive phases. Good governance is necessary for appropriate infrastructure delivery (ibid.), because it directly effects human development and environmental sustainability. Governance is what coordinates all the different components together and all the actors involved. Until now, most of the focus on governance of infrastructure has been on financial challenges, while the broader governance perspective has been neglected (Van der Velde, 2013). In this thesis the infrastructure of focus are the primary flood defenses. This research will contribute to the embedding of more governance elements into asset management for primary flood defenses, such as public acceptance and stakeholder engagement. Poor governance is one of the main reasons why infrastructure projects fail to meet their timeframe, budget and service delivery objectives (Wijnia and Herder, 2010). Infrastructure projects with deficient governance often result in high costs, ineffective delivery, delays, accelerated deterioration due to poor maintenance, etc. (OECD, 2015). Despite the fact that public infrastructures experience rapid development through the ages, the institutional settings that govern them seem to be lagging behind (Wijnia and Herder, 2010). Infrastructures, including primary flood defenses, started as a private enterprise, but eventually were placed under government control. Recently, this has been reversed with the liberalization and deregulation of many infrastructures (Wijnia and Herder, 2010). However, this has caused other problems and the perception of risk associated with infrastructure came to the surface. Infrastructures are “under pressure” from governments, the market, the public and challenging legal and performance

requirements (Wijnia and Herder, 2010). Figure 1 below is a visual representation of these pressures.

Barriers are necessary to investigate when attempting to improve the governance of asset management because barriers prevent governance from implementing policies. In other words, barriers cause governance deficiencies. Barriers are the consequences of "action in financial, cultural and policy realms that raise questions about the efficacy and legitimacy of adaptation as a response to climate change" (Adger et al., 2007). This definition is used because proactive asset management is meant in a broader sense to contribute to climate change adaptation. There is a strong parallel between "adaptation" and "proactivity". What is ultimately determined to be a barrier depends on the goal of adaptation, which varies between different contexts. Barriers can be overcome with sufficient skills, creativity, and appropriate resources. In the current thesis, barriers will be determined at each stage of the asset management cycle in both the long-term and maintenance phases.

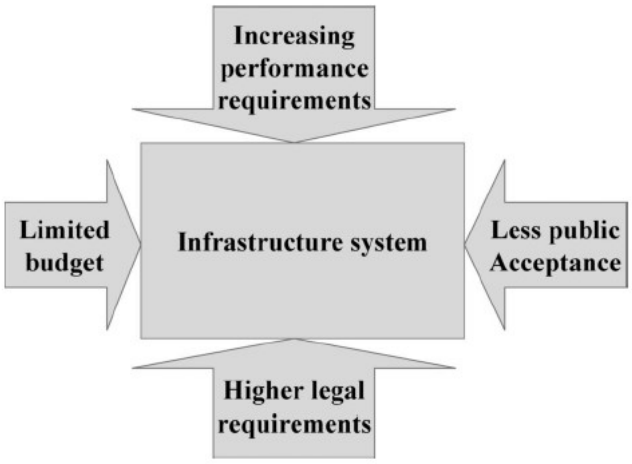


Figure 1: Pressures on infrastructure assets (source: Wijnia and Herder, 2010)

1.2 Problem Definition

The traditional type of asset management adopts a reactive approach which focuses on short-term consequences and responding to immediate disaster, without considering future climate change uncertainties. In other words, long-term planning is not that much considered yet, which is done at the strategic management level. This approach can be very costly, as it is usually (but not always) much more time-consuming and investment-intensive to replace damaged infrastructure than maintaining existing infrastructure (Oonk-Abrahams, 2015). There is greater need to shift to proactive asset management that would invest in the long-term maintenance of existing primary flood defense infrastructure. There are indications that the asset owners face **governance barriers** to implementing a proactive asset management approach seeing as how their assets are not performing at their optimal capacity due to aging and poor maintenance. There are a variety of reasons for this which will be explored in depth; among them being that there is a lack of clear roles and responsibilities, and there is insufficient long-term planning (Sayers et al, 2014; Rijke et

al., 2012). To come up with effective strategies to implement asset management appropriately, a clear proactive asset management framework needs to first be identified, followed by identification of barriers to implementation of this proactive AM framework which is the essence of this research. Some barriers that asset owners must face include the growing impact of climate change, constrained budgets, aging flood protection assets, and the pace of technological change (Oonk-Abrahams, 2015). In Europe and in other parts of the world, the infrastructure investments are not moving in the planned direction, and in general the supply of infrastructure cannot keep up with the demand (World Economic Forum, 2014). This applies to the North Sea Region as well. For the North Sea Region, aging infrastructure is the primary maintenance-related problem (World Economic Forum, 2014).

1.3 Knowledge gaps

Generally, and still to this day, asset management is considered to be primarily an engineering discipline, as asset managers do not always recognize the social and cultural issues (Van der Velde, 2013). There have been no comprehensive studies on the interaction of governance barriers and asset management to date (Van der Velde, 2013). The goal of the current research is to contribute to this gap by exploring the types of governance barriers faced by asset owners in all seven North Sea Region (NSR) countries, and to provide insight into how and to what extent these hamper the adoption of a proactive framework to asset management. Barriers to adaptation have hardly been defined in the literature, and there are no clear indicators for identifying and assessing them systematically (Biesbroek, 2014). The categories used in this thesis are taken from a variety of sources and are distinguished as the following: institutional, resource, cognitive, information and communication, participation (Adger et al., 2007; Ekstrom and Moser, 2010, Biesbroek, 2014; Biesbroek et al., 2013). These categories will be elaborated in chapter 2 in the analytical framework for barriers section, and examples provided for each, as well as possible opportunities to overcome them. The majority of studies on barriers use small-n inductive case approaches while comparative studies across different contexts are few (Biesbroek, 2014). Also, empirical studies on intervention strategies are scarce. The current thesis will contribute to closing these gaps.

1.4 Contribution

This thesis contributes to solving this problem by examining how the governance barriers for the chosen asset owners in each country plays out in practice and to identify opportunities for overcoming these barriers. It is important to note that it was possible new categories of barriers emerged from the analysis of the new interviews, along with new patterns and/or themes. Not only the barriers and opportunities, but also the current asset management strategies of each country and national contexts have been investigated and compared between asset owners where relevant and generalized for the NSR countries where appropriate.

1.5 Research Questions and causal diagram

The **central research question** of this thesis is the following**:**

What are the governance barriers that asset owners in the North Sea Region face to proactive asset management implementation for primary flood defenses and what are practical opportunities to overcome them?

The **sub-questions** that address this central research question are:

1. What is proactive asset management for primary flood defenses? [**theoretically-determined**]
2. What is the national context of each NSR country? [**empirically determined**]
3. What is the current asset management strategy for primary flood defenses in each country of the North Sea Region? [**empirically-determined**]
4. How can barriers in the governance of asset management be defined and conceptualized? [**theoretically-determined**]
5. What are the significant barriers to proactive asset management implementation that asset owners in the North Sea Region countries encounter in practice? [**empirically-determined**]
6. What ideas do the asset owners have for overcoming the significant governance barriers? [**empirically-determined**]

Causal diagram:

This diagram (Figure 2) shows the relationship between the barriers, opportunities to overcome, implementation of proactive asset management and also the national context.

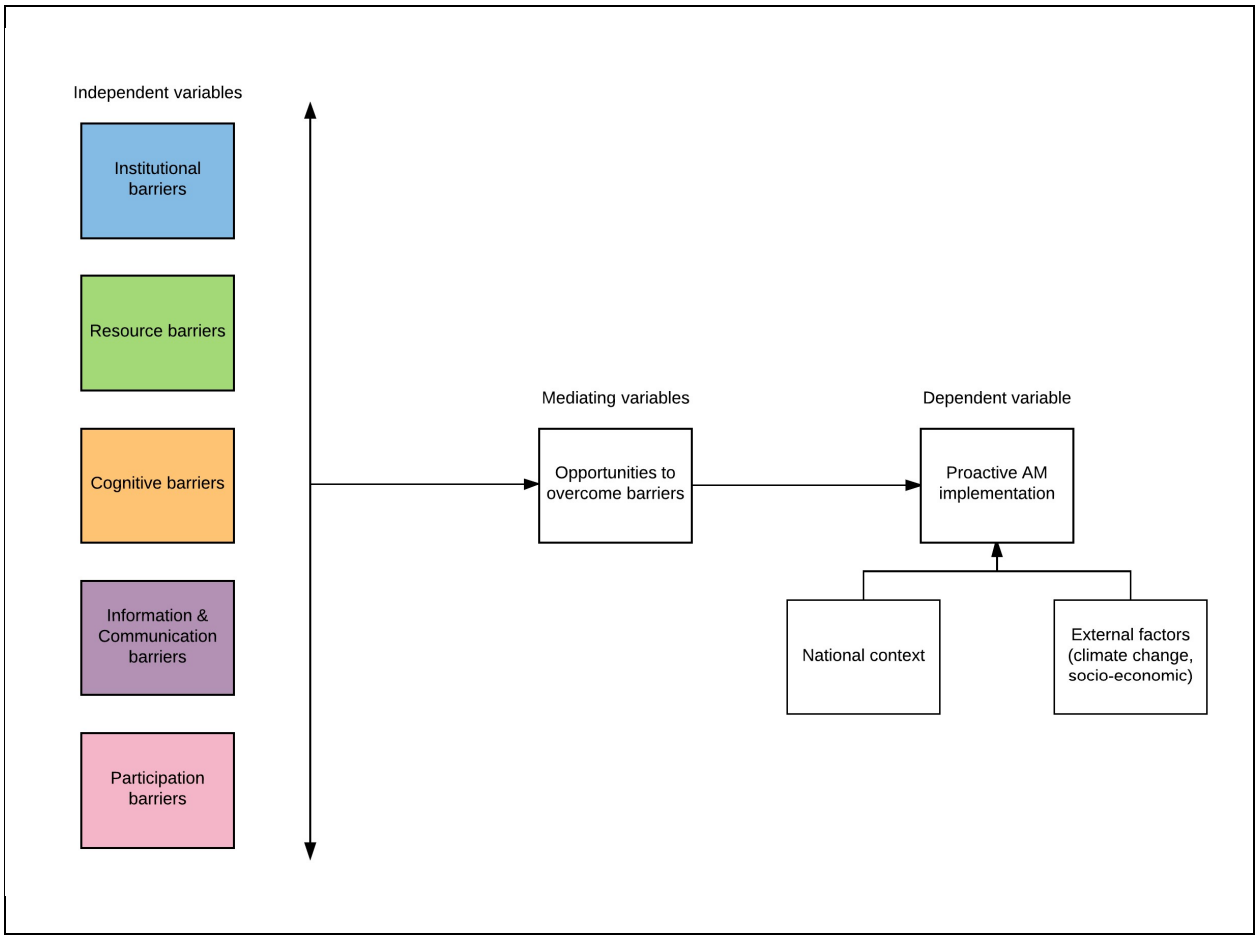


Figure 2: Causal diagram

The governance barriers in the current asset management strategies are the independent variables which influence the level of proactive asset management implementation, the dependent variable. The opportunities to overcome barriers are the mediating variables that facilitate the influence of barriers on proactive AM implementation. The national context consisting of the roles and responsibilities and relevant policies and plans of the respective countries, as well as the external factors, also have an influence on proactive asset management implementation, but it is more difficult to measure them because these are dependent on other factors such as culture and level of flood risk in the country. The colors used for each category of governance barrier is applied throughout the rest of the thesis as well to enhance visual representation.

1.6 Scientific and Societal Relevance

1.6.1 Scientific Relevance

The proposed research is scientifically relevant because the asset management of primary flood defense infrastructure has not been sufficiently investigated before in the North Sea Region (Oonk-Abrahams, 2015). Moreover, governance barriers in current asset management strategies that each asset owner faces across the NSR have not been clearly identified before, and there are yet no solutions for overcoming those barriers (ibid.). Research on asset management for primary flood defenses has been dominated by the natural sciences mainly in the civil engineering, hydraulic engineering, climate modelling and scenario building. This is gradually changing via the shift towards a sustainable development perspective, in which socio-economic aspects are included (Biesbroek et al., 2009). In addition, there are limited conceptual frameworks to analyze governance barriers to adaptation, which play an important role in their analysis (Biesbroek et al., 2013). Also, there are limited studies about how barriers emerge, and how to deal with them remains limited (ibid.). There is yet no commonly accepted assessment framework for asset management, and no commonly accepted analytical framework for barriers (Biesbroek et al., 2013). The main conclusion of previous research on barriers to adaptation is that barriers can seriously prevent the development of adaptation strategies, but how and to what extent is not part of the analysis. This thesis contributes to theory by integrating different theories on asset management from both strategic asset management and operational asset management that take dynamic relationships between stakeholders and future uncertainties into account, thus giving it a proactive element. In addition, this thesis includes an analytical framework to identify governance barriers that asset owners face at different levels and stages of the asset management cycle in a practical way, something that has been lacking in previous research (Biesbroek et al., 2013).

1.6.2 Societal Relevance

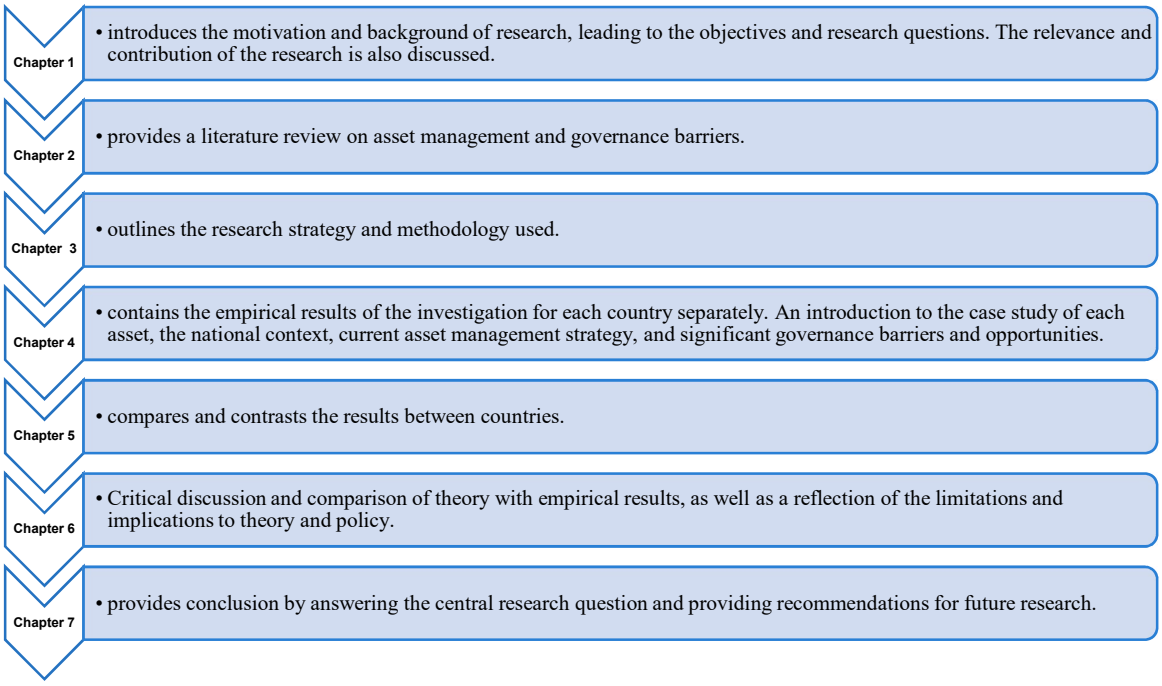
The innovation and practical value of the research lies in its development of a clear proactive asset management framework and the use of that framework to guide the asset owners of primary flood defenses in the North Sea Region (NSR) to improve the planning and maintenance strategies of primary flood defense infrastructure by the asset owners.

The results of this research are expected to be consequential for the social (safety and health of coastal inhabitants) and economic (reduction of investment costs) in the North Sea Region. Coastal flooding indirectly impacts people's physical and psychological health, the economic situation of a country, and political situation (Oonk-Abrahams, 2015). Importantly, societal costs for maintaining these assets can have a big impact on government budgets. Governments around the world face an urgent need for new or updated critical flood defense infrastructures that are essential for the preservation of the social, economic, and environmental well-being, whether such assets are owned by the state, privatized, or a hybrid of these (Schanze, 2006). Failure of these critical flood protection assets could result in high costs because of flood damage, risk to life and damage to the overall national security.

Research on asset management has not been previously conducted in the North Sea Region, and the fact that it will be undertaken now with this project is significant and the results uncertain. It is expected that the knowledge and results gained at the end of this research will generate practical recommendations for asset owners. Moreover, governance barriers in asset management strategies have not been investigated before, as governance has not been involved very much in asset management research, which has been strictly within the realm of the engineering disciplines (Biesbroek, 2014). Governance is important to investigate because it includes the study of stakeholders and how they interact with each other to implement policy (Biesbroek, 2014). The engineering sciences are already well-established, what is lacking is the governance that acts to translate the scientific language into policy, and to convince actors what must be done and how. It is important to mention that previously the focus of asset management was on the individual asset (e.g. dike). Now, this is challenged by asking relevant stakeholders to think about the entire network of assets (e.g. waterways), in order to create a new paradigm of thought and move towards an integrated decision-making process on both individual asset and network level.

1.7 Outline of research

The research is structured in (7) chapters and a brief outline of the chapters is presented below:



2. Research Perspectives

In this chapter asset management for primary flood defenses is first defined and an evaluative framework for proactive asset management is introduced that was derived from a synthesis of the relevant literature. It is mean to be used as a benchmark against which the current asset management strategies of the asset owners in the North Sea Region (NSR). It is presented along with the different stages that need to be taken at each tier-strategic management level, tactical handshake and operational management level. Afterwards an analytical framework for the governance barriers is presented composed of five categories of governance barriers that encompass a wide variety of barriers to the implementation of the proactive asset management framework that could potentially emerge in practice.

The bodies of literature for asset management that are investigated for the **strategic level** are adaptation pathways, strategic flood management and adaptive delta management (ADM). Risk and Opportunity-based Asset Management for Critical Infrastructure (ROBAMCI) (De Klerk and Den Heijer, 2016) and International Levee Handbook (ILH) were reviewed (CIRIA, 2013). The ROBAMCI and the ILH include a holistic discussion of asset management as a whole and so are the foundation that was used to construct the ideal model for proactive asset management. In this thesis the ROBAMCI and ILH are used to explain what goes on at the **operational level** of asset management. Van der Velde et al. (2013) illustrate what goes on at the strategic, tactical and operational levels of asset management as well as who the main actors are at each of those levels. In this thesis, Van der Velde (2013) is used to explain what goes on at the **tactical handshake** level of asset management. This evaluative framework is proactive, because it aims to capture the dynamism of the decision-making process. No matter how well the design of this framework is, it is still likely to fail because of differences between contexts and future uncertainties. That is why it must be made as robust and flexible as possible.

In the next section governance barriers are defined and the analytical framework that was derived from the literature (Ekstrom and Moser, 2010; Adger et al., 2007; Biesbroek et al., 2013) will be explained. This framework was used to categorize the governance barriers that asset owners across the NSR face to implement a proactive asset management strategy.

2.1 Asset Management

This section begins with a brief discussion of what asset management is, followed by a literature review of the three different levels of asset management for primary flood defenses and a description of stages that take place within each of those levels.

2.1.1 What is Asset Management?

There are various definitions of asset management in the literature. According to Van der Velde et al. (2012), asset management is the balancing of cost, performance and risk over the lifecycle of an asset (both tangible and intangible). These are the main indicators of asset management and all three must be addressed equally. Asset management is made up of three different levels: **strategic, tactical**, and **operational**. The entire operation of an asset not only depends on the physical assets themselves, but other intangible aspects as

well, such as information, funding, and cognitive aspects (Van der Velde et al., 2012). The human dimension is often left out of asset management studies, and this thesis contributes to bridging the gap by introducing a framework on governance barriers to asset management.

According to Wijnia and Herder (2010), asset management is often a bottom-up process which does not reach the strategic level. This is because it is sometimes difficult to convince the top management of the strategic value of asset management and of aligning organizational goals with technical and operational standards (Van der Velde, 2013). Often there is a lack of communication between the two levels due to a missing tactical level. Moreover, it was also recognized in this study that asset management requires a change in maintenance paradigms and that it should focus on life-cycle costing (LCC). In other words, strategic planning is often missing from operations. Currently, asset management is in need of a new maintenance plan in the operational management level that is more adaptable and the focus should be on utilizing lifecycle costing tools in order to be able to choose a more optimal solution for the design of infrastructure; one that is more cost-effective and durable.

2.1.2 What are the Asset Management Roles?

Within the tiers of asset management that have been explained above, three main roles can be distinguished: the asset owner which is situated at the strategic level, the asset manager at the tactical level, and the service provider at the operational level (Van der Velde, 2013). It often is the case that an organization, like Rijkswaterstaat in the Netherlands, for instance, to act as both asset owner and service provider. What is often missing is the asset manager, whose responsibility is to relay information from the strategic level to the operational level. It is often observed in practice that asset managers are left out of the decision-making process until after or during implementation. It is then too late for them to give their own opinion and to know all the information required way in advance to be able to translate it from strategic management to operational management and back. For the purpose of this thesis, it is important to know that the organizations interviewed were all asset owners.

2.1.3 Introduction to Asset Management Literature

There are already existing frameworks for asset management but not many that combine both the strategic and operational levels together. In addition, there is inconsistency in terminology across different frameworks. The initial step in deriving the proactive asset management framework was to review all relevant frameworks, six of which have been used for this research. The frameworks have been allocated to strategic management, the tactical handshake and operational management. The following sections explains each of the steps in the **strategic asset management level**, **tactical handshake** and the **operational asset management level**, using the relevant literature. The framework is schematically represented in the form of infinity symbol (see figure 3), which shows how the asset management process travels from the strategic management level through the tactical, down to the operational and back. The following literature goes beyond traditional decision-making and focus specifically on how to approach decisions under deep

uncertainty which have a long-term impact. The theories described follow a bottom-up approach in which plans can be revised and planning steps repeated until level of desired performance is reached.

Strategic Level

The strategic level is for the entire network of assets. It also focuses on the longer-term, a period of 2100 years into the future (Gersonius et al., 2015) and thus contains lower detail due to numerous uncertainties about the future. Also, it has lower updated frequency, meaning that that the cycle at this top level of management is run once every 10 years or more, as needed. The following paragraphs illustrate the literature that explains what strategic asset management is in relation to primary flood defenses.

The **Dynamic Adaptive Policy Pathways theory** (DAPP) of Haasnoot et al. (2012) is one of the many new theories developed for planning under conditions of deep uncertainty. Its goal is to help decision-makers create a strategic vision of the future, commit to short-term actions and at the same time establish a framework to guide future actions. An important challenge of long-term planning research to keep in mind is that short-term action cannot prove the efficacy of the method in the long-term (Haasnoot et al., 2012). To determine the efficacy of a planning strategy as accurately as possible, it is necessary to apply it to a real-world problem. Characteristics of this framework include: (1) thinking beforehand of ways a plan might fail and design actions to guard against such failures; (2) prepare for actions that might be triggered later in order to keep a plan on track to meet its objectives; (3) implement a monitoring system to identify when such action should be triggered. In addition, maps are drawn to visualize sequences of possible actions through time. Some pathways are more attractive than others due to costs or negative/positive side effects. A valuable characteristic of this framework is that it uses different perspectives of different stakeholders to identify alternative preferred measures and socially-robust actions. The framework has been applied in the Dutch Delta Programme where it is referred to as the Adaptive Delta Management (ADM) model, and results show that it is a worthwhile approach to further use and test in other policy domains and countries (Gersonius et al., 2015).

The **Collaborative Risk Informed Decision Analysis** (CRIDA) framework is a British model and builds upon the Dynamic Adaptive Policy Pathways. It was specifically designed to address plan development when significant uncertainty exists about future conditions. Like the Dynamic Adaptive Policy Pathways, it provides a step-by-step approach to planning. It is intended to serve as a framework that can be easily modified to fit the specific needs of any plan. Also like the DAPP framework, CRIDA avoids "locking" in on a single strategy (Gilroy et al., 2015). Its reliability is enhanced by the fact that it relies on the collaboration of multiple actors to integrate modeling, participation and planning.

Strategic Flood Management (SFM) is another paradigm that has been developed by Sayers et al. (2014) to address long-term planning under conditions of deep uncertainty.[1]

[1] *"The process of data and information gathering, risk analysis and evaluation, appraisal of options, and making, implementing, and reviewing decisions to reduce, control, accept, or redistribute flood risks. It is a continuous process of analysis, adjustment and adaptation of policies and actions taken to reduce flood risk (including modifying the probability of flooding and its severity as well as the vulnerability and resilience of the receptors threatened). Strategic Flood Management (SFM) takes place as part of a wider*

This definition depicts a proactive approach to asset management, in contrast to a traditional linear management model (reactive approach) (Sayers et al., 2014). The article outlines three stages to strategy development and compares them between reactive and proactive models: (1) deciding what is needed; (2) deciding how to achieve it; and (3) understanding the external and internal influences (ibid.). The characteristics of an SFM plan are that it has to be: (1) based on an understanding of the whole-systems behaviour and societal goals, and how these may change over the longer term; (2) use knowledge of risk and uncertainty to inform decision; (3) seek to implement a portfolio of measures and instruments to manage risk; (4) operates as a continuous process that monitors, reviews and adapts to the future as it becomes known. The SFM framework also provides ten 'golden rules' as guiding conditions for progress that are characteristic of plans for deep uncertainty (Table 1). These rules are guidelines that can serve as a way to overcome barriers. See Sayers et al. (2014) for a detailed description of them.

Table 1: 10 Golden rules to guide progress

10 Golden Rules
1. Accept that absolute protection is not possible and plan for exceedance
2. Promote some flooding as desirable
3. Base decisions on an understanding of risk and uncertainty
4. Recognize that the future will be different than the past
5. Do not rely on a single measure, but implement a portfolio of responses
6. Utilize limited resources efficiently and fairly to reduce risk
7. Be clear on responsibilities for governance and action
8. Communicate risk and uncertainty effectively and widely
9. Promote stakeholder participation in the decision-making process
10. Reflect local context and integrate with other planning processes

The **decision-making framework** of Willows & Connell (2003) supports the views in the already discussed literature on strategic asset management. Their framework has been purposely developed to be flexible, and applicable to a range of problems associated with climate change including flood risk. It is both circular and iterative; meaning that decisions are revisited over time, and criteria are refined over time as conditions change. It is useful to apply in practice, because it provides questions to guide each step of the process.

Tactical Level

The tactical handshake is simply the bridge between the strategic and operational management levels, and the way this is evaluated is by determining whether there is consistent communication between the two levels. The purpose of the tactical handshake is to ensure understanding and communication between the strategic level and the operational level. It takes place in the medium term, which is up to 2050 (Gersonius et al., 2015). Tactical management can be seen as an implicit process that allows an asset manager to choose the best tactics or methods from the strategic level for each situation that arises

approach of integrated basin or coastal planning and focuses on reducing flood risks and promoting environmental, societal and economic opportunities (both now and in the longer term). It recognizes that risks can never be removed entirely and that reducing risk is often at the expense of other societal goals" (pg. 138).

in the operational level (Van der Velde, 2013; de Klerk and Den Heijer, 2016). Thus, it is a key to the level of proactivity that is implemented.

Operational Level

Implementation of the strategic asset management strategy takes place at the operational level. This level is focused on the short-term-typically up to 2025 (Gersonius et al., 2015). The plan is reviewed about every 5 years, thus it has higher update frequency than the strategic level. Two frameworks are applicable for the operational level: the **Risk and Opportunity Based Asset Management for Critical Infrastructure** (ROBAMCI) developed by Den Heijer and De Klerk (2016) at Deltares, and the International Levee Handbook (ILH) (CIRIA, 2013) developed by a consortium of organizations in the UK. The ROBAMCI framework consists of three parts: (1) process scheme for life-cycle management of public infrastructure; (2) toolbox to quantitatively assess life-cycle decisions and a model to assess the quality of information in relation to different life-cycle decisions. So far, applicability has only been tested for the process scheme, and that is be the only component that will be touched upon in this thesis. The goal of this framework is to show in a business case the large performance gains that can be achieved by adopting a risk-based approach to asset management for the Dutch infrastructure industry. Many similar schemes have been made in the literature, so the process scheme is not innovative. Specific attention was given to the relation between the strategic and operational levels. For example, functional requirements at operational level usually lead to specific asset technical requirements.

The International Levee Handbook (ILH) was designed by an international team of experts (CIRIA, 2013). It incorporates all the main elements of good asset management practice. It takes a risk, performance, and systems-based approach to asset management for the operational level of asset management.

2.1.4 The Proactive Asset Management Evaluative Framework

Figure 3 displays the integrated asset management framework that was derived from the aforementioned literature and it has been designed by the author of this thesis together with members from the Dutch scientific team from UNESCO-IHE, Van Hall Larenstein University and Deltares. The asset owners also added their own input during the coordination meeting in Malmö in order to reduce researcher bias, and their suggestions have also been taken into consideration when designing the figure. The principal idea behind this framework is for it to be applicable every context in the North Sea Region and thus be user-friendly for the asset owners.

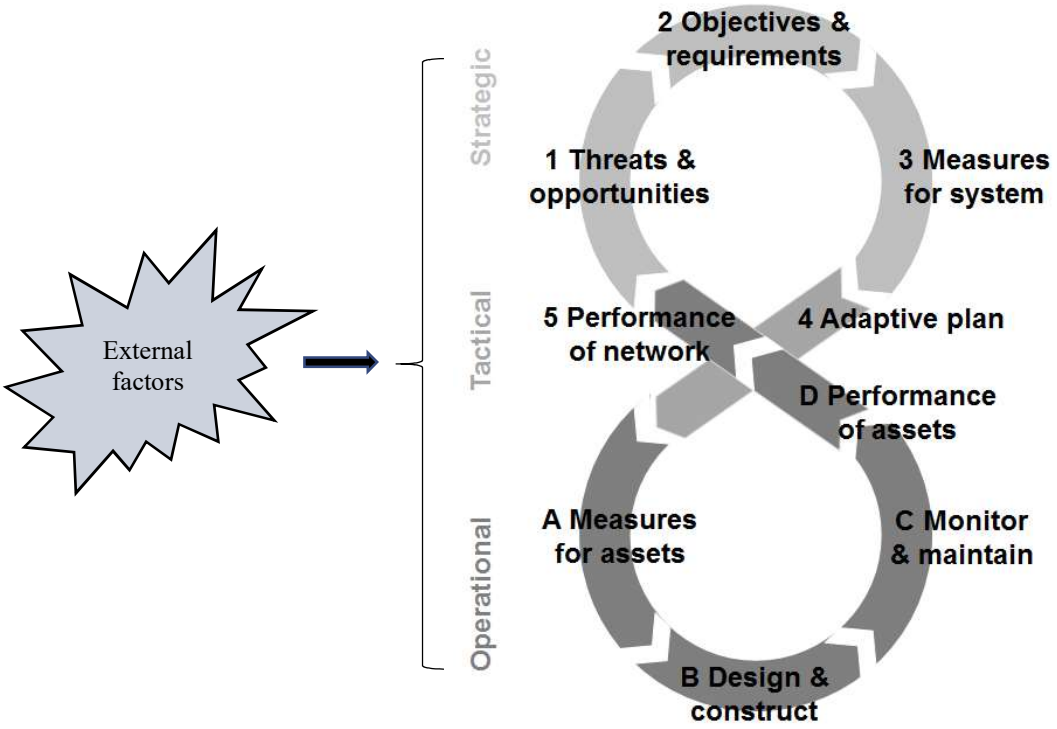


Figure 3: Proactive asset management framework showing the strategic, tactical and operational levels as well as how external factors indirectly impact what happens at each of those stages.

The following sub-section details all of the stages in each level of the derived proactive asset management cycle shown in figure 3. It is based heavily on the timeframes in which decisions are made, from short-term, through the medium term, to the long-term. The estimated time-scales are taken from Gersonius et al. (2015). The strategic level should have long-term planning up until 2100 and beyond, the tactical handshake medium-term planning up to 2050 and beyond and the operational level should have short-term planning up to about 2025. In this section, the key stages of the asset management framework are described for the strategic level, tactical handshake and operational level. For each stage the key issues are discussed as well as the types of activities that should be undertaken to realize proactive asset management.

Strategic Level of Asset Management (up to 2100)

Stage 1: Threats and opportunities

The first stage at the strategic level is to identify and analyze vulnerabilities of the entire flood protection system as a whole, and then to identify possible opportunities to act upon. The current situation and context in which asset management takes place must be analyzed (Haasnoot et al., 2012). External factors include the socio-economic situation, the climate change situation, and other important drivers that affect flood risk. Vulnerabilities are developments that can harm the extent to which the objectives can be achieved, and opportunities are developments that can help in achieving the objectives. Any threats must

be clearly defined before proceeding to the next stage. A risk assessment of the vulnerabilities needs to be completed in order to:

- Characterize the nature of the risk
- Provide qualitative/quantitative estimates of the risk
- Assess the consequences of uncertainty for decision measures
- Compare the sources of risk

Also, the location of the study area (e.g. case studies or national context) should be described, and a specification of the major uncertainties provided (ibid.). Indeed, these uncertainties should include a discussion of the future, but do not have to be restricted to those. Any type of uncertainty that plays a role in the decision-making should be clearly outlined. In order to be able to pinpoint windows of opportunities for change, the current situation and possible future situations need to be compared to the specified objectives in order to identify whether there are any points of improvement.

Stage 2: Objectives and requirements

It is necessary to establish well-defined asset management objectives for primary flood defenses and devise clear performance requirements, before setting out to implement measures and operationalize the assets (CIRIA, 2013). Policy decisions include the overall objectives, and the decision-making criteria to be used for choosing best practices and measures (Willows and Connells, 2003). The policy should provide the project or organization with a foundation for the subsequent processes and necessary tools needed to achieve the objectives, through a process of continuous improvement (ibid.). The responsible authority at the strategic level of management should be responsible for this. It must be evidence-based and auditable in its application (Willows and Connells, 2003). Another factor to take into consideration is that the synchronization between short-term and long-term goals may be affected, and a back-up will need to be set in motion that will be needed to deal with this. During the planning process, it must be asked whether the decision is expected to provide long-term benefits (>10 years), or have other possible long-term consequences, and not only focus on the short-term maintenance of assets. As such, consideration of climate change scenarios will be important, as well as the stakeholders that could potentially be affected by these decisions in the long-term, other than the specific assets in question (ibid.).

In order to define the performance requirements of primary flood defenses, it is first crucial to understand the nature and type of loads they will have to endure, and what should be the maximum level of risk that it can sustain. Safety standards must also be established to ensure that the desired policy objectives are achieved. The decision-making criteria that reflect future uncertainty, project team's attitudes to risk and decision making culture, and the different stakeholders that participate (CIRIA, 2013; Willows & Connells, 2003).

Stage 3: Measures for system

In this stage, the involved decision-makers have to identify all possible measures and evaluate the measures. The aim of this step is to ensure a range of different possible options for measures to take. Identified measures could also include the 'do-nothing' and 'no/low regret' options. Then the newly created portfolio of measures for the system needs to be assessed. To do this, the effects of each identified measures is assessed based on the outcome indicators for each of the scenarios. These can be presented using scorecards (Haasnoot et al., 2012). The results of the analyses can be used to identify the sell-by-date

for each measure. Furthermore, the vulnerabilities and opportunities need to be reassessed, to determine whether the measure was able to reduce or remove a specified threat, and whether the measure was able to utilize a specified opportunity. Also, it is interesting to determine whether each measure is able to create new opportunities and or threats. The measures deemed to be ineffective are screened out, and only the most promising measures are used to construct the adaptation pathways (Haasnoot et al, 2012). The main purpose to assess measures is to provide a robust basis upon which to recommend the preferred measured to meet the overall objective and performance requirements. Differences in the effectiveness of the different measures should be analyzed. A pathway consists of the selection of measures that have been identified in the previous stage, and they are lined up in such a way that depending on the situation taking place at any one time, a new measure is activated once its predecessor is deemed to no longer be able to meet the objectives. Finally, the preferred measure can be selected. This is the preferred measure according to Haasnoot et al., 2012. This preferred measure will form the basis of the adaptive plan.

Stage 4: Adaptive plan

The adaptive plan is the asset management plan that takes account of the short, medium and long-term time horizon, and which should be implemented at the operational level. The preferred measure selected in stage 3 forms the basis for this plan, along with a monitoring system that needs to be set up. In practice the measure is implemented, and using the information provided in the adaptive plan, can be changed or stopped, depending on the situation at hand (Haasnoot et al., 2012). For this reason, the adaptive plan is key to implementing a more proactive asset management strategy.

Stage 5: Performance of network

The information collected in the adaptive plan is used to assess performance of the entire network using a prescribed set of indicators, and based on that, an assessment report can be made. An assessment report should consist of an evaluation of the monitoring process and update on the performance of the network and any external triggers that might affect the system along the way (CIRIA, 2013).

Tactical Handshake (Up to 2050)

All stakeholders are responsible for ensuring that communication between the two levels remains coherent and is done frequently. Systems-engineering principles should be used to connect the strategic level with the operational level (Van der Velde, 2013).

Operational Level of Asset Management (Up to 2025)

Stage A: Measures for assets

In this stage, the asset owner must first identify all potential designs for the assets based on the planning and analysis that took place in the strategic level. Also, all types of interventions that meet the technical requirements specified in stage 3 of the strategic level

must be specified here. The decision for which primary flood defenses should have priority to be assessed and improved should also be taken in this stage, and the preferred design selected (Marquez, 2009). Life-cycle costing (LCC) can be used for choosing the most cost-effective measure and to determine as accurately as possible the future cost of maintenance. Cost-benefit analysis (CBA) tools can be used to determine the design costs (Van der Velde, 2013).

Stage B: Design and construct

This stage is where implementation of the entire asset management scheme takes place. Before designing and carrying out the construction of primary flood defenses, the desired or intended functions of the primary flood defense need to first be clearly defined. The appropriate design and end structure of the primary flood defense will be dependent on these and on the criteria that have been formulated in the third stage of the strategic level and stage C of operational level discussed previously. The design part should include the activities that address the management of the primary flood defenses throughout its entire life-cycle, and the designer or consultant needs to consider all the associated and interrelated components of the flood risk system, including external factors (e.g. socio-economic and climate change), and all available resources and data/information (Den Heijer and De Klerk, 2016). Construction of the primary flood defenses should be done in accordance with the design plans and specifications. Construction should aim to minimize public and environmental impacts, optimize investment, increase available resources, and address any deficiencies in performance (CIRIA, 2013). In addition, and very important, this stage should include the maintenance plan as well, which is based on the established design standards defined at the strategic level.

Stage C: Monitor and maintain

Monitoring of assets should be done by systematic recording over time in order to establish trends in the variability of the data on asset performance so that possible problems can be detected as early as possible and be maintained in a proactive way (CIRIA, 2013). The frequency of inspection can vary significantly, but generally involves the use of specific indicators that can be created via computational modeling, but also notable and visible changes in the environment (ibid.).

Stage D: Performance of assets

The performance assessment of the primary flood defenses takes place by analyzing the monitoring process that took place in the previous stage. The results of the monitoring process should be presented in an assessment report (CIRIA, 2013). This stage is also where decisions about whether or not to decommission, or whether it is safe to just repeat the operational cycle or enter the strategic level again, is made. If certain components of the asset have been degraded or damaged, then repairs or adaptation might need to be undertaken. Depending on the urgency of the situation at hand, rapid intervention may be necessary.

The assessment of performance should include performing an evaluation of the primary flood defense characteristics and comparing them against current requirements. The assessment can be either a qualitative or a quantitative process, and this should be

decided upon in the strategic level for both long-term and short-term situations, and be adapted accordingly (CIRIA, 2013).

The guidelines of what should be done at each level of asset management according to the proactive asset management framework are made explicit in Table 2. These guidelines have been used to reflect on the current asset management strategies of each country in chapter 4, and to compare the current asset management strategies across countries in chapter 5. It may have been determined that the empirical results show incongruence with the theoretical framework, and thus make a contribution to theory.

Table 2: Guidelines for levels of Asset Management

Strategic level (up to 2100)	- Adaptive plan with long-term perspective - Risk-based approach (whole-system) - Established safety and design standards
Tactical Handshake (up to 2050)	- Clear and open communication between strategic and operational levels - Presence of an asset manager - Systems engineering perspective
Operational level (up to 2025)	- Appropriate tools for selecting measure for assets - Innovative techniques - Clearly-allocated budget system - Regular maintenance in line with adaptive plan - Assessment of performance criteria

The next section introduces the governance literature and possible barriers to implementation of asset management, by synthesizing asset management and governance literature.

2.2 Analytical Framework for Governance Barriers

This section first offers a brief introduction to the literature on governance barriers that was assessed and then an in-depth description of each category of barrier.

2.2.1 Introduction to Literature on Governance Barriers

The literature that had been used for the analytical framework on governance barriers was taken both from asset management and governance strands in order to synthesize the literature in a meaningful way an situate the governance barriers into a specific policy context. Barriers are defined as "obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc" (Ekstrom and Moser, 2010: pg.1). Leadership, strategic thinking, resourcefulness, creativity, collaboration and effective communication are required in overcoming them. However, overcoming barriers does not necessarily lead to a successful outcome (ibid.). Recent studies began to address questions such as to what

extent social factors and conditions obstruct our ability to adapt proactively to future environmental changes, shifting attention from just merely technical and biophysical barriers to governance barriers as well (Ekstrom and Moser, 2010). The current thesis also focuses only on governance barriers. Asset owners face different governance barriers to asset management. This thesis makes use of an analytical framework for governance barriers derived from literature that was later used to analyze the barriers that emerged in practice.

The barriers analytical framework in this thesis is made up of the following categories taken from the previously mentioned literature: institutional, resource, cognitive, information and communication, and participation barriers. These were chosen because they cover a wide-range of specific barriers. Moreover, they are all touched upon in the literature used, but some have different names. Additionally, the recent literature on asset management implementation shows specific governance barriers that have been determined empirically and potential opportunities are drawn from theory. This was done for the purpose of bridging the gap between theory and practice. Examples of barriers from both governance and asset management literature is discussed in the following sub-sections.

The categories of governance barriers have been taken from: Ekstrom and Moser (2010), Adger et al. (2007), Biesbroek (2014), and Hamin et al. (2014). The paper of Ekstrom and Moser (2010) was especially useful because it is derived from decision-making literature and describes different categories of barriers on which this thesis has been based on, as well as in which stages of asset management the governance barriers take place in. The authors also discuss opportunities for overcoming barriers, but to do this one first needs to determine why and how a barrier arises. The solutions for overcoming the barriers lie in the analysis of the location in which the barrier takes place, its source, and the nature of the barrier.

The following sub-sections elaborate each of the governance barriers categories with illustrative examples from the governance barriers literature as well as the relevant asset management literature.

2.2.2 Institutional Barriers

Institutional barriers refer to the established governing processes that restrict individuals from stepping over boundaries that are out of the reach of certain actors. Institutions are societal arrangements that are context-specific (Biesbroek et al., 2013). Moreover, institutional barriers refer to those barriers in policy processes that stagnate policy processes, which are beyond the capabilities of individuals to break through and need collective action to change those (Biesbroek et al, 2009).

An “institutional void’ is an indicator of an institutional barrier, and it refers to a “lack of institutions enabling, facilitating, or stimulating adaptation to climate change” (Biesbroek, 2014). Many of the institutional barriers to proactive asset management implementation result from the absence of asset management institutions. According to the public administration literature, an institutional void means that there are no institutions that address the issue in particular. In those situations, decision-making without the proper authority is challenging, particularly for the legitimacy and efficacy of collective decisions. Opportunities suggested from the climate adaptation literature is to fill the void with new

institutional structures, including regulations, instruments, organizations and mechanisms (Biesbroek et al., 2009). Bieskbroek et al. (2009) argue that many of the current innovative ideas are being developed because of the institutional void.

Another important institutional barrier is fragmentation, which in the literature is expected to be a significant barrier to development and implementation of adaptation strategies (Biesbroek et al., 2014). This barrier refers to the large differences between different sectors and different levels of governance. Fragmentation is a lack of "connection and coordination among institutions, organizations, individuals, and policies at different levels and scales" (ibid. pg.57).

In contrast, "institutional crowdedness" refers to the opposite situation when a plethora of old and new institutions competing on what should be done to adaptation and flood protection (Biesbroek, 2014). For example, the EU Water Framework Directive, EU Floods Directive and national water plans can contradict each other, and this causes confusion in tasks and responsibilities, reducing efficiency.

Another important institutional barrier is fragmentation, which in the literature is expected to be a significant barrier to development and implementation of adaptation strategies (Biesbroek et al., 2014). This barrier refers to the large differences between different sectors and different levels of governance. Fragmentation is a lack of "connection and coordination among institutions, organizations, individuals, and policies at different levels and scales" (ibid. pg.57).

Legitimacy is also an important indicator of institutionalism, the lack of which can result in an institutional barrier. Legitimacy describes the state of conforming to legal norms and requirements, or recognized principals and accepted standards of behavior (Biermann, 2014). Legitimacy refers to laws and regulations that have been formulated in a way that they are enforceable and effective (Rijswick et al., 2014). A lack of enforcement will hamper the effectiveness of asset management and governance and in the end may lead to conflicts and decreasing legitimacy and credibility. Core dimensions of legitimacy are the acceptance and justification of authority. Acceptance refers to the degree to which rules or institutions are accepted by a community as being authoritative.

Ineffective leadership is another type of institutional barrier. Critical at any stage of asset management, but especially stage 1 setting objectives and requirements (Ekstrom and Moser, 2010). If there are no clearly defined objectives, then leaders are not required to dedicate any effort or attention to the issue at all (ibid.). The manifestation of ineffective leadership differs depending on context. This can only be discovered empirically. Good leaders must demonstrate high skill in communication, as well as openness, creativity, and honesty. Leaders can present barriers in two ways: (1) by being absent from the process, (2) by limiting the process. According to Harmin et al. (2014), leadership poses the greatest barriers to adaptation. It also has to do with the roles and responsibilities of relevant actors. An example of ineffective leadership from the asset management literature is the lack of clear roles and responsibilities present in well-intentioned plans (Sayers et al., 2012).

Also, political parties tend to think short-term up to the next election, and it can be difficult to influence their political agenda (Sayers et al., 2013). The short-term horizon of politicians and policies refers to the incongruence between long-term processes of climate change and the short-term horizon of politicians and policies. Many politicians tend to focus on societal issues which are deemed more pressing and for which solutions can be implemented within their terms of office. Climate change-related issues are not yet fully included in policies, due to reasons such as skepticism for climate change and ignorance about personal vulnerability.

2.2.3 Resource Barriers

A resource is a source or supply from which benefit is derived. In the literature it refers mostly to financial means, but can also include technical resources, expertise, and time (Ekstrom & Moser, 2010). A resource barrier is a lack of those assets that are necessary to achieve the desired goal. This type of barrier can occur at almost any stage of the asset management process, but especially at the operational management level where the technically-intensive processes take place (Ekstrom and Moser, 2010). A lack of resources is usually among the first responses most practitioners give when asked why they are lagging in asset management (Wijnia and Herder, 2010).

Financial barriers typically present huge set-backs for carrying out asset management plans (Adger et al., 2007). Recent literature shows that service providers are keener on acquiring as much funding as possible as on using the available funding as efficiently as possible (Wijnia and Herder, 2010). It also happens that there is not enough budget available for major projects which leads to incomplete or delayed outcomes (Sayers et al., 2013). Hamin et al. (2014) conducted interviews, and regarding lack of resources, most respondents replied that the barriers are specifically time and money. Asset owners feel discouraged to invest in solutions aimed at improving infrastructure due to the need for high investments (Hamin et al., 2014).

Conflicting time-scales are also an example of a resource governance barrier. The time-constraints of projects is discussed in Gersonius et al. (2015) and Fabricius and Curry (2015). These occur as a result of long-term changes in the climate system and short-terminism in decision-making and policies (Biesbroek, 2014). A specific example is the difference in the traditional long-term planning found in strategic policy documents (20-30 years) and the long-term impacts of climate change (100 years or more). Conflicting time-scales make it difficult to quickly implement adaptation into policy and practice. For example, large infrastructural works need to take into account the long-term impacts of climate change in order to construct the infrastructure in a climate-proof way, and planning for this can take a long time because of many future uncertainties (ibid.). There are also human resource barriers which include the availability of staff, time to become informed of new decisions, managerial support, and skillful and qualified employees. The lack of staff barrier is discussed in Fabricius and Curry (2015); Sayers et al. (2015) and de Klerk and Den Heijer (2016). There are also physical resources (technological) and natural resources (availability of land).

The scarcity of resources could be viewed as an opportunity for some actors because it can motivate creativity, efficiency and flexibility, and thus is indirectly related to cognitive barriers.

2.2.4 Cognitive Barriers

Cognitive barriers refer to people's ideology, values, or beliefs, as well as education and cultural backgrounds that prevent real transformation from taking place in the desired orientation (Shu and Bazerman, 2010). Cognitive barriers have both a direct and indirect impact throughout the entire cycle of asset management (Ekstrom and Moser, 2010).

From the point of view of psychology, individuals always approach new problems and solutions based on their pre-existing system of values and beliefs, and their experiences. People's ideologies can either act as barriers to or drivers of the process in

question. Cognitive barriers refer to capacity, knowledge, and expertise to carry out a particular task to the end (Adger et al., 2007). People's knowledge of certain topics such as sea level rise about climate change, or even their perception of the topic, can vastly differ or be extremely limited (Hamin et al., 2014).

The lack of willingness to act is also a specific type of a cognitive barrier (Biesbroek, 2014). These refer to the attitudes, ethical beliefs, and norms and values that explain why individuals choose to engage in adaptive behavior. Studies have shown that the most effective motive leading to adaptation is the occurrence of an extreme event, such as flooding (ibid.). This missing motive to adapt to change could be to a wide variety of other cognitive barriers, including a lack of understanding, skepticism about climate change issues such as sea level rise, no sense of urgency and conservative methods. Institutions could externally motivate actors to start adapting even though they are not intrinsically motivated themselves. The literature often makes reference to the occurrence of extreme events such as extreme floods to be a main external motivator (Biesbroek et al, 2009).

Conservative methods is a cognitive barrier outlined in Gersonius et al. (2015). According to the authors, it is defined as risk and uncertainty aversion characterized by decision-makers which focus on the status quo. This is a barrier to adaptation for the long-term and thus a proactive approach to asset management. This barrier can negatively influence the willingness to identify as many options for measures as possible, as this is a great risk (ibid.).

Cognitive barriers not only have direct impacts on the implementation process of AM, but also indirect impacts, such as what information is valued and distributed (Biesbroek et al., 2009). Available resources are dependent on the issue of values and beliefs, because resources are a product of a choice people have made, whether to produce them or not, based on their values and beliefs (ibid.).

2.2.5 Information and Communication Barriers

Information and communication go hand in hand in asset management. Communication and information exchanged between the different levels of asset management via the tactical handshake is a perpetually occurring process, and it is very important that is done right (Oonk-Abrahams, 2015).

Information barriers refer to fundamental and applied research on asset management, data availability for monitoring and assessing performance of assets and credibility and legitimacy of information. A lack of communication between science, policy, and society in long-term adaptation and maintenance of flood protection infrastructure assets can result in a low level of awareness, skepticism, and denial (Biesbroek, 2014). Throughout the asset management cycle, information and communication is a frequently occurring and critical process (Ekstrom and Moser, 2010). Information-related barriers have got to do with how information is created and how it is communicated.

Common examples include misunderstood information, and lack of communication between stakeholders which can severely disrupt social interactions where they are needed (Ekstrom and Moser, 2010). According to Klerk and Den Heijer (2016) there is a misunderstanding of information among asset owners because of its highly abstract definition. Proper communication of information must be delivered to the appropriate

audience. In addition, different asset owners need different types of information suitable for their line of work and understanding. According to the results of Hamin et al. (2014), lack of information was not the main barrier for most respondents, but was a contributing issue to other barriers such as leadership.

Information about the entire network of assets must be made available to each level of asset management and everyone should be brought on the same page. There needs to be a central database/register that integrates data of all assets on a national network scale. Software planning tools can help with this (Van der Velde, 2009).

2.2.6 Participation Barriers

Participation refers to the level of public participation taking place in the decision-making process of the asset management cycle. Participation barriers typically occur in the design and construct stage of the operational level, because that is where the outcome of asset management for primary flood defenses is made visible, and if the public is not consulted beforehand in the decision-making process, they often oppose the new developments (Ekstrom and Moser, 2010). Who and in what way the public participates in the decision-making processes of asset management differs by governance level (national, regional, local), origin of the process, and the style of decision-making (Ekstrom and Moser, 2010).

Participation differs from the institutional category, as participation can also refer to citizens and other affected stakeholders that are not implicated directly into the decision-making process, or are in a position of power. Excluding stakeholders from participation in the asset management decision-making process can hamper successful collaboration and lead to the development of multi independent collaborative agreements which interfere with or undermine the asset management cycle (Currie and Fabricius, 2015). Another example from the asset management literature is a lack of collaborative governance and integration across disciplines (Sayers et al., 2012). Rijke et al., 2012 discusses the lack of public participation.

Legitimacy was until recently a standard that only states were expected to establish. Only states could enforce other actors to comply with the standards. However, now the role of the non-state actors (citizens, NGOs, private owners, etc.) has increased substantially, and governance processes have started to become a more common occurrence (Biermann, 2014), and they are starting to have a significant impact even though their decisions are not legally binding. For this reason the legitimacy of non-state actors becomes important. The standard of democratic control requires that those who are governed should be able to control those who govern them (ibid.). One way to increase the participation of citizens in decision-making processes of projects that ultimately affect them is by becoming involved in civil society organizations. Involving the civil society can ultimately strengthen the strategic planning of long-term projects and help them become more sustainable (Biermann, 2014).

Stakeholder engagement would improve the quality of decision-making by making it more transparent and making better use of the information and knowledge that is available in society, and improving its accessibility (Rijswick et al., 2014).

2.2.7 Application of framework in this research

This framework has been used to guide the analysis of governance barriers in each NSR country, and ultimately to facilitate the comparison among these 7 countries. Per country, each governance barrier category is described by strictly analyzing the significant barriers which have emerged empirically, some of which have been asked based on the literature review. However, similar barriers have been named the same way for every country in order to allow for a robust comparison in the next stage. The interview guide follows a simple structure in which the respondents have been asked to explain their barriers. The examples of barriers that have been given from the literature is used in chapter 6 when comparing the results to the literature. A drawback of this framework is that there are some overlaps between categories. For instance, this is evident between the institutional and participation categories, as well as the 'communication' aspect of the information and communication category. Also, it cannot be determined fur sure whether an important category has been left out, potentially rendering the framework incomplete. This framework was useful for the analysis part of this thesis (chapter 4 and 5), because it provided detailed grounds on which to draw conclusions from the research. The next section presents the results for each country. Table 3 summarizes the specific barriers that have been discussed for each category.

Table 3: Examples from the literature of governance barriers for each category

Institutional barriers	Resource barriers	Cognitive barriers	Information & communication barriers	Participation barriers
-Institutional void -Fragmentation -Ineffective leadership -Lack of clear roles and responsibilities -Lack of political will	-Lack of funding -Lack of staff -Lack of time -Lack of land	-Lack of knowledge and expertise -Willingness to change -Conservative methods	-Lack of available data -Lack of information on assets -Lack of communication between stakeholders	-Lack of collaborative governance -Lack of public involvement

3. Research Methodology

This thesis is both theory and empirically-driven, but the focus is on the latter. This chapter outlines the research methodology used in carrying out each component of the research depicted in figure 4. Qualitative analysis was undertaken using multiple methods to achieve triangulation or corroboration of the results (Biesbroek, 2014). These methods were: questionnaires, methodological baselines, semi-structured interviews, and validation of preliminary observations, workshop discussion and validation, and discussions with members of the scientific team for further validation. The questionnaires are secondary completed by the asset owners prior to the start of this thesis project. The data gathered from these questionnaires were inputs for the national contexts. The semi-structured interviews are the primary data of this thesis, as well as the data gathered during the workshop and methodological baseline notes for the current asset management strategies (see figure 4).

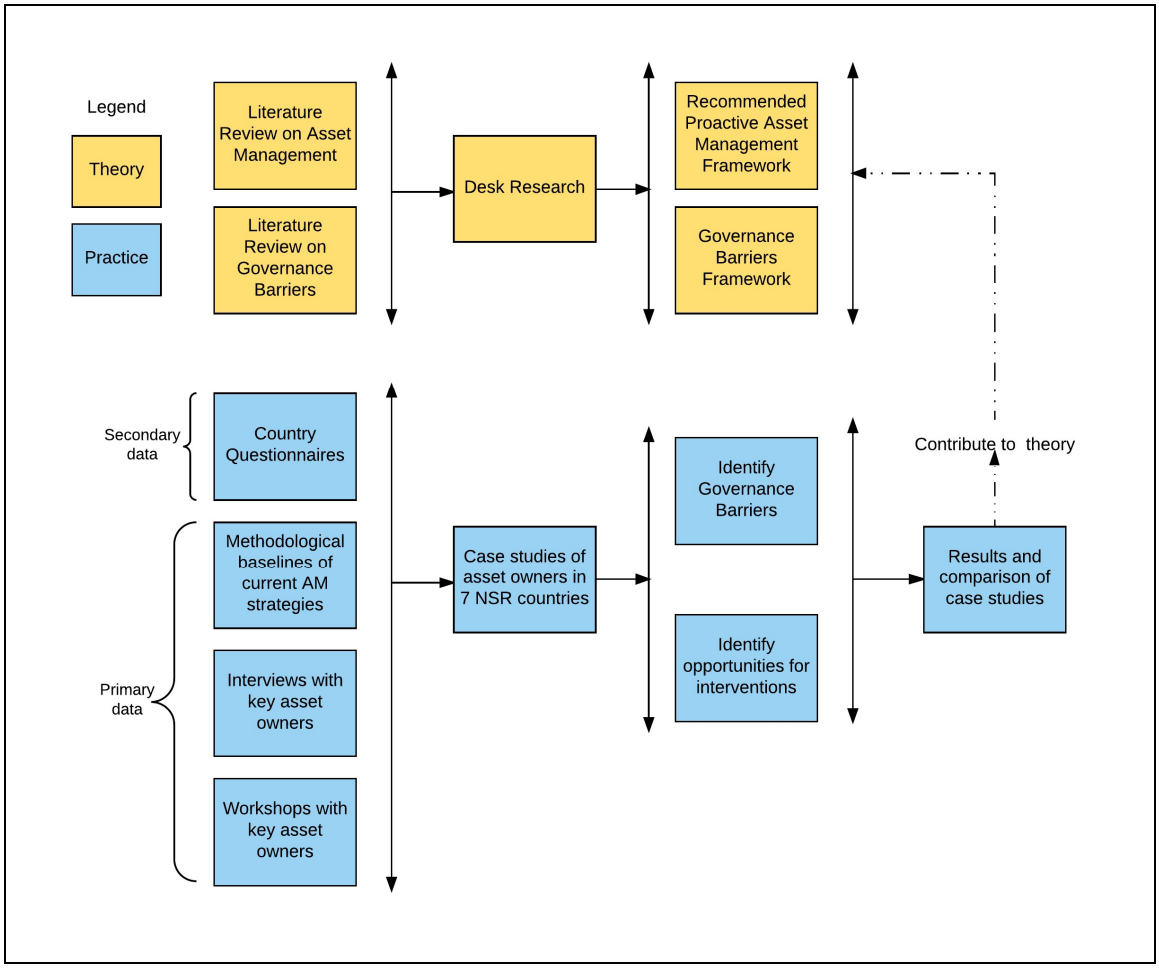


Figure 4: The methodological steps of the research

3.1 Comparative Case Study approach

A comparative case study approach was used for this thesis. The comparative case study method is "…the non-statistical comparative analysis of a small number of cases" (George and Bennet, 2005: pg. 151). The reason for using a comparative case study approach is to explain the similarities and differences of how barriers in different contexts manifest (Biesbroek, 2014). In this thesis a cross-national comparative case analysis was used to compare the different national approaches to asset management strategies. A comparative case study was used to compare the barriers between specific asset owners within those countries. The type of research conducted was a comparative case study analysis of all seven North Sea Region Countries (NSR). A comparative case study was chosen because by comparing different contexts one can come closer to understand in which situations certain barriers can occur and how these contexts have an effect on the asset management strategies put in place. This was done by first investigating each country separately in terms of its national context, current asset management strategies, improvement goals the asset owners want to make in their current strategies, and central to this research, the governance barriers that the asset owners are facing that would make it difficult to adapt a proactive asset management approach, as well as the opportunities they had suggested to overcome these barriers. All these factors are elaborated on in chapter 4 for each country. Afterwards, in chapter 5, the countries are compared in terms of their national context, current asset management strategies, and governance barriers and opportunities to overcome these barriers. The relationship between all these factors is discussed. Solutions from theory are also included in chapter 6 where appropriate, in order to show the relationship between the theoretical and empirical parts of this research.

3.2 Desk Research

Desk research was conducted for the literature review on asset management and governance barriers (the yellow part in figure 4). The literature was carefully selected and analyzed in order to construct a flexible and robust proactive asset management framework that could be applicable to all the NSR countries, and be used as a benchmark against which to measure the current strategies. Desk research was also used for analyzing the questionnaires that the asset owners had filled out containing the national contexts of their countries and current asset management strategies. Also, desk research was used to analyze the notes that the asset owners have provided in which they elaborated on their current asset management strategies.

The literature review on Asset Management entailed accessing various databases and library sources. Relevant scientific journals to collect information about asset management include the Journal of the International Society for the Prevention and Mitigation of Natural Hazards; Journal of Global Environmental Change; Journal of Climate Change; and International Journal of River Basin Management. These will be collected from Google Scholar and Scopus databases.

3.3 Case sample selection

Asset owners from each North Sea Region (NSR) country were chosen as the units of analysis. These asset owners were selected by the Interreg North Sea Programme to be partners of the FAIR project. These are listed in table 4 and **Appendix D** outlines the specific respondents that participated in the semi-structured interviews. The respondents were chosen based on their level of involvement with the FAIR project. A list of candidates was provided by the internship supervisor at UNESCO-IHE. The respondents have a variety of different backgrounds and expertise, and their specific positions are identified in **Appendix D.** On the first workshop on February 3rd, hosted in Malmö, Sweden, the names of participants were collected and the interviews were scheduled to take place between February 23rd and March 24th. With the exception of Norway (one), Sweden (three), and the Netherlands (4) two candidates have been interviewed from each organization, all operating authorities with the exception of the County Board of Skåne. In the Netherlands two people from two different organizations were interviewed. In Sweden one person from one organization and two people from another, and in Norway, the real asset owners (municipalities) were unwilling to participate. It must be noted that the EA in the United Kingdom and the NVE in Norway are not official partners of this project, and thus they were unable to invest that much to provide all the information required of the actual partners.

Chapter 4 elaborates on the significant barriers that these asset owners are facing. The current asset management strategies analyzed in chapter 4 are also a reflection of the whole country, however not everything mentioned there can be generalized as the only the asset owners interviewed for this thesis provided the information. For some countries, like Germany and Denmark, the asset management strategies could not be entirely generalized for the whole country. In Germany each Federal State practices a slightly different asset management and only insights from Hamburg State were collected. In Denmark the current AM strategy outlined for the most part is that of the west-coast where the DCA operates.

Table 4: Asset owners interviewed in each country

Country	Asset Owner	# of interviewees
The Netherlands	Rijkswaterstaat	2
	HHSK water board	2
Belgium	MDK	2
Germany	LSBG, Hamburg	2
United Kingdom	Environment Agency (EA)	2
Denmark	Danish Coastal Authority (DCA)	2
Sweden	County Board of Skåne	1
	Helsingborg Municipality	2
Norway	Norwegian Water Resources and Energy Directorate (NVE)	1

3.4 Data Collection

The type of data and the way in which it has been collected for this thesis is detailed below for the national context, the current asset management strategies and the significant governance barriers and opportunities to overcome for each North Sea Region (NSR) country.

3.4.1 National Context

The countries as a whole are also briefly analyzed, by discussing the national context for asset management consisting of the roles and responsibilities as well as the relevant policies and plans. This is done by examining the questionnaires (see figure 4). Each asset owner from each of the NSR countries has been asked to fill out a questionnaire created by the Scientific Team of the Interreg FAIR project. The information regarding the national contexts is found in secondary data in the form of questionnaires which were filled out by the asset owners prior to the start of this thesis. The most important value of the questionnaire is that it provides information on the national context in which asset management is based, consisting of the key stakeholders and their roles and responsibilities, as well as relevant policies and plans.

The questionnaires themselves are confidential, but one can find a template in **Appendix F**. Not all of the questions pertaining to each section are relevant for the analysis of this thesis, as many of the topics covered in this questionnaire are of a technical nature that do not address governance aspects. This is because the scientific team that created these have either a civil engineering or hydraulic engineering background, and they are more interested in the operational level of asset management, and in how the flood defense infrastructure is designed and maintained. This is beyond the scope of this thesis, thus, the results of the questionnaire have been selectively analyzed to only deal with those questions that are directly linked to governance, including policies, roles and responsibilities, and improvement, barriers, and opportunities. The national context was most relevant for this research, but specific parts of the case study were also important for analysis as they were linked back to the national context. For example, the specific barriers could also be explained by the barriers at national level, and the context of the case study also depended on the context of the country.

3.4.2 Current Asset Management Strategies

The asset owners have been asked during the coordination meeting in Malmö to fill out the asset management template consisting of their particular approach to asset management, including formation about what they do in each step, and which policy documents are relevant. These templates are referred to as methodological baselines of the countries, and are primary data (see figure 4). The purpose of these methodological baselines was that, together with the questionnaires, they illustrated the national context and the current asset management approaches, and served as a basis for designing the semi-structured interview questions.

3.4.3 Governance Barriers and Opportunities to overcome

The identification of governance barriers, the core part of this thesis, was done via semi-structured interviews, the second set of primary data (see figure 4). The questions had an overall consistent structure while at the same time maintaining openness to allow for self-reflection and free expression on the part of the asset owners. The main questions have been pre-formulated beforehand based on the methodological baseline assessment and questionnaires, but it often happened that follow-up questions were formulated during the interview, as new ideas or observations were made during the discussion with the asset owners. The asset owners had quite a bit of freedom in expressing their viewpoints and asset management procedures, and their responses were used only for scientific research purposes. See **Appendix E** for an outline of the interview guide. The interviews have also been coded in Nvivo qualitative analysis software (see **Appendix B.1** for a description of the nodes). The barriers have been coded in the same way for every country in order to facilitate ease of explanation and comparison between countries in chapter 5. Naturally the characteristics of the barriers differ for every country but they have been coded in terms of the topic addressed more than the problem actually being faced. The specifics of each country will be detailed in chapter 4 and elaborated on in chapter 5.

3.5 Credibility of the research

The applicability of the proactive AM framework to the countries of the NSR have been validated during the workshops by asking the asset owners whether they understand it and would like to make any changes to it that would fit their particular context better.

Results of the interviews have been validated by first writing preliminary results in a PowerPoint and sending them to the asset owners for verification, giving them the opportunity to include more relevant additions such as the specific stages of asset management in which the most relevant barriers occur.

A three-day workshop was held in Rye, East Sussex, UK between March 20th and 22nd, 2017. One of the workshops was specifically on the identified governance barriers, which the author of this thesis helped organize. The main purpose of the workshop was to validate the preliminary results of the interviews and especially to facilitate discussion and social learning amongst the asset owners via face to face interaction in small groups regarding opportunities to overcome the governance barriers they are facing in their asset management implementation, based on the analytical framework provided in this thesis. This two hour workshop was divided as follows:

1. A short introduction into the preliminary results of the interviews
2. Plenary discussion about the main barriers in which all the asset owners were asked to write down what they consider to be the main barriers on a piece of paper
3. In-depth discussion in smaller groups about opportunities to overcome the main barriers listed, providing the asset owners with the chance to interact and share knowledge and experience with each other

3.6 Method of Analysis

Firstly, the questionnaires were studied to identify the national context for each country as well as any preliminary barriers, and the methodological baseline notes were used to analyze the current asset management strategies of each country. Afterwards, the interview transcripts were coded in Nvivo software, and each similar barrier was coded the same for each country in order to ease comparison. In chapter 4 the significant barriers are introduced for each asset owner in the NSR countries. Significance was determined intuitively by the author based on the emphasis provided by the respondent during the interview. The frequency of which countries face certain types of barriers are introduced and compared in chapter 5. The reason why frequency is determined by country is because it is easier than to show which asset owners, but the text explains which elaborates which specific asset owners mentioned a type of barrier. The frequency was determined using the Nvivo software.

4. Independent Country Results

In this chapter the results of each country are presented. Firstly the case study for each asset owner is introduced, then the national context consisting of the roles and responsibilities and the relevant policies. After that the significant barriers are illustrated for each asset owner including a diagram depicting in which stage of asset management it takes place. Afterwards the opportunities mentioned by the asset owners to overcome the most significant barriers are discussed. A short reflection is presented at the end.

It is important to recall that the introduction to the case study and the national contexts are taken from the questionnaire, while the information regarding the current asset management strategies are taken from the methodological baseline templates. The governance barriers and ways to overcome them are taken from the semi-structured interviews.

4.1 The Netherlands

In the Netherlands, the asset owners that have been interviewed are Rijkswaterstaat and the HHSK water board. There were two respondents from each organization.

4.1.1 Introduction to the case study

Rijkswaterstaat

For the FAIR project, Rijkswaterstaat has a case study on the island of Marken for dike reinforcement. Marken is a peninsula in the lake Marker, close to Amsterdam. It is about 20 km north east of Amsterdam. The source of flooding on Marken is lake overtopping from Lake Marker. The existing flood defense infrastructure there is an 8 km dike ring with a grass cover and stone revetments. The space is also shared with a small harbor, houses of historic interest, and some hydraulic structures. Due to the peat subsoil, settlement is one of the greatest challenges because of the high risk of subsidence. Marken is a small island with about 1800 residents. The island is a popular place to be visited by tourists (mainly one-day visits). Since the island does not have important infrastructure services, the low amount of residents and the low flood risk, the new safety standard is low (1/100 flooding probability). The last flood was in 1916, with 16 human casualties on Marken. If Marken does not meet the new standards by 2035 it can be concluded that asset management had not being delivered successfully.

Figure 5: Island of Marken (source: Rijkswaterstaat)

HHSK Water Board

The Hoogheemraadschap Schieland and the Krimpenerwaard **(HHSK**) water board has a case study called Project Krachtige IJsseldijken Krimpenerwaard **(KIJK)**, or powerful IJssel dikes Krimpenerwaard in English. It is located in dike ring area 15, between Rotterdam and Gouda, along the river Hollandse Ijssel. It is a flood protection project under the Dutch Flood Protection Programme (HWBP). The HHSK is partly below sea level, so without dikes this area would be flooded. The scope of the project is 10, 15 km of dikes along this river. The main goal behind this project is to apply a Systems Engineering approach which is about looking at other multi-functional solutions, so the focus will not only be on dike reinforcement. The greatest source of flooding is from high water levels in the river Hollandse Ijssel due to heavy wind storms, high river discharge after heavy precipitation, and tidal influences from the North Sea through the Nieuwe Maas. The dikes, which have an asphalt road cover, are also used for houses, offices, schools, monuments, hydraulic structures, and harbors. This combined with heavy population can pose a risk to safety. The dikes of project KIJK are part of dike ring area 15 in The Netherlands. This area has 200.000 inhabitants. A dike breach has a potential damage figure of about 1 billion euros and about 150 victims. If project KIJK does not meet the new standards it can be concluded that asset management has not been implemented successfully.

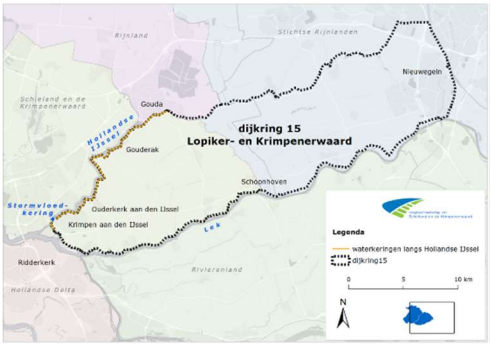


Figure 6: Location of Project KIJK (source: HHSK)

4.1.2 National Context for Asset Management

Roles and Responsibilities

The division of flood management roles and responsibilities in the Netherlands is quite rigid with numerous authorities and a top-down system. At national level the Ministry of Infrastructure and Environment is responsible to set the safety standards for the medium-term (2050 years), while Rijkswaterstaat, the agency of the Ministry has an operational role to manage national primary flood defenses. At the regional level are the water boards which have an operational role to realize the prescribed safety standards in their respective regions. The funding roles are structurally distributed between the Ministry, Rijkswaterstaat and the water boards.

Relevant Policies and Plans

The EU Floods Directive is followed in the Netherlands. At the national level is the Water Plan from which the Water Act (2010) sprang forth. The Water Plan describes the measures

and the Water Act explains how to implement those measures for the primary flood defenses. The Water Act is the most important document regarding AM for primary flood defenses in the Netherlands. Plans are laid out for the short, medium and long-term. The safety standards are laid out in the medium term. The division between the short, medium and long-term is structured. There is also the Delta Programme from which the Adaptive Delta Management (ADM) originated.

4.1.3 Current Asset Management Strategy at national level

The steps taken in the Dutch asset management system for primary flood defenses and how they compare to the ideal framework for proactive asset management explained in chapter 2 on research perspectives are presented in detail in **Appendix A.1**. Where appropriate, each stage of the strategic and operational levels is explained, although it was difficult to acquire information on all the stages. The following paragraphs briefly analyze each level of asset management by focusing on the guidelines specified in table 3 of chapter 2. These guidelines are written in italics.

At the **strategic level**, the *safety standards* are defined in stage 2. There are new safety standards outlined in the Water Act (2010), and at present they are still considered abstract and are not yet fully implemented. The challenge is to meet these new standards in 2050. These new safety standards consist doing life-cycle costing (LCC) calculations. An *adaptive long-term plan* is put in place, which is the output of the strategic level, known as the Delta Plan, illustrated in the Delta Programme. According to the information provided in the questionnaire, the goal of asset management in the Netherlands is to move towards a full *risk-based approach*. It is already well on its way, as can be seen with the HHSK project KIJK. In project KIJK, Dutch water boards for the first time are employing a whole-system approach meaning the combination of solution in a broader perspective, ant not just focusing on reinforcement of the dikes. The success of this remains to be seen and evaluated.

The **tactical handshake** is not that much taken into consideration and the two levels still run fairly separate. This is the focus of Rijkswaterstaat for the Marken case study; to decide how best to deliver set goals. This is defined at the tactical level. The improvement goal suggested by Rijkswaterstaat is to implement the 'meten, weten, handelen' (measure, know, act) procedure that would ensure a more coherent asset management between the strategic and operational levels, but it is still under development. Also, exploiting mainstreaming opportunities is an improvement goal of Rijskwaterstaat, meaning that the short-term actions at the operational level should be in sync with the long-term opportunities suggested at the strategic level. According to HHSK, if the wishes of all stakeholders would be included and everyone brought on the same page, then the tactical handshake would be made more explicit.

At the **operational level**, regarding the *selection of measures*, The HHSK is using LCC more and more often to determine which measure is the most cost-effective. This level is the focus of HHSK in project KIJK. The goal is to implement as many *innovative techniques* as possible,in compliance with the risk-based approach discussed at the strategic level. *Maintenance* is performed regularly by following the duty of care principal (zorgplicht) to make sure that legal safety standards are complied with. Maintenance yet needs to be performed more frequently in order to avoid having to reinforce the primary flood defenses as much as possible. An *evaluation of asset performance* is now done more

often than before due to greater uncertainties. However, the assessment of performance could still be improved by allocating more attention to it.

The next sub-section details the most significant governance barriers faced by Rijkswaterstaat and the HHSK water board. These have been determined empirically by interviewing two respondents from each organization.

4.1.4 Governance Barriers to Asset Management Implementation

Governance barriers and asset management

The most significant governance barriers in the Netherlands, which have been determined by the author based on a thorough analysis of the data, are illustrated separately for Rijkswaterstaat and the HHSK in the diagrams below.

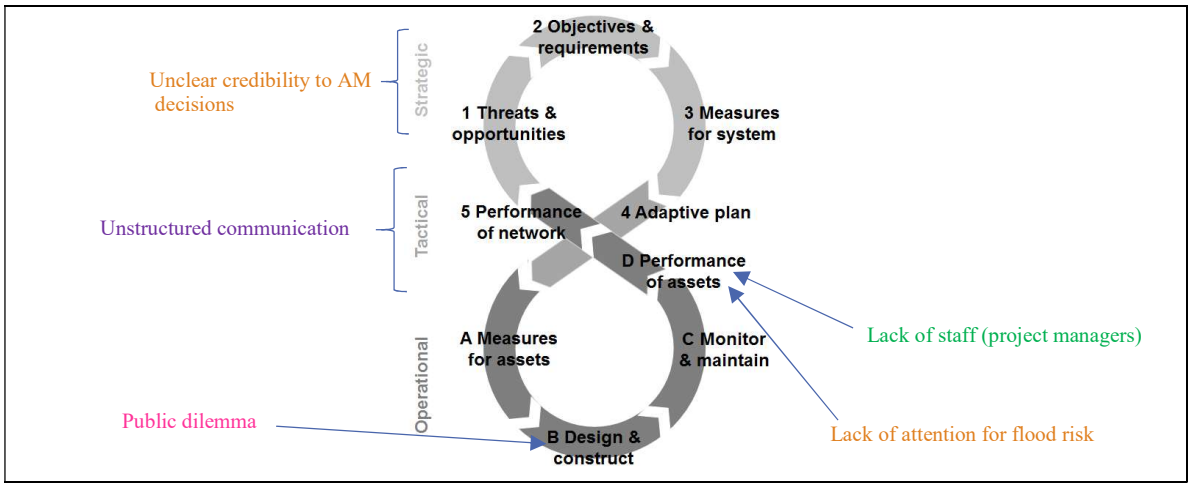


Figure 7: Significant barriers for RWS

Governance barriers are occurring at all levels of asset management at Rijkswaterstaat. *Unclear credibility to asset management decisions* is situated generally at the strategic level and *unstructured communication* is at the tactical level, since that is where the communication between the strategic and operational levels is supposed to be transferred. The rest of the barriers are located in specific stages of the operational level. *Public dilemma* takes place in stage B, and both *lack of attention* and *lack of staff* take place in stage D.

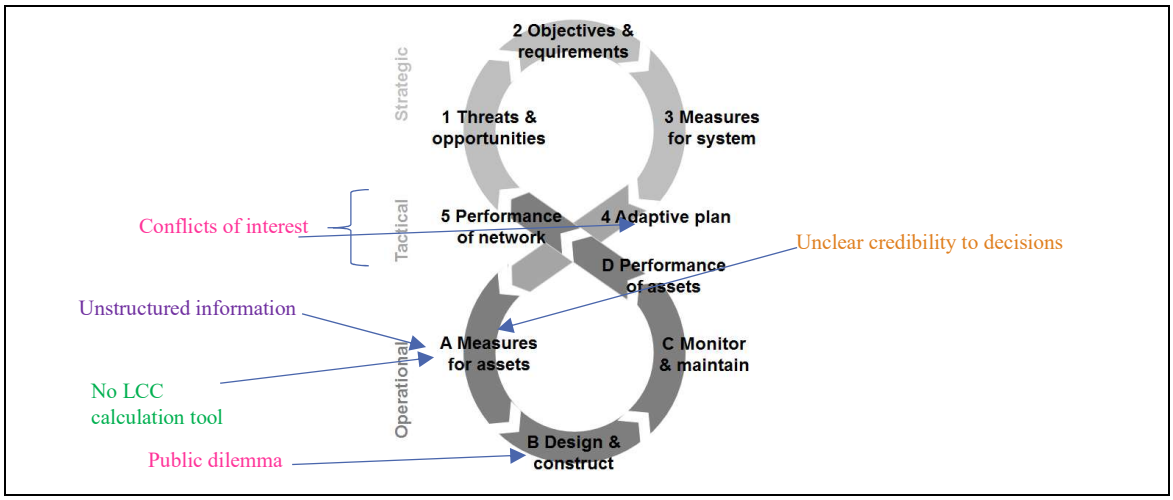


Figure 8: Significant barriers for HHSK

There are no identified barriers that are happening particularly at the strategic level at HHSK. *Conflicts of interest* happen throughout the asset management cycle. At the operational level *no LCC calculation tools* and *unstructured information* occur in stage A, and *public dilemma* in stage B.

Overall, these diagrams depict the governance barriers to proactive asset management implementation in the Netherlands, with a look at national level (Rijkswaterstaat) and regional level (HHSK). Both Rijkswaterstaat and HHSK have *public dilemma* in stage B of the operational level. In the next section a description of the most significant barriers is provided for both Rijkswaterstaat and HHSK. Please see **Appendix B.2** for a detailed description of all empirically-derived barriers.

Description of governance barriers

Institutional barriers

Rijkswaterstaat

There are no significant institutional barriers identified for Rijkswaterstaat. See **Appendix B.2** for specific examples of this type of barrier present in Rijkswaterstaat.

HHSK

At the national level there is a *conflict of interest* between different stakeholders over what they want to achieve with the dikes. In the past the wishes of every important stakeholder (e.g. person in charge of maintenance) were not incorporated. So there were a lot of complaints and it was highly inefficient to complete a project. This is also due to a lack of coordination which may be due to the hierarchical governance system in the Netherlands. Most asset management decisions are made at the highest level of the Ministry, and it is very difficult to influence them from the regional and local levels. The *conflict of interest* barrier is situated throughout the entire cycle of asset management.

Resource barriers

Rijkswaterstaat

An important resource barrier at Rijkswaterstaat is the *lack of staff*, specifically project managers. The project managers are responsible for implementing projects, so they are especially important. This is a significant barrier because it is difficult to overcome due to the rigid asset management procedures in the Netherlands and the fact that the number of project managers decrease over the years. This shows the lack of attention to flood management (see cognitive barriers). This barrier is situated in stage D of the operational level of asset management-performance of assets.

HHSK

At HHSK, the significant resource barrier is that there is no official *LCC calculation tool* available for innovative techniques. This barrier is situated in stage A of the operational level of asset management-measures for assets.

Cognitive barriers

Rijkswaterstaat

There is *unclear credibility to asset management decisions*, and this is because of high levels of uncertainty due to lack of knowledge on external factor scenarios (e.g. climate change, socio-economic). This has also to do with uncertainties surrounding the risk-based approach, since Rijkswaterstaat does not know the outcome of it because they have not used it before. This barrier is found at the strategic level of asset management.

Another important cognitive barrier at Rijkswaterstaat that was discovered was the *lack of attention* to flood risk management at the level of the Ministry. The shift in the political agenda is very difficult to influence due to rigid procedures at national level. This barrier is also found at the strategic level of asset management.

HHSK

The HHSK also faces the *unclear credibility to decisions* barrier in stage A with regards to the failure mechanisms that come with the risk-based approach, in particular piping. Since they are just starting to implement these innovative techniques for the first time, it cannot be determined with absolute certainty that the decisions made are the right ones. For more of cognitive barriers at the HHSK see the **Appendix B.2.**

Information and communication barriers

Rijkswaterstaat

There is *unstructured communication* between the strategic and operational levels of management, and this occurs at the tactical handshake, which is where clear communication between the two levels is supposed to take place. This is a barrier to the efficient and effective implementation of the adaptive plan.

HHSK

There is *unstructured information* on the condition of the assets, and the technical requirements for each of the components. This is especially visible at the HHSK water board. In addition, the information is scattered throughout the organization, which in turn is responsible for a highly time-consuming process (see **Appendix B.2**). A proper data and information storage tool is missing. This barrier is found in stage A-measures for assets of the operational level of asset management, because information on the assets is needed to analyze the different measures possible before choosing the right one. So this barrier negatively impacts the selection procedure in this stage.

Participation barriers

Rijkswaterstaat

The *public dilemma* barrier is found in stage B of the operational level of asset management-build and construct. Too much public involvement can cause delays in the implementation process because the public sometimes protests that the construction work is causing nuisance to them. This can interfere with the work and increase chance for conflict, as was mentioned under the institutional category.

HHSK

The *public dilemma* barrier implies that there are complaints coming from the local inhabitants as a result of the construction work taking over the space of other industries, preventing people from building new houses and obstructing their view of the sea. This is because there is little space in the Randstad area, the economic-intensive part and home to the majority of the Dutch population. The public is not always well-informed, and this is a barrier to including the interests of all stakeholders into the decision-making process as much as possible.

4.1.5 Opportunities to Overcome Significant Barriers

This section outlines the opportunities for overcoming the most significant barriers detailed in the previous section as determined by the asset owners.

Table 5: Opportunities to overcome for RWS

Barrier	Opportunity to overcome
Unclear credibility to decisions	- Systems engineering-combining technical engineering and project management- should help to verify in the end that they make what they intend to make - Some researchers at TU Delft are developing what is called the “line of sight” to determine whether the right activities are done
Lack of staff	No specific opportunities have been mentioned. Now there are more project managers available, but change is happening very slowly and erratically, and it is very difficult to influence national decisions.
Lack of attention	- Knowledge platform for risk approach (KPR)

	- Education programme, together with the water boards-a consortium of STOWA, IHE, and HKF. - Emphasis on education and culture is highly needed in order to continue to attract the younger generation to this industry in the future.
Unstructured communication	- The way to overcome it is by improving the assessment of the performance of the network and of the assets.

Table 6: Opportunities to overcome for HHSK

Barrier	Opportunity to overcome
Unclear credibility to decisions	- HHSK water board is doing pilot projects with two other water boards for which they have an innovation budget from the HWBP. They are considering to use a new kind of construction and include the maintenance department in the pilot projects, so that they know what they can expect. Every maintenance department should ask itself: - What is the lifespan of the dike? - How many times a year should maintenance be done?
Conflicts of interest	Learning from the mistakes of projects done before. Now the HHSK is involving the asset manager more in the design and construction stage so that he can have his opinion before the project is complete.
No LCC calculation tools	There is currently no solution, the HHSK water board is wondering if there could be something web-based developed since it will be easier than doing the calculations in excel. HHSK has a lot of experience with calculating LCC for traditional techniques, but not for the innovative ones. They are implementing them in phases and review the progress at the end of each phase. The investment is done by the HWBP when trying it out. When it's determined that it's working well, the water boards don't receive the whole financial support anymore, only 90% of it.
Unstructured information	Overcoming this can be quite a challenge. There would be a lot to gain if all the reporting done on the performance of the primary flood defenses would be unified. This is currently done with the same software in the whole country, but it's not visible to all water boards. A web-based and more unified system of reporting would be good. There is a geo-information system put in place and there is a common standard between all water boards, but a lot of improvement is needed to have more detailed information placed in it. It needs to be linked to the document management system. There needs to be someone responsible for filtering the information and giving it to the right person. Information must provide knowledge about the exact state of the assets, it must be up-to-date, and include a time-line in reporting. More inspection and reporting is needed which is to be used as input for the geo-information system. The goal is to implement this nation-wide. Also, employees need to be educated to work according to the protocol of the new risk-based approach, as it is still very abstract for them.
Public dilemma	HHSK hires landscape architects. Inhabitants living outside of the dike ring areas are more susceptible to floods and have to think twice about building their homes there. Also, people living within the dike ring area have to be more aware and to understand why these dikes are needed. The ideal solution would be to de-densify the coast, but that is impossible because it is the Randstad, home to the greatest economic area of the Netherlands.

4.1.6 Summary

Rijkswaterstaat

At Rijkswaterstaat several insights can be described. At the strategic level. The *unclear credibility to decision-making* is a barrier because it cannot be certain that right decisions are made; decision-makers (i.e. asset managers) may exhibit risk-adverse behavior. According to Rijkswaterstaat, the way to overcome it would be to fully adopt the whole-systems approach by applying it in all projects, as this would help them achieve their target of implementing the new risk-based safety standards. This means keeping options for measures open as much as possible. TU Delft is already working on developing the "line of sight" to ensure these right decisions are made, indicating how important this is considered to be. In addition, the maintenance department should be included in these pilot projects.

Regarding the *lack of staff* barrier, no specific opportunities have been mentioned because this is tied to decisions made at the level of the Ministry, thus Rijkswaterstaat has minimum influence over decisions pertaining to the number of staff, specifically project managers. Overcoming this barrier is key to improving the performance assessment stages at both levels of AM, because there would be more expertise and attention dedicated to it. The knowledge platform and education consortium developed to address the *lack of attention* for the assessment stage would be beneficial in the long-term because it will attract more young people to the field of flood risk management, thus ensuring continuation.

Unstructured communication is a barrier for the tactical handshake and it may be a cause for the *lack of attention* and *unclear credibility to decisions*, because without clear communication between the strategic and operational levels, it is difficult to prioritize the issue. The respondents first suggest improving the assessment of the performance to know better the status of the primary flood defenses to determine precisely whether they meet the safety standards or not.

HHSK

No barriers at the strategic level have been identified for HHSK. The focus for them seems to be at the tactical and operational levels. However, HHSK also shares the unclear credibility to AM decisions barrier with Rijkswaterstaat, and it suggests to conduct pilot projects with other water boards to verify whether their innovative techniques meet the standards. In the future, HHSK and other water boards could work closely with Rijkswaterstaat to resolve this issue.

The *conflict of interest* is a barrier for the tactical handshake and for the adaptive plan stage at the strategic level. To solve this problem, the HHSK is involving the asset manager more in the design and construct stage. This may also improve the *unstructured communication* mentioned by Rijkswaterstaat, but is representative of AM in the Netherlands in general.

At the operational level, the Netherlands is advanced with its measure selection method and having *no LCC calculation tool* does not keep asset owners from pursuing LCC, so this barrier is not deemed to be as significant as the rest, but HHSK would like to figure out a solution for this.

Overall, the Netherlands is considered a forerunner in asset management for primary flood defenses, especially due to its risk-based approach and use of LCC to ensure cost-effectiveness and its use of the whole-systems approach.

4.2 Belgium

The asset owner that was studied for this thesis was the Coastal Division; an agency of the Ministry of Public Works and Mobility (MDK).

4.2.1 Introduction to the Case Study

The case study of the Belgian Coastal Division is widening of the sea wall in Middelkerke municipality by means of a stilling wave basin in order to attract more economic and touristic activities while at the same time protecting the municipality from coastal flooding. Belgium has only 6 km of coast, and the sea wall at Middelkerke covers 2.8 km of this. Middelkerke is a weak spot in the defense against the sea. The source of flooding in this area is the sea. Middelkerke is a community with 19.000 inhabitants and an important touristic and economic area, and everything will be flooded if the sea wall is breached. The greatest challenge is to have the support of all the people living there as well as the authorities, because the construction will cause nuisance for a long period of time. There are no reported floods in this area from the past. The project is financed by Flemish government and municipality. After the construction of the new sea wall new flood risks assessments will be done periodically to determine the safety of Middelkerke and based on that a judgment of the success of asset management will be given.

Figure 9: Location of Middelkerke (Source: MDK)

4.2.2 National Context for Asset Management

Roles and Responsibilities

At the national level is the Ministry for Public Works and Mobility (MDK) which sets the safety standards, and the Coastal Division, an agency which implements the standards and has a funding role. The Coastal Division is only responsible for preventing coastal flooding. In this way it is very similar to the Dutch system as the Coastal Division operates in a similar fashion as Rijkswaterstaat, only that in Belgium there are no water boards operating at regional level.

Relevant policies and plans

At the national level there is a Coastal Safety Masterplan which is similar to the Dutch Delta Plan, outlining the measures that must be followed. The long-term plan, Vlaamse Baaien, is similar to the Dutch Delta Programme in that it identifies whether there is a need to revisit the national approach towards water management. Safety standards, like in the Netherlands, are set in the medium-term, in the Coastal Safety Masterplans.

4.2.3 Current Asset Management Strategy

The asset management focus for the Coastal Division is operational, but recently it has also started to look at more at the strategic level.

At the **strategic level**, there is an *adaptive plan* which outlines the *safety standards* that have to be met. It also takes the long-term into account. Cost benefit analysis (CBA) is performed to *select measures*. A *risk-based approach* is starting to be adopted, by incorporating different kinds of elements that are not solely based on the sea walls themselves, for example by creating an additional touristic or natural value. According to the Coastal Division, the *assessment of the network performance* could be improved by adopting the Dutch method of probabilistic failure assessment.

The **tactical handshake** has not really been described in either the questionnaires or the interviews, however the Coastal Division did briefly mention that, since theirs is a small organization with roughly six people, and they are all responsible for both the strategic and operational levels, since they are the only asset owner on the coast of Belgium and must act as asset owner, asset manager and service provider. However, it is highly likely that the tactical handshake in Belgium still has to be improved, following in the footsteps of the Netherlands. According to the Coastal Division, a starting point would be to engage all the relevant stakeholders in the early stages of the decision-making process.

At the **operational level**, life-cycle costing (LCC) could be used more in order to *select the most optimum and cost-effective measure* but it is currently not a priority for the Coastal Division. The *budget system* is fixed during the design and construct phase could be a drawback for major projects as they would not have enough funding to complete the project. The Dutch method of splitting the budget into phases cannot work in Belgium because then there would be a different contractor for each phase due to the internal administration system, and that is not desirable. The goal of the Coastal Division is “to

come up with a low cost design and building solution that is also very effective". The *assessment of the performance* of individual assets can be improved by providing an official report on their status. Overall, all stage of the AM framework has been addressed. However, there is still some room for improvement.

4.2.4 Governance Barriers to Asset Management Implementation

Governance Barriers and Asset Management

The most significant governance barriers for the Coastal Division are:

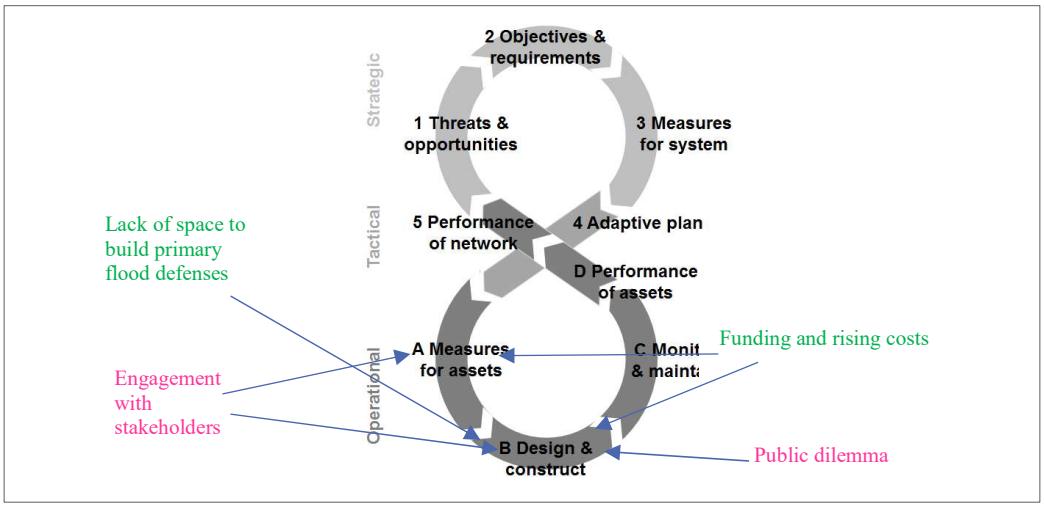


Figure 10: Significant governance barriers for Denmark

An important observation is that all the significant governance barriers are found at the operational level of asset management (recall that the asset management focus of the Coastal Division is at the operational level).

Description of Governance Barriers

Institutional barriers

There are no significant institutional barriers identified by the Coastal Division, however they do mention *lack of political will* as one (see **Appendix B.3**). However, it is not considered significant because the Coastal Division believes it can manage it.

Resource barriers

The most significant resource barrier is the *funding and rising costs* in stage A and B. The Coastal Division receives a limited budget every year to implement the plans, and this can sometimes be a problem when they need to make major investments. It is difficult to change

the fixed annual budget because of the current administrative system in Belgium. Ideally it would be good to split the budget into different phases but that would require a different contractor for each phase, which complicates the project. Another resource barrier faced by the Coastal Division is the *lack of space* to build primary flood defenses, since the Belgian coast is only 67 km long and the space is used by many different industries especially the tourist industry and it is also a highly popular place for people to live. This barrier affects stage B of the operational level.

Cognitive barriers

No significant cognitive barriers have been identified for Belgium, please see **Appendix B.3** for a description of a *lack of knowledge and expertise* barrier.

Information and Communication barriers

There are no significant information and communication barriers. See **Appendix B.3** for a description of *lack of data* regarding the conditions of primary flood defenses, and also the climate change scenario analyses.

Participation barriers

It can be difficult getting all the stakeholders involved earlier in the projects, hence the *lack of stakeholder engagement* barrier in stages A and B. There is also a *public dilemma* in the form of public protests as a result of not getting all the stakeholders involved earlier in the projects and due to *lack of space to build,* since the Belgian coast is very dense.

4.2.5 Opportunities to Overcome Main Barriers

This section outlines the opportunities for overcoming the most significant barriers detailed in the previous section as determined by respondents from the Coastal Division.

Table 7: Opportunities to overcome in Belgium

Barrier	Opportunity to overcome
Lack of stakeholder engagement	There are lots of shareholders involved, so it is important to involve everyone in the early phases of asset management decision-making. Before asking for a building permit, the Coastal Division and any other operational authority has to take time to discuss with everyone their plans so that they are all on the same page. Otherwise there is a chance that they will be denied the building permit. The local government is responsible for providing the building permit, but if there are some stakeholders and shareholders that have not been consulted about the project, then the local government might receive complaints and not provide the permits. The main concern of the politicians is that the people are happy, which is why the people must be convinced first of why the plans are necessary, and then the politicians. It is important to involve all relevant stakeholders in the beginning of the process in the design phase. Most of the time they hire a communication bureau who

	does this for them, as they are very specialized in convincing people. The media can also help in providing coverage.
Funding and rising costs	An option for dealing with the limited fixed annual budget if big investments need to be made with certain projects is to split the budget into phases, but this is not the most optimal solution because that would require having a different contractor for each phase which can cause problems at the operational level because different methodologies and different materials will be used for the construction. At the operational level they want to do everything at once and not split it into separate phases. The best possible alternative at the moment is to ask the Flemish government for additional money for that project, and this can usually be obtained when providing good argumentation. The issue is an administrative one, so perhaps the way they organize this internally will have to be changed, but it is not known how or whether that is even possible.
Public dilemma	In the last years the Coastal Division have started to acquire more support from the people by explaining to them their design plan and trying to convince them that the work is necessary. It was noticed that the people began to understand and to agree with the plans, and now they are fewer protests from before, although they have not ceased entirely. Now for each project that they do they invite the inhabitants to large events where they present the plan and the inhabitants have the opportunity to ask questions and even offer input. There will always be some complaints as they cannot disappear entirely, but now they are very minor. The most useful advice to the other asset owners is to involve the inhabitants earlier in the decision-making process, before implementing the projects. Another thing the Coastal Division is doing to reduce the protests from the people is to hire landscape architects that could make the structures aesthetically pleasing for the people, despite the high walls which may cause nuisance.

4.2.6 Summary

All the significant governance barriers identified by the Coastal Division as being representative of Belgium, affect the operational level of asset management. The strategic level follows in the footsteps of the Dutch one, however due to certain elements in the national context, such as the administration that prevents the budget to be split into phases and perhaps the fact that only the Coastal Division has an operating role, this may be part of the reason why it is difficult to involve all the stakeholders in the decision-making of every project, because it slows down the implementation process.

Based on the analysis of the Belgian AM strategy, achieving a low-cost and effective design and building solution that is also cost-effective is one of the main priorities of the Coastal Division in order to achieve a proactive level of AM. All of the significant barriers are taking place at the operational level, in stages A and B. At the strategic level, the Belgian strategy follows the Dutch one closely. Opportunities to overcome have been suggested for all the barriers aside from *lack of space to build*. Interestingly enough, this is considered by the author to be a distinctive barrier for Belgium, because it has the smallest coast out of all the other countries (67 km) and many other industries and inhabitants use that space. It can be said that this barrier is responsible for the *public dilemma* barrier due to the intensive land use and competition for land. However, the *lack of space* is inevitable and must be accepted, according to the Coastal Division, which is why they do not consider

it significant. Regarding the *public dilemma* barrier, the Coastal Division has started to acquire more support from the people, which is helping them to improve the effective delivery of projects. Furthermore, by addressing the *lack of stakeholder engagement* barrier, this will indirectly resolve the *public dilemma* barrier and ultimately *lack of space to build* barrier because the main issue in Belgium, as discussed in the interviews, is the sometimes inefficient implementation of projects and the possibility of not acquiring license to build.

4.3 Germany

The asset owner studied for Germany was the Hamburg state authority for Roads, Bridges and Waters (LSBG).

4.3.1 Introduction to the Case Study

The existing flood defense infrastructure in Hamburg consists of 40 flood protection gates, about 25 km flood protection walls, 78 Km of main dykes and 39km of dykes in the second defense line. The pilot gates are the: flap gate „Landungsbrücken Brücke 6“,sliding gate „Große Elbstraße“ and sliding gate „Brooksbrücke“. The source of flooding in Hamburg is storm surges from the River Elbe. This makes it different than the cases in the other NSR countries. The inner city of Hamburg is a dense urban setting. There is a mix of residential and commercial activities. There is no separation of risks in order to provide a high constant level of protection. The last flood was in December 2013 with a height of about 6,09m NHN in St. Pauli. Almost all flood protection infrastructures had worked as expected. The flood protection gate St. Pauli “Landungsbrücken Brücke 6” couldn’t get closed because of human maloperation. But the notch was closed with stop logs. There were no damages on civil infrastructure and no one got hurt. The maintenance of the public flood protection gates is financed by the federal state. The funding for the construction range is also secured.

Figure 11: Location of flood protection gates (Source: LSBG)

4.3.2 National Context of the Current Asset Management Strategy

Roles and Responsibilities

The Ministry of Environment at national level has funding responsibility for primary flood defenses, but not fully like in Belgium and the Netherlands. At the regional level, some Federal States have water boards, but not in every state. Hamburg, the state that was investigated for this thesis, does not have a water board, and therefore the LSBG operating authority is responsible for 100% of the 30% of the remaining funding for its primary flood defenses. The other 70% is funded by the Ministry. However, water boards do not have an operating role in every state, but in some have a permitting power. This inconsistency might be a cause for some barriers.

Relevant plans and policies

Germany follows the EU Floods Directive. There are Masterplans similar to that of Belgium, describing the measures, only that each Federal State has a different Masterplan. There are plans for the short –term and medium-term, but the short-term plans were not defined in the questionnaire. The Federal States develop their own legal safety standards and design criteria for their primary flood defenses.

4.3.3 Current Asset Management Strategy

LSBG provided information regarding their current asset management strategies in Hamburg, but considering the fact that German federal states differ widely in their strategies, it cannot be concluded that the summarized information (see **Appendix B.4**) is representative of the entire country. The AM focus in Hamburg is a mix of strategic and tactical.

At the **strategic level**, in Germany there are no national *safety standards* for primary flood defenses because each Federal State defines its own standards for its assets. The standards are based on international and national engineering standards. In Hamburg the safety standards are not *risk-based*, however risks are considered to a certain extent in order to improve the weakly parts first. There is a monitoring programme in which uncertainties are considered. The Masterplan is considered to be the *adaptive plan* in Germany, however there is yet no official long-term planning put in place. The clear indicators for the assessment of network performance shows that the network performs adequately, according to LSBG.

Regarding the **tactical handshake**, the LSBG claims this needs to be greatly improved by checking the legal conformity of the operational level to the safety standards.

At the **operational level**, regarding the measures for the assets, in Hamburg specifically, the flood gates are built following a highly complex design which runs the risk of needing reinforcement due to insufficient knowledge about the design. This results in high cost for maintenance. According to the respondents from LSBG, for the future they need to make cheaper and safer *maintenance* that is in line with the safety standards. Each flood protection gate needs a specific maintenance plan. Stage A for *choosing the measures* is not sufficiently addressed yet as there is no long-term plan specified at the strategic level

yet. The current method used to identify and select measure is conservative according to the LSBG, and LCC is rarely used. As mentioned before, there are large differences between Federal State regarding the *budget system* for maintenance and this affects its quality. As in the strategic level, the *assessment of performance* for individual assets follows very clear criteria and results show that they perform at an acceptable level but that there still is a lot of room for improvement in showing how they conform to the strategic level; hence the focus on the strategic and tactical levels.

4.3.4 Governance Barriers to Asset Management Implementation

The governance barriers mentioned in this section are particular for LSBG, since each federal state practices asset management in different ways, it is difficult to generalize for the entire country.

Governance Barriers and Asset Management

The significant governance barriers and the corresponding stage of asset management in Hamburg are:

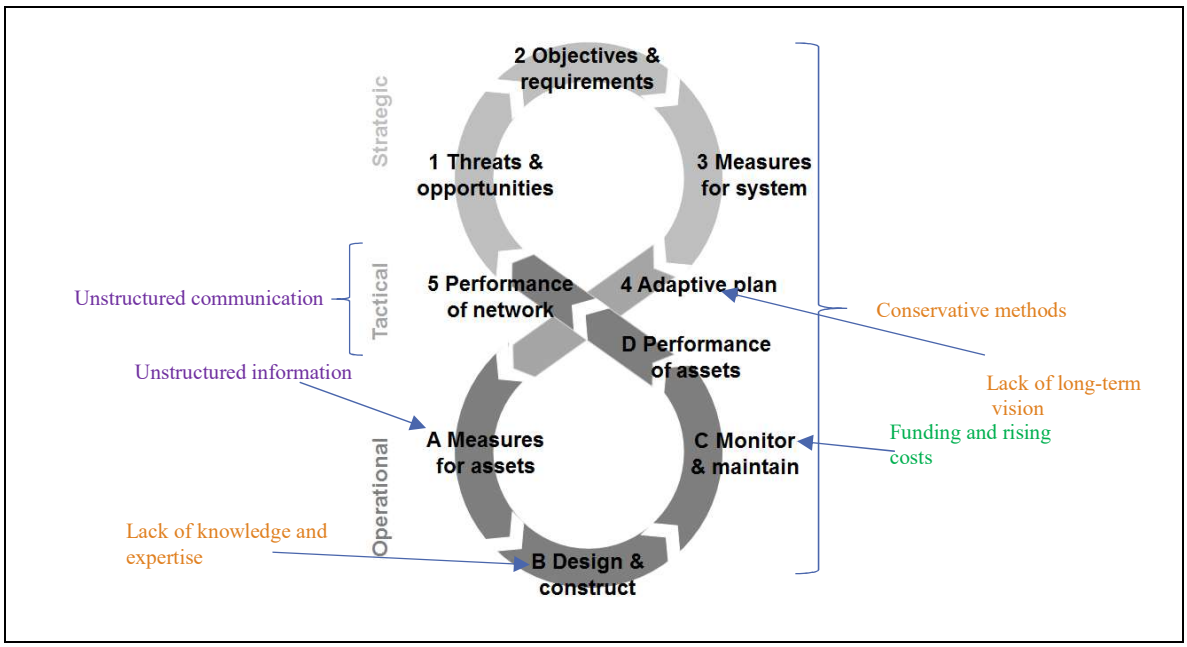


Figure 12: Significant governance barriers for LSBG

Judging from this visual portrayal, there are governance barriers taking place at all levels of asset management and in a variety of stages. This makes for dynamic and challenging results. One can see that *conservative methods* is taking place throughout the entire cycle, and it may be that this barrier is responsible for the occurrence of many other barriers, although this is only speculative. For instance, *conservative methods* may be responsible for the *lack of a long-term vision* in stage 4, which in turn may result in the lack of funding

and rising costs at the operational level. *Unstructured organization* is an interesting barrier because it directly impacts on stage 1 of the strategic level.

Description of Governance Barriers

Institutional barriers

Please see **Appendix B.4** for an overview of other institutional barriers including *lack of EU certification* and *loss of warranty*. These barriers are not considered to be significant because the *lack of knowledge and expertise* barrier is the cause and hence that one should be prioritized first.

Resource barriers

The LSBG in Hamburg faces *lack of funding and rising costs* for the maintenance of its flood protection gates. This is in part because of outsourcing of maintenance knowledge, which results in the loss of technical staff that know how to do proper maintenance at low cost. These barriers are identified to be situated at the operational level in general. The *lack of funding* barrier is a result of a *lack of a long-term vision* barrier (see cognitive category).

Cognitive barriers

There is a *lack of knowledge* on making both cost-effective and high quality flood protection gates. Currently they are built in a very complex way; and because of this it is difficult to maintain them in the future because there is a *lack of knowledge* on how to do that (See **Appendix B.4** for a brief description of the *too much complexity* barrier). Also, in Germany other possible innovative techniques are not considered, so there are no LCC calculations to determine other innovative techniques. This affects the quality of how stage A and Stage B are done. In other words, they follow *conservative methods* which are not fit to face the current challenges in asset management for primary flood defenses. These *conservative methods* need to be modernized, and this barrier is found throughout the entire cycle of asset management.

Information and communication barriers

Choosing the best technical design to achieve the highest safety requirement is highly dependent on good information, and in Hamburg and other German states there is *unstructured information* and it is difficult to find information in Hamburg because there is no geo-information and document system. This barrier is found in stage A-measures for assets in the operational level. Please see **Appendix B.4** for other information and communication barriers.

Participation barriers

No significant participation barriers have been identified. See **Appendix B.4** for a description of the public dilemma barrier. It is not considered significant because it was mentioned by the respondents it cannot be overcome and must be accepted.

4.3.5 Opportunities to Overcome Main Barriers

Opportunities to overcome for some of the barriers have been identified by the LSBG:

Table 8: Opportunities to overcome at LSBG in Hamburg

Barrier	Opportunity to overcome
Lack of funding and rising costs	- Make LCC calculations in order to optimize the decision-making process for choosing the most suitable and cost-effective design measure, and then not so much maintenance will be needed.
Conservative methods	- A more systems-engineering oriented approach could help as well as a more holistic and integrated way of thinking.
Lack of long-term vision	- Develop an adapted structure. Then they can discuss this structure within the organization and try to implement it in the contracts with the designers and builders. The LSBG is hoping to gain ideas about how to make this adapted structure together with the FAIR partners.
Unstructured information	- To make a geo-information system where they can easily access the data they need.
Lack of knowledge	- Reduce outsourcing of knowledge for maintenance

4.3.6 Summary

As mentioned previously, the main AM point of improvement in Germany is to make an official long-term plan. The need for this is observed in the state of Hamburg, which was the Germany case study for this thesis. However, the need for a long-term adaptive plan could also be the case in other states. The main point of concern observed at LSBG in Hamburg is the funding for maintenance and how to improve the quality of the maintenance. Most of the barriers in Hamburg occur at the operational level. Most significant barriers seem to originate with the *lack of long-term vision* barrier. The LSBG suggested to develop an adapted structure but does not mention anything about what should go into this structure. They are hoping to gain ideas for that from the other FAIR project partners. The *conservative methods* barrier is related to the *lack of a long-term vision barrier*, because without a long-term vision it is difficult to break from tradition and adopt a risk-based approach. A systems-engineering and a holistic and integrated way of thinking would help to change the perspective and adopt a more proactive approach to AM, according to the LSBG. For this, more knowledge is needed, but there were not a lot of opportunities mentioned for that aside from trying to stop experts from leaving the organization. The LSBG does not want to rely on external experts for the maintenance, but prefer in-house engineers.

The *lack of funding and rising costs* for maintenance seems to be the most significant barrier identified by the LSBG as the respondents reflected on that one the most. Thus far, the most cost-effective measure has not yet been discovered, and this is in part due to the fact that the flood gates are built in very complex ways, which makes them more

expensive to maintain and their performance uncertainty also higher. This is an outcome that the LSBG cannot afford because they are only AM authority in the state of Hamburg operating these assets. The opportunity to begin LCC calculations seems indeed appropriate, because so far it is the most advanced method for selecting the best measure. As of yet, no opportunities have been identified for *unstructured communication*; it was only mentioned that it is an important barrier.

4.4 Denmark

The Danish Coastal Authority (DCA), an agency of the Danish Ministry of the Environment, was the asset owner investigated for Denmark.

4.4.1 Introduction to the Case Study

The case study for the FAIR project in Denmark are dikes and locks in the medieval town of Ribe, West coast of Denmark. The decision focus is in deciding how to best protect the low-lying areas around Ribe from future storm surges from the Wadden Sea and water levels rising in the local river, Ribe Å. The area around Ribe is a large low-lying plain containing mostly drained farmland. The area is currently protected by frontier dikes from the Wadden Sea. The town of Ribe is located right at the bottom of the floodplain with a population of around 8000. The rest of the Ribe floodplain is mostly rural. The river Ribe Å runs through the medieval town-center, the drained farmland, and finally passes through the Kammerslusen lock before draining into the Wadden Sea. Thus, the source of flooding in Ribe is two-fold: from the sea caused by dike-breaching or over-topping during storm surges; flooding of the Ribe Å River. The probability of flooding from the river is greatest during storm surges because the dikes and sluices are closed automatically during that time, and water levels rise due to the discharge in the rivers. The main existing infrastructure protecting the Ribe floodplain from the Wadden Sea is a grass-covered dike. If the dike is breached, large areas of Ribe could be flooded.

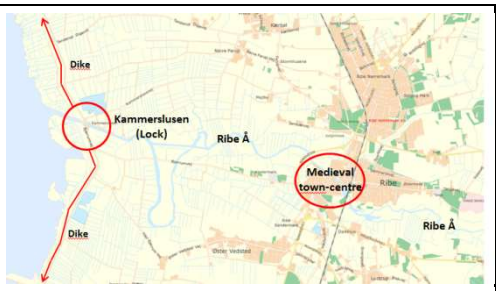


Figure 13: Location of town of Ribe and Ribe River (Source: DCA)

4.4.2 National Context for Current Asset Management Strategy

Roles and Responsibilities

Asset management is not centralized in Denmark. As a result, detailed goals and requirements are not established, beyond the overarching goal of ensuring flood protection. There are two ministries at national level, however they do not have AM responsibilities for flood protection and no responsibility for coming up with safety standards and design criteria. The Danish Coastal Authority (DCA), an agency that operates only on the West-

Coast of Denmark, is responsible for realizing politically-determined safety standards. This means that safety standards are not determined for the overarching goal of protecting people's safety from floods, but instead are determined by changing political agendas. Since politics is short-term the prescribed safety standards are also short-term, changing in accordance with the political decisions being made. Furthermore, the DCA only owns one sluice. In Denmark, municipalities and private landowners are the principle asset owners in Denmark. Funding for the west-coast is provided by the Danish government and municipalities with support from the DCA. In the rest of the country funding is the responsibility of the private landowners in line with the self-funding principal, which often leads to the implementation of the cheapest solution.

Relevant Plans and Policies

Denmark follows the EU Floods Directive, obliging some municipalities to develop risk-based plans for designated areas at high risk of flooding. There are no asset management plans in Denmark at the moment in either the long-term, medium-term, or short-term. At the local level, on the West-Coast, there are climate adaptation plans. In Ribe there are sluice practice plans. On the West-Coast, short-term 5 year plans are agreed upon. Every 10 years the DCA updates the safety standards for the Wadden sea dikes. Afterwards the results are reported to the relevant dike associations and officials for further possible actions. There are no policies at national level.

4.4.3 Current Asset Management Strategy

Only information for the west-coast of Denmark was provided because its asset management operates differently there than in the rest of the country (**Appendix B.5**). It is not determined whether Denmark follows a specific type of asset management.

At the **strategic level** there are no national *safety standards* as these vary along with the political party in power. More and different types of network measures have started to be considered. Denmark needs to further expand its criteria for choosing measures for the system. Municipalities have an *adaptive plan* called the climate change adaptation plans, but a longer-term vision is needed to challenge the status quo to change. There is a resistance to change attitude ingrained in the general Danish cultural climate, and not only for the flood protection industry. The Danish government currently has not defined an acceptable risk, meaning that it does not follow a *risk-based approach*. Many international papers define this as a crucial parameter to define if sustainably, cross-cutting and holistic solutions are to mitigate and adapt for future flooding. Without defining an acceptable risk municipalities do not know what to protect themselves against.

There is strong evidence that the **tactical handshake** is almost nil, as, according to the DCA, "the strategic level just runs once, and then the operational level detaches itself and runs by itself". It is evident that Denmark is still focused on the operational level, and that the tactical handshake is missing, as there is no consistency between the operational level and the strategic level, and both levels demonstrate uncertainty when it comes to the measures taken, as the plans, requirements, and results are not detailed enough.

At the **operational level**, aside from the West-Coast where the DCA is the main operating authority, in Denmark it is up to the individual landowners to protect themselves

from flooding. Municipalities currently use an *ad-hoc method to implement measures,* instead of prioritizing them. Thus, CBA or LCC are not performed. In addition, the municipalities and private landowners are responsible to fund the *maintenance* of their own assets, following the Danish *self-funding principle*. Lastly, more detailed monitoring and maintaining report is needed, as well as an *assessment report* for all the assets in the registry.

4.4.4 Governance Barriers to Asset Management Implementation

The significant governance barriers in Denmark and the corresponding asset management steps are:

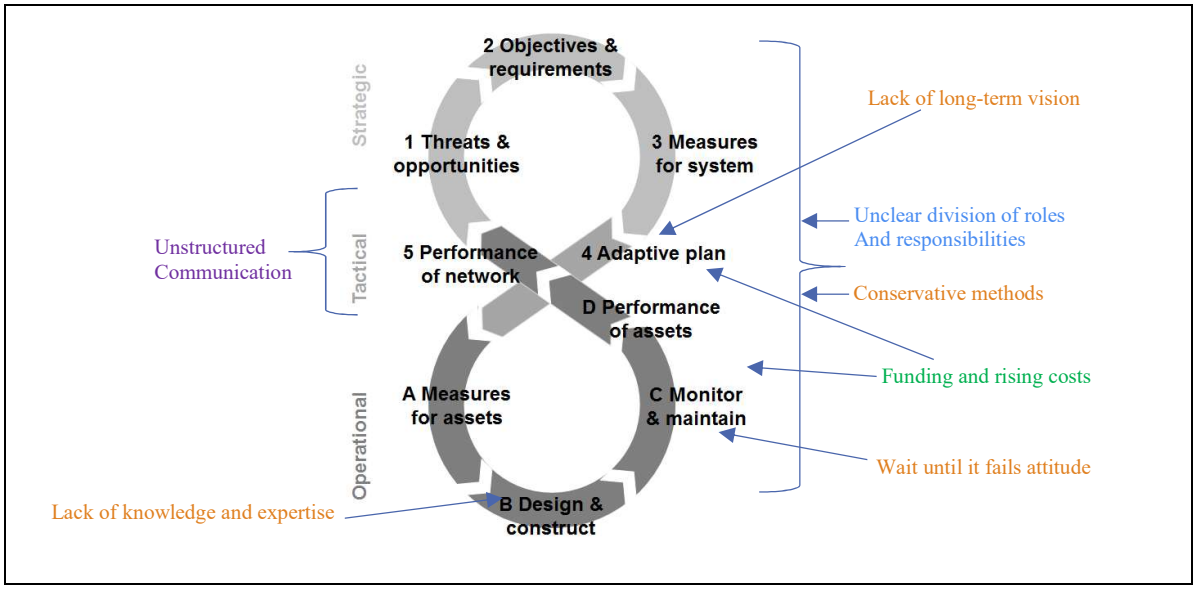


Figure 14: Significant governance barriers for Denmark

Judging from the above visual portrayal, it can be deduced that governance barriers occur throughout the entire asset management cycle in Denmark. *Conservative methods* take place throughout the entire asset management cycle, possibly influencing the occurrence of the other barriers indirectly. The *lack of a long-term vision* at the strategic level may influence the *lack of funding and rising costs* for maintenance at the operational level (stage C) and also the *wait until it fails attitude*. The *unstructured communication* barrier may in fact be the cause of all the other barriers, including *conservative methods*, because it is situated at the tactical level meaning that because of it there is a lack of communication between the two levels of asset management and since the operational level cannot function properly without the strategic level, the maintenance department waits until the last moment to make repairs.

Institutional barriers

The only significant institutional barrier for Denmark is *unclear division of roles and responsibilities.* According to the respondents from DCA, as it is now it is the responsibility of the private landowners to protect their houses from coastal flooding. However, the roles

are very diffuse and unclear. There should be one authority responsible but as it is now that is not happening.

Resource barriers

Another barrier to developing a long-term strategic plan is *funding and rising costs.* Paradoxically, the asset owners skip the maintenance step and wait until an asset fails to undergo major renovations, which is also very costly. Moreover, there is competition for funding between flood risk management and other industries, which is why flood risk management is not always prioritized (see **Appendix B.5**). The *funding and rising costs* barrier is situated in stage C.

Cognitive barriers

The main reason why it is difficult to set priorities for the long-term in Denmark is because it is not common to look very far into the future, it's just the way the culture is. It is a *wait until it fails attitude* put in place, and only when the asset starts breaking down are major renovations put under way. This is also in part due to the *conservative methods* barrier that is present in all industries in Denmark as a whole. *Conservative methods* is thus present throughout the entire asset management cycle. Also there is a *lack of technical knowledge* which prevents a more detailed adaptive plan to be made. This barrier is situated in stage 4 and stage B.

Information and communication barriers

There is *unstructured communication* between the strategic and operational levels, and this is why there is no tactical handshake present.

Participation barriers

No participation barriers were explicitly discussed. See **Appendix B.5** for a description of the *lack of stakeholder engagement* barrier.

4.4.5 Opportunities to Overcome Main Barriers

Table 9: Opportunities to overcome for DCA

Barrier	Opportunity to overcome
Lack of a long-term vision	- DCA would like to develop a national adaptive plan that will help them to decide if the sluices need to be adapted by a certain time in the future. They want the following information to be incorporated in the plan: at first the strategic approaches about policy objectives and performance requirements need to be included and the plan for how the sluice should be operated. The next type of information that needs to be included is about the condition of the sluices which can be determined via some surveys.
Unstructured communication	- The communication between the strategic and operational levels can be improved via more holistic strategies at national level.

4.4.6 Summary

The challenge in Denmark is to define safety standards for the long-term and adopt a risk-based approach. The significant barriers occur throughout the AM cycle. There are many significant barriers identified for Denmark, yet only two opportunities. Indeed, the respondents from DCA focused most on the *lack of a long-term vision* and *unstructured communication* and resolving these could end resolving some of the other ones. However, it would have been good to have identified some opportunities for *unclear division of roles and responsibilities* and *funding and rising costs* barriers as well. Funding and cost-effectiveness is a key topic to address regarding AM. However, judging from the data, it seems that the DCA have very clear and specific ambitions for how to address the *lack of a long-term vision* barrier and ultimately to formulate a clear long-term adaptive plan. They would like to make a framework to help them get closer to a risk-based approach which could be applied by all municipalities in Denmark, and they have already defined what they want to place in that framework.

4.5 United Kingdom

The Environment Agency (EA) of the Department for Environment, Food and Rural Affairs (DEFRA) was the asset owner investigated for the United Kingdom.

4.5.1 Introduction to the Case Study

No specific case study was provided for the UK because it is not a FAIR project partner. However, a few things can be mentioned about primary flood defenses in the UK in general. As a result, the UK will be discussed more generally without zooming in on a particular case. However, what can be said about the UK, is that the flood risk is very heterogeneous, meaning that it can occur in both rural and urban areas, and these areas can be both defended or undefended. Thus the attention to flood management is not evenly distributed throughout the country. During the trip to Rye for the workshop, there were also some site-visits, and one of them was the Dymchurch sea wall in Dymchurch village in Kent which defends the Romney Marsh from the sea (cover photo of thesis). It stretches from Folkestone in East Kent to Rye in Sussex.

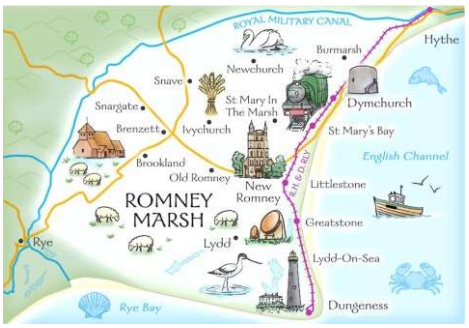


Figure 15: Location of Dymchurch sea wall (source: http://theromneymarsh.net/)

4.5.2 National Context of the Current Asset Management Strategy

Roles and Responsibilities

The UK has clearly-defined roles at the national, regional and local levels with regards to AM for primary flood defenses. The Department of the Environment, Food and Rural Affairs (DEFRA) is responsible for setting the safety standards and for funding all AM authority via the Environment Agency (EA). The EA is a branch of DEFRA and has both an operational role. The 11 regional Flood and Coastal Committees (RFCCs) have an asset manager role to provide a link between AM authorities and other relevant stakeholders to develop mutual understanding. Perhaps this is where the tactical handshake is situated, with the RFCCs. Further evidence of this remark is that they are responsible for ensuring that coherent plans are in place between the strategic and operational levels.

Relevant Plans and Policies

The UK follows the EU Floods Directive. At the national level the UK has a Floods and Water Management Act (2010). Important to note about this document is that it also contains an AM plan that focuses on the network of assets and describes how the EA should maintain its primary flood defenses in the short, medium and long-term. The long-term plan is looking at 50-100 years into the future, similar to the Netherlands and Belgium. The medium-term plan is looking at 15 years into the future, and the short-term plan is reviewed annually, however no information is provided on that in the questionnaire.

4.5.3 Current Asset Management Strategy

There is no data regarding the asset management strategies for the UK because it is not a FAIR partner, but some information was obtained from the questionnaire. In the UK the AM target is to implement the ISO 55000 by 2018.

At the **strategic level** in stage 2, there are both minimum and identified *safety standards* that need to be met. The minimum needs are the lowest unavoidable cost for maintaining statutory compliance and continue operation for a system accepting that the Standard of Service may decline as a result. The identified needs refer to the lowest whole-life cost to provide the required Standard of Service usually defined by target condition. The cost will reflect the best balance of maintenance and replacement over the assets whole-life period, and where best practice is adopted to comply with health, safety and environmental requirements. Legislation for the construction and operation is provided – but not the standard of protection.

Regarding the **tactical handshake,** it has not been very much discussed by the EA in neither the questionnaire nor the interview, however there is evidence that it is not well-developed since the operational departments are autonomous and do what they want independently of each other, meaning that they probably do not hold themselves accountable to higher levels of management, but it is important to note that this is only a speculative claim, and further investigation will have to be done in order to determine with certainty the situation of the tactical handshake in the UK.

Not much is known about the **operational level**, only that the departments run independently of each other. To create a more uniform asset management and to increase efficiency and effectiveness of its service, the EA will have to change its organizational culture from a fragmented one to a unified one, according to the EA itself. In addition, the respondents have said that they would like to form more partnerships with other stakeholders.

4.5.4 Governance Barriers to Asset Management Implementation

The most significant governance barriers in the UK and the corresponding asset management stages are:

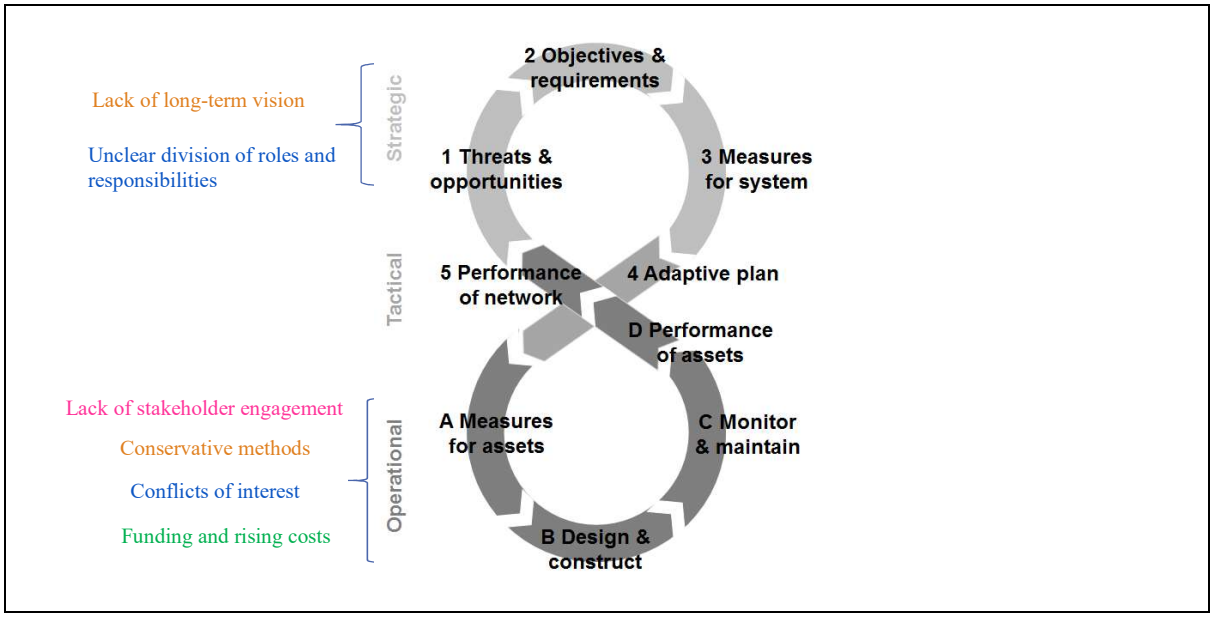


Figure 16: Significant governance barriers for the UK

Judging from the above visual portrayal, it can be seen that there are governance barriers in each level of asset management. No barrier was mentioned for the tactical handshake explicitly but that does not mean that there are no barriers there, because if the tactical handshake was fully present then there would likely not be so many barriers at the operational level. What is interesting about this depiction is that almost all of the identified barriers are allocated generally to one of the levels and not at a specific stage. This may be because in this specific analysis the EA was only discussing asset management generally and not for a particular case. It is difficult to determine, but it may be that allocating the barriers in this holistic manner may prove advantageous because the improvement to each level of asset management could take place coherently and not with each stage in part. But this is hypothetical and needs to be determined empirically in future research.

Institutional barriers

The *conflicts of interest* is a barrier to achieving the ISO 55000. It manifests itself in the form of a fragmented organizational culture. Each operational department within the Environment Agency (EA) has its own way of working. There is a lack of uniformity in the approach to asset management for primary flood defenses across the country. This barrier occurs generally in the operational level.

There is also an *unclear division of roles and responsibilities* regarding funding commitments at the strategic level. This barrier also causes the *conflicts of interest* barrier because *unclear division of funding responsibilities* leads to a lack of funding, which leads to competition between the different departments. Each department believes that their need is more important than that of other departments. This makes them appear as if they have a profit-driven mentality, which goes against the asset management goal of improving efficiency at lower cost. This competition for money negatively impacts the rural areas, leading to further competition. Now they have a new budget allocation system based purely on economics rather than personal opinion that will hopefully improve the situation.

Resource barriers

There is a *funding and rising cost* barrier because it is not allocated evenly throughout the country as a result of the competition for funding and lack of funding commitments barriers.

Cognitive barriers

People in the EA are conservative, and this is the reason why it is difficult to shift the organizational culture from a fragmented one to a uniform one. People engage in reactive behavior, meaning that they wait until a catastrophe happens before taking action. People want to achieve efficiency right away, but results cannot be acquired instantly. This indicates that the organization does not think very long-term, hence the barrier *lack of long-term vision*. Conservative methods are still place because of this *lack of long-term vision*. *Conservative methods* typically occur at the operational level because it is found in the actual implementation of projects and in the ways of working. The *lack of long-term vision* barrier is found at the strategic level because it is what defines the strategic level, this long-term vision.

Information and communication barriers

No information and communication barrier was identified as being a significant barrier in the implementation of proactive asset management. However, the *lack of data* on the asset conditions seems to be a cause to the inconsistent approaches in the operational departments. See **Appendix B.6** for more results on this category of barriers.

Participation barriers

There was nothing explicitly mentioned about participation barriers, only that more stakeholder involvement is not likely to offer a sustainable solution to influence governmental decisions. Please See **Appendix B.6**.

4.5.5 Opportunities to Overcome Main Barriers

Table 10: Opportunities to overcome for the UK

Barrier	Opportunity to overcome
Unclear division of roles and responsibilities	- The EA mentioned that money would be available if the treasury changes the rules around the way the costs are estimated and benefits and do the business cases together. If there is political will then something can be done, but at the moment there isn't.
Conflicts of interest	- The only incentive the operational departments have is that if they don't meet government expectations and improve their asset management then it can affect their funding. More positive incentives needed. Also they have a new budget allocation system that is based purely on economics and not on opinions.
Fragmented organizational culture	- To improve the corporate social responsibility within the organization. Also to develop knowledge management system would be useful.

4.5.6 Summary

As in Denmark, opportunities to overcome have not been identified for every significant barrier identified in the UK. An interesting observation is that all the opportunities that have been identified have been for all the significant institutional barriers identified by the EA. This could mean that the institutional barriers are prioritized, which may indeed be the case since the respondents focused the discussion mostly on the *fragmented organizational culture*. The proposed opportunity by the EA to overcome this barrier is to encourage more collaboration between the different operational departments and improve the internal CSR by increasing transparency. The *conflicts of interest* and *unclear division of roles and responsibilities* are in part a result of the *fragmented organizational culture* barrier. The *unclear division of roles and responsibilities* and *conflicts of interest* barriers are related, because both have funding as a common factor. Currently, there are no positive and lasting solutions to overcome these barriers.

4.6 Norway

The Norwegian Water Resource and Energy Directorate (NVE) of the Ministry of Petroleum and Energy was the asset owner investigated for Norway.

4.6.1 Introduction to the Case Study

Norway also is not a FAIR partner and this is also in part because it does not have very many primary flood defenses and therefore not much can be said about it, but the Norwegian Water Resources and Energy Directorate (NVE) has shared some information in the questionnaire regarding the potential of flood risk in the country.

> Norway has recently begun experiencing an increase in temperature and an increase in extreme rainfall by 35% in the last 30 years. Due to this there have been observed more rain floods, sea level rise, and flooding in urban areas caused by storm water runoff. There also seems to be a change in flood patterns from larger floods in the big rivers and waterfalls in rural areas to rapid floods in shorter and steeper rivers/creeks, which causes large damage to property and infrastructure. Land use planning is considered key in Norway to adapt to this changing climate when new buildings and infrastructure are built in risky areas. Norway is keener on adapting and accepting the changing climate, rather than fighting against it. Therefore they would like to focus more on nature-based solutions and less on primary flood defenses. Not much information has been provided on the kinds of primary flood defenses that they actually have.

4.6.2 National Context for the Current Asset Management Strategy

Roles and Responsibilities

Asset management is not centralized, as a result, detailed goals and requirements are not established, beyond the overarching goal of ensuring flood protection. The Ministry of Petroleum and Energy is responsible for prioritizing areas to build and funding, and the Ministry of Local Government and Modernization is responsible for determining the safety standards and setting the regulatory framework. The Norwegian Water Resources and Energy Directorate (NVE) is an agency of the Ministry of Petroleum and Energy with the responsibility to realize the prescribed safety standards, but it also provides financial support for municipalities. (See **Appendix B.7**). Overall, flood protection is a societal responsibility, where municipalities are responsible for their inhabitants according to the Natural Hazards Insurance Act. Private landowners are also responsible for coastal protection.

Relevant Plans and Policies

The EU Floods Directive is not implemented in Norway. There are no safety standards defined at national level, aside for the Planning and Building Act, which defines the legal standards for new buildings only, determined with the use of CBA. There is no long-term planning for AM aside from funding (3-5 years into the future). The Meld. St 15-white paper states that individual landowners are responsible to protect own property and buildings when making use of areas that may be hazardous.

4.6.3 Current Asset Management Strategies

No much information has been provided on the current asset management strategies for Norway because Norway is not a FAIR partner. However, a few points can be mentioned based on the information provided in the questionnaire.

At the **strategic level** the legal *safety standard* must be met. This legal framework applies only to the construction of new buildings. However the legal limit for existing buildings is not set and the safety level is determined based on cost/benefit analysis and other factors. Therefore this stage has not yet reached the proactive level.

Regarding the **tactical handshake**, not much has been mentioned. The respondent from the NVE has explained that there is both a strategic and operational department, but that they could be collaborating more than they do now.

At the **operational level** in stage A, the investments in flood protection measures are mainly prioritized by risk and cost/benefit analysis, on an annual basis. NVE has a newly developed cost/benefit tool after the Austrian model, which also allows taking into account the climate change effect on floods when *selecting.* They are currently not using LCC tools. Potential improvements can be made in the future, but it cannot yet be known whether that would be necessary for Norway. In stage C, regarding the *budget system* The Ministry of Petroleum and Energy grants the NVE a yearly *budget* to fund physical assets for flood protection, usually up to 80% of the cost. The funding stream into the future is quite secure, but budgets can vary from year to year, depending on how much they are able to use before the end of the year. There is no existing *maintenance* plan, since only the municipalities and owners are responsible for the maintenance of their assets.

Overall, Norway is currently still at the strategic level. The NVE is still working to develop a detailed asset management plan which they can then implement. The tactical handshake is missing. The struggle lies in implementing the strategic plan. The main improvement goal for Norway according to the NVE is “to improve society’s ability to handle landslides and floods by providing knowledge for society and inhabitants”.

4.6.4 Governance Barriers to Asset Management Implementation

The significant governance barriers that Norway faces to asset management implementation are presented in Figure 17 below:

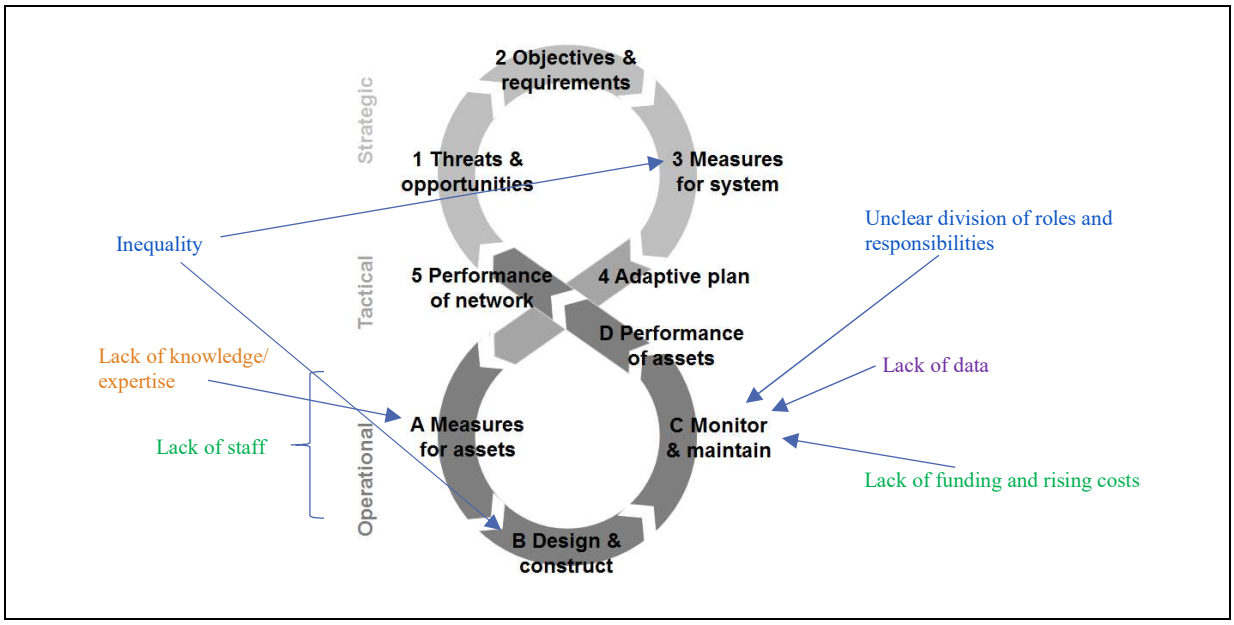


Figure 17: Significant governance barriers for Norway

What is interesting about the Norwegian case is that most of the barriers that have been identified have not yet occurred but have the potential to occur in the future when the operational level is reached. The *inequality* barrier in stage 3 of the strategic level and stage B of the operational level, which is already taking place, has the potential to impact the implementation of operations in the future, because it leads to an inability to prioritize focus areas where to build the primary flood defenses. The *lack of data* for all currently existing primary flood defenses causes this inability to prioritize focus areas of where to build them. The *unclear division of roles and responsibilities* may be responsible for causing project delays and *lack of funding and rising costs* for maintenance and ultimately insufficient maintenance which may lead to re-enforcement resulting in even higher costs.

Institutional barriers

The *unclear division of roles and responsibilities* could be reconsidered at the operational level (see **Appendix B.7**). The NVE's role is to help the municipalities improve their maintenance strategies. This cannot be achieved if the NVE ends its role at the design and construction stage. The role of the NVE does not go beyond construction and funding; it is not involved with the maintenance and assessment of performance of the primary flood defenses. They need to help the municipalities more with the maintenance. This barrier is found generally at the operational level.

Resource barriers

Municipalities sometimes lack funding for maintenance. The Norwegian Energy Directorate (NVE) is not always able to help them because natural hazards vary throughout

the country and some areas are more urgent to deal with than others, and at the same time populations are dispersed. Also, the NVE is only able to fund municipalities after they have thoroughly inspected the assets; otherwise they have to wait until a flood actually happens. See **Appendix B.7** for more resource barriers. The *lack of funding and rising costs* barrier typically occurs at the operational level of asset management.

Cognitive barriers

The *lack knowledge and expertise* barrier is relevant in Norway because municipalities and the NVE have trouble figuring out which focus areas to prioritize for primary flood defenses (**Appendix B.7**). This depends on knowledge of climate change scenarios and also population growth.

Information and communication barriers

Importantly, there is *Lack of data*-no central register in Norway containing detailed documentation of all the assets. This is because responsibility for asset design and construction is shared between the municipalities and the NVE. This is a barrier because the NVE is not aware of all the assets that are built, and so they have difficulty when deciding how to prioritize. The *lack of data* barrier is situated at stage C-monitor and maintain, and the lack of prioritization of focus areas impacts stages 3 and B.

Participation barriers

Private landowners should work more closely with the municipalities on the maintenance of assets. Nothing more was mentioned regarding this type of barrier (**Appendix B.7**).

4.6.5 Opportunities to Overcome Main Barriers

Table 11: Opportunities to overcome for Norway

Barrier	Opportunity to overcome
Inequality	- According to the NVE the primary flood defenses in the most hazardous areas should be prioritized first for construction and maintenance. In some places the risk of floods is lower, so those areas are not prioritized. The decision would also depend on the amount of population in a certain area. In areas with especially small populations, it is better for those people to learn to cope with the floods then for the government to prioritize those areas.
Lack of data	- The NVE was considering to be responsible for making this national register but says that it would be more practical if the municipalities would be responsible for making their own register because they already have access to all the information concerning their assets and thus it would be more efficient this way.
Time-consuming process and lack of staff	- The NVE proposed that the right funding and the right competencies are needed to implement the projects more efficiently, meaning in less time. The municipalities also need to hire the right people. More consultancy would be needed and geo-technical experts.

4.6.6 Summary

Opportunities for only three of the barriers have been proposed by the NVE. To address *inequality* between municipalities, the NVE proposed that the most hazardous areas should be prioritized. It seems that one uniform AM policy for all of Norway is not possible, but this is fine as long as those areas where primary flood defenses are needed are clearly identified.

Regarding the *lack of data* on asset conditions in municipalities, it seems that the most appropriate solution is for the municipalities to create a central register for all their assets, just like the NVE has already done, and then share this register with the NVE so that it will be enabled to assist the municipalites not only in the design and construct stage, but also in the maintenance and performance assessment stage. This opportunity should automatically address the *unclear division of roles and responsibilities* barrier as well, as the NVE's role shall be expanded to achieve its full potential.

4.7 Sweden

The municipality of Helsingborg was the asset owner investigated for Sweden, and the County Board of Skåne also investigated as they are the main FAIR project partner and it was also interesting to also gauge their perspective on the Swedish case. They both share similar perspectives regarding the governance barriers.

4.7.1 Introduction to the Case Study

The Helsingborg municipality has recently begun to experience more cloudbursts and sea level rise. Helsingborg, and many municipalities in Sweden, do not really have flood protection infrastructure, aside from storm water pipes. They are really missing infrastructure, because in the past they were not in need of it. Helsingborg municipality has two case studies: Råå village and Knutpunkten. They are both located close to the sea side and Råå is located in the lowlands. There is no existing flood defense system at Knutpunkten, and in Råå there is a natural levee (sand dunes), but its performance can be improved.

4.7.2 National Context for the Current Asset Management Strategy

Roles and Responsibilities

At the national level, the Swedish Civil contingencies agency (MSB) of the Swedish Government is responsible for civil protection, public safety and emergency safety, and it does not share these responsibilities with any other authority. It is a branch of the Swedish government. The County Administrative Boards represent the Swedish Government at regional level and coordinate the municipalities in their respective counties. Due to the Swedish self-governing system, the municipalities can do whatever they want regarding their AM practice.

Relevant Plans and Policies

Sweden follows the EU Floods Directive. There are no AM policies at national level. At local level there are long-term comprehensive plans (updated every 4 years). These plans describe how municipalities want water areas to be used. In the medium term these comprehensive plans are subject to change and focus on smaller areas, and in the short-term even more detailed comprehensive plans exist for a specific area which are legally binding (5-year implementation). The years for these time-scales are not determined in the questionnaire. Also, like in Norway, there are no plans on how to secure existing buildings.

4.7.3 Current Asset Management Strategy at National Level

Not much information can be given regarding the current asset management strategies for primary flood defenses in Sweden because it is in early stages of the strategic level. Only the stage in which information has been collected empirically via the questionnaires and methodological baselines is provided in **Appendix A.5**. Overall, there are no clear design criteria and no *safety standards*. There are Comprehensive plans for each municipality and detailed comprehensive plans for specific geographical regions which are the closest to an adaptive long-term plan, but they only look 100 years into the future. However, there are sea-level scenarios which have been developed looking at 2065 and 2100. According to the municipality of Helsingborg, some improvement goals for Sweden are to consolidate and improve the role of municipalities for AM implementation into the long-term, and to develop a more unified asset management for Sweden as a whole to the extent that that is possible and to ensure that flood protection measures are implemented in an efficient way when the time comes.

At the moment, in preparation for the operational level, Helsingborg municipality is looking at how potential levees will look like in the existing environment and where they can be built. For future buildings and levees, asset management is performed successfully, but must be done in existing surroundings as well. Thus, due to the fact that asset management has not yet been implemented in Sweden, not much can be said about it.

4.7.4 Governance Barriers to Asset Management Implementation

Governance Barriers and Asset Management

The significant governance barriers to asset management implementation that Sweden faces are:

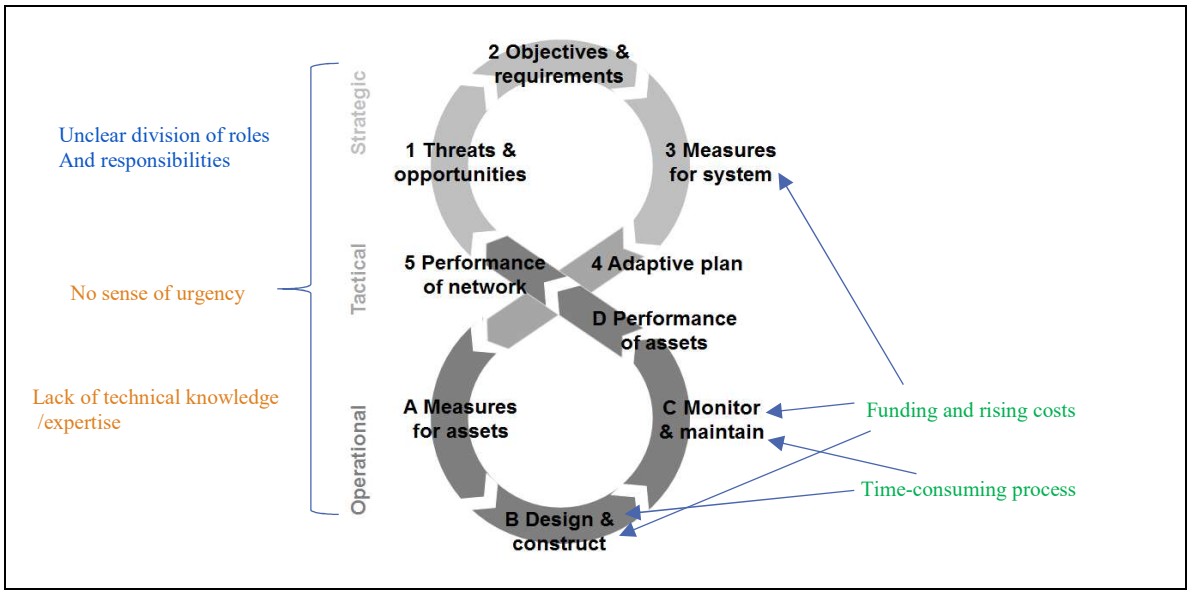


Figure 18: Significant governance barriers for Sweden

Many of these identified barriers are predictive for the future. For example, the *lack of funding for construction and maintenance* barrier has not yet taken place because investments in building primary flood defenses has not happened yet, it is still in the planning phase. However, the way things are panned out at present, this barrier has the potential to affect stages B and C at the operational level when the time comes. *The unclear division of roles and responsibilities* barrier affects the entire asset management cycle as a whole. Due to *no sense of urgency*, which also affects the entire asset management cycle, there is *lack of funding and rising costs* for crisis management plans which are supposed to be developed in stage 3 of the strategic level. The crisis management plans are also not enforced so that is one of the issues. This lack of funding for crisis management plans also results in a time-consuming process, because once a crisis occurs and there is no plan put in place, it can take a long time to recover from it as opposed to if a plan was already developed to deal with it beforehand. Due to a *lack of technical knowledge* on climate change it is difficult to actually make a detailed comprehensive plan and thus to implement it.

Description of Governance Barriers

Institutional barriers

There are *unclear division of roles and responsibilities* and unified national policy on asset management and so the responsibility for asset management lies totally with the municipalities. There are large differences between municipalities in terms of resources and level of flood risk and due to the Swedish self-governing system, the responsibilities are often blurred. This barrier impacts the entire asset management cycle.

Resource barriers

Some of the municipalities *lack funding for crisis management plans* and investment in scenario analyses is needed in order to have a longer-term plan and make preparations. This barrier impacts stage 3 of asset management. The smaller municipalities also *lack funding* for the construction and maintenance stages. Due to these barriers, it is *a time-consuming process* for municipalities to fund and implement the projects all on their own. For other resource barriers please see **Appendix B.8**.

Cognitive barriers

There is a general cultural paradigm in Sweden of having *no sense of urgency* to flood risk, and this is probably because of its long history of not being at war and of not having experienced any major natural catastrophe for a long time. This barrier impacts the entire asset management cycle.

Information and communication barriers

No significant information and communication barriers have been identified, see **Appendix B.8** to find out more about this type of barrier in Sweden.

Participation barriers

No main participation barriers have been identified, see **Appendix B.8** to find out more about this type of barrier in Sweden.

4.7.5 Opportunities to Overcome Main Barriers

Table 12: Opportunities to overcome for Sweden

Barrier	Opportunity to overcome
Unclear division of roles and responsibilities	- According to the County Board of Skåne and Helsingborg Municipality, it would be easier to have one responsible authority for asset management. For now, the national government could increase its role, since now only the municipalities are taking care of their primary flood defenses.

4.7.6 Summary

Since Sweden is at the phase of formulating its strategic level of asset management, it is currently difficult to assess whether the opportunities identified are sufficient to overcome the barriers and ultimately lead to proactive AM implementation. It is also difficult to determine more or less what the Swedish ideal of a proactive AM is at this stage. Furthermore, only one clear opportunity has been identified. The most for *unclear division of roles and responsibilities*, more specifically, the fact that there is no leading AM authority. The most feasible action that could be taken now is to stimulate the national government to increase its role via democratic discussion, in which the municipalities try to convince the Swedish government that they need more help with funding and creating an adaptive long-term plan for asset management. However, it is important to note that this will become more of a problem in the future when Sweden will actually have primary flood defenses. At the moment most elements discussed are speculative.

5. Comparative Analysis

5.1 Comparison of national contexts

In this section the countries are compared in terms of their national context consisting of funding role and responsibilities, and existence of plans and policies. The main remark about this section is that the responsibilities of actors differ between countries.

Table 13: Comparison of the national contexts

Country	Roles and Responsibilities	Relevant Policies and Plans
The Netherlands	-Ministry of I & E leads the AM decisions and sets the safety standards. -Rijkswaterstaat is the national operating authority and the water boards are the regional operating authorities -Funding responsibility is divided between these 3 authorities -Rijkswaterstaat and the water boards are responsible to implement the safety levels set by the Ministry.	-EU Floods Directive -Adaptive plan: Delta Plan from the Delta Programme for the short, medium and long terms -Water Act (2010) explain how to implement the new safety standards
Belgium	-MDK Ministry leads the AM decisions and sets the safety standards -Coastal Division is the national operating authority for coastal protection -Both MDK and Coastal Division have a funding role	-EU Floods Directive -Integrated Coastal Safety Masterplan that outlines the safety standards that must be met (for the short, medium and long terms)
Germany	-Ministry of Environment has only a funding role but does not set the safety standards -Each Federal State has its own AM operating authority which is also responsible for setting the standards for that state	-EU Floods Directive -Masterplans at national level determine the measures that must be implemented to realize the safety levels -Plans for short and medium terms but long-term plans have not been considered that much yet
Norway	-No leading AM authority -No details goals and safety standards for new buildings -One Ministry responsible for funding and another for setting the safety standards -NVE is the operating authority responsible for realizing the safety standards and also for providing	-No EU Floods Directive -No long-term plan for AM

	additional funding support for municipalities	
Denmark	-No leading AM authority at national level, meaning that national safety standards are not established -DCA operates on the west-coast and in the rest of the country private landowners and municipalities are responsible for AM -DCA aims to implement politically-agreed upon safety standards	-No adaptive AM plans for neither of the short, medium or long-terms -For the short-term the focus is on maintaining the sluices and only recently the long-term has started to be discussed
United Kingdom	-DEFRA is the leading AM authority -EA is the operating authority -At regional level the RFCCs link the national AM authorities with other relevant stakeholders	-EU Floods Directive -Adaptive plan: Floods and Water Management Act (2010) for the short, medium and long terms
Sweden	-No leading AM authority -Municipalities have autonomy in their AM decisions -County Administrative Boards are responsible for maintaining the link between Swedish government and municipalities	-Adaptive plans: Comprehensive plans for municipalities and detailed comprehensive plans for specific regions, but do not contain sufficient information yet

Roles and responsibilities

The Netherlands, Belgium and United Kingdom are similar in that the national level plays an important AM role. In each of these countries the Ministry is responsible for setting the safety standards and for contributing to the funding of primary flood defenses. These countries are also similar in that all three have a national operating authority responsible for implementing those safety levels and which also share a funding role. Norway also has a national operating AM authority.

On the other end, Sweden, Denmark and Germany are similar in that neither of them have a leading AM authority at national level due to the large differences across regions and municipalities. Sweden is the most extreme in that it has no operating authority, the municipalities have operating role in their own right, each with their own adaptive plans. In Denmark the municipalities are also the main asset owners, but in the west-coast part of the country the DCA plays a major operating role to protect against coastal flooding, similar to the Coastal Division in Belgium. What stands out for Denmark is that the safety standards change with every political election, meaning that they are not decided upon based on safety, but on changing political agendas. Germany's Federal States each have their own operating authority, in Hamburg being the LSBG, and each state has its own

established safety standards. Germany can also partly be compared to the Netherlands in that some states have water boards which share AM responsibility, but not all.

Relevant policies and plans

All NSR countries follow the EU Floods Directive with the exception of Norway, which is not a European Union country. At national level, the Netherlands has the most clearly established adaptive plan with measures outlined in the Delta Plan for the short, medium and long-term and the Water Act (2010) detailing how the new safety standards should be implemented by 2050. Belgium follows closely behind with an Integrated Coastal Safety Masterplan outlining the safety standards that must be met. Germany also has masterplans but each Federal State has its own and do not yet consider the long-term very much. The United Kingdom also has a well-established adaptive plan called the Floods and Water Management Act (2010) similar to the Dutch Water Act (2010.

Sweden, Norway and Denmark do not yet have clearly defined AM plans and policies. In Sweden each municipality has its own comprehensive plan which is further detailed for specific regions but these plans do not yet contain all the necessary information regarding primary flood defenses because Sweden does not have any yet. Norway and Denmark do not yet have adaptive AM plans.

Overall, it can be said that each country is different with regards to their national context, but there are some similarities, and countries can be grouped together based on some specific aspects. Future research could focus more on how the national context influences the maturity of asset management strategies.

5.2 Comparison of Current Asset Management Strategies

5.2.1 General Overview

All countries have an operational asset management strategy put in place, but they are at different stages in the implementation process and the strategies differ depending on national context and improvement goals. Only the Netherlands and Belgium have developed a strategic level for their asset management; and Sweden, Denmark and Norway would like to develop this process through FAIR. The tactical handshake is relevant for the Netherlands and Denmark because they have a larger network of assets with many actors, but it is less relevant for Belgium and Sweden because they have smaller systems with fewer actors.

The Netherlands seems to be the closest to what is considered a proactive asset management strategy. It has very clearly defined safety levels in the adaptive plan at the strategic level. This is a main requirement to achieve proactive asset management. Germany also has prescribed safety levels, but a different one for each state. Norway and Sweden are not at that stage yet, but since there are such vast differences across the countries, it can be predicted that having only one legal safety standard for the whole is not feasible because the flood risk differs between regions, unlike in the Netherlands. So for those countries it would be better to have different prescribed safety levels. Germany has already done this, but this is more because of differing priorities between states.

Denmark, Sweden and Norway are far behind on their asset management strategies compared to the other countries. The first thing to do is define a set of safety standards and make or improve an adaptive plan for the long-term. Denmark seems to be more ahead regarding the selection of measures. Norway and Denmark are a bit similar in that they both have an operating authority that helps the municipalities fund their projects. Sweden does not have this because it follows a self-governance process, where the municipalities are alone responsible for funding.

When comparing the strategic level between countries, it was investigated whether the following factors were present and in what ways:

- risk-based approach
- safety standards
- adaptive plan with long-term perspective

When comparing the operational level between countries, it was investigated whether the following factors were present and in what ways:

- selecting measures
- innovative techniques
- Budget system
- maintenance
- performance assessment

5.2.2 Comparison

Table 14: Comparing the different levels of current asset management strategies

Country	**Strategic level**	**Tactical Handshake**	**Operational level**
NL	-Defined safety standards -Adaptive plan put in place that takes account of the long-term -Has adopted a risk-based approach	-Have system put in place but is often overlooked unless a problem occurs -Systems engineering	-LCC used more and more to select cost-effective measures -Starting to implement more innovative techniques -Maintenance in accordance with safety standards -Evaluation of asset performance is done every 6 years
BE	-Adaptive plan that takes the long-term into account -Safety standards established	-Strategic and operational levels do communicate with each other, but could still be improved - Systems-engineering employed	-CBA is performed to select measures -Fixed budget for the design and construct stage -Assessment of performance should follow a more official procedure
DE	-No national standards for safety, but differ per Federal State	N/A	-High costs for maintenance -Conservative methods for selecting measures based on design standards

	-No official adaptive plan		-Assessment of performance for individual assets show positive results but could still be improved
UK	-Safety standards established -Adaptive plan -Moving towards a risk-based approach	-Not well-developed since the operational departments are autonomous	-Not much data on this -EA respondent has mentioned that the technical part is well-developed
DK	-No stable national safety standards and no acceptable risks defined -No national adaptive plan, but municipalities have risk management plans (beginning to move towards a risk-based approach)	N/A	-Municipalities use an ad-hoc method to select measures (CBA and LCC are not performed) -No assessment report
SE	-Legal safety standards for existing buildings and primary flood defenses -A longer-term perspective is needed for the adaptive plan	N/A	N/A
NO	-Legal safety standards for existing buildings	-Strategic and operational departments at NVE could be collaborating more than they do now	-Measures are chosen using CBA -Yearly budget for physical assets -Maintenance could be improved -Difficult to assess asset performance

N/A=does not exist

Strategic level

The Netherlands is generally in the frontlines of the strategic level and asset management in general. It has well-defined *safety standards* and a clear *adaptive plan* which takes the long-term into account. A risk-based approach is undertaken that takes the whole-system into account. The Coastal Division in Belgium follows closely behind by beginning to look at a combination of nature-based solutions with primary flood defenses, for instance. The EA in the UK is also comparable to Belgium and the Netherlands in that it also has established *safety standards*, a *long-term adaptive plan*, and is moving towards a *risk-based approach*, although it claims to be far from full implementation. The LSBG in Hamburg, Germany has *safety standards* but different ones for each Federal State, with no clear adaptive plan yet and far from implementing a risk-based approach. Municipalities in

Denmark have *safety standards* but they constantly change depending on political agendas and there is no national *adaptive plan*. The long-term is currently left out of consideration.

Sweden and Norway are similar in that they are both in the phase of formulating their strategic level. Sweden has some *adaptive plans* but they currently do not take account of climate change so much, while Norway has no adaptive plan at all. Neither Sweden nor Norway have defined *safety standards* yet. What distinguishes Norway from the other countries is that the strategic level is moving towards a living with floods' mentality, because the population is highly dispersed and it is nearly impossible to provide equal flood protection throughout the whole country. This could be considered a *risk-based approach*, but specific for Norway.

Tactical Handshake

Most countries have a missing or underdeveloped tactical handshake. The asset owners just said that the tactical handshake is missing or not present to a sufficient degree to allow easy and efficient transfer of insights from the strategic level all the way down to the operational level. The Netherlands is also a frontrunner for the tactical handshake, because, as was seen with the HHSK water board in project KIJK, they have recently started to do systems engineering, in which the strategic department closely collaborates with the operational department. In Belgium, the tactical handshake is not such a big problem because the Coastal Division operational authority is so small with only about six staff members and the communication between the strategic and operational departments within the organization is close and transparent. In Germany, the LSBG in Hamburg have mentioned as an opportunity that they would like to adopt the systems engineering approach as well. In Denmark, the strategic level has the tendency to just run once and then the operational level just runs by itself. The tactical handshake was not discussed for Norway and Sweden but it is predicted to also not be present because the strategic level is not that well developed yet.

Operational level

At the operational level, a key point is ensuring that the best measure for the primary flood defenses is chosen and that there is enough funding for maintenance to also achieve high quality. The best selection tool to date is life cycle costing (LCC). The Netherlands is the only country that has implemented it to a high enough level. The HHSK water board is experimenting with this now for the first time by adopting as many innovative techniques as possible for project KIJK, making the Netherlands the first country in the world to employ this technique. Thus, the Netherlands is a frontrunner in choosing between many different measures. Belgium hasn't yet prioritized LCC but it is doing CBA when choosing between different measures and so far it is working pretty well for them. Norway is also doing CBA and it is using the advanced Austrian model tool. Since Sweden is still in the research and development phase and does not yet have many primary flood defenses, it also does not have very many types of measures that it considers. In the future it will probably also consider the LCC. In Denmark neither LCC nor CBA is used for identifying measures, as the municipalities prefer using an ad-hoc, random method of selecting the measures. The Danish Coastal Authority (DCA) would prefer to adopt either CBA or LCC.

Since neither Norway nor Sweden have very many primary flood defenses, not much can be said about their operational level.

Overall, each of the seven NSR country has different strategies they employ for the different levels of asset management, but many factors are comparable. The Netherlands appears to be the frontrunner of what is defined as proactive asset management in the theoretical framework of this thesis, followed closely by Belgium and the United Kingdom. The different strategies employed by the other countries seem in great part to do with their national contexts, however, to gain an even wider perspective on this subject, it is necessary to look at the governance barriers that the NSR countries are facing in their current asset management strategies. The following sub-section compares the different categories of barriers across countries.

5.3 Comparison of Barriers

5.3.1 General Overview

All categories of barriers were mentioned by all countries except for participation barriers, which were not discussed for the UK, Denmark and Norway. Cognitive barriers have the highest frequency followed by resource and institutional barriers. Participation barriers were mentioned the least. All countries have at least some common barriers with each other. The next sections are divided according to the governance barriers categories and the specific barriers compared between countries. Moreover, a comparison of opportunities to overcome proposed by countries independently, but also with insights from the workshop is provided. The tables presented in this section present which asset owners identified with a particular barrier.

5.3.2 Institutional barriers

The most commonly occurring institutional barriers across all the asset owners in the NSR countries are *conflicts of interest*, *inequality* and *unclear division of roles and responsibilities* (see table 15). This section compares all the barriers listed in the table in terms of their significance.

Table 15: Number of countries with each institutional barrier

Institutional barriers	Frequency (# of countries)	Countries
Conflicts of interest	4	UK, SE, DE, NL
Inequality	3	DE, SE, NO
Unclear division of responsibilities and ownership	3	SE, NO, DK
Lack of enforcement	2	DK, SE
Lack of EU certification	2	UK, DE
Lack of political will	2	UK, BE
Rigid procedures	1	NL
Loss of warranty	1	DE

Conflicts of interest

According to the results in chapter 4, this barrier is significant for all asset owners that have identified it as a barrier (table 15). In the Netherlands there is a conflict of interest between authorities on what they want to achieve with the primary flood defenses. A respondent from the HHSK mentioned that in the past they did not incorporate the wishes of every stakeholder, especially the wishes of the maintenance department. However now they are beginning to do that and are noticing some improvement in the efficiency of the project.

In Sweden, the Helsingborg municipality and Skåne County Board have identified frequent conflicts taking place between municipalities and countries over decisions relating to flood protection, but it is not viewed as a significant barrier because they settle differences via democratic discussion, and, if necessary, have the Court of Justice make the final decision. In the United Kingdom, on the other hand, the Environment Agency (EA) has identified the conflicts of interest as a significant barrier. Since the operational departments work independently because of a fragmented organizational culture, they have frequent competition for funding. The difference between Sweden and UK is due to the fact that in Sweden there are frequent discussions for settling differences whereas in the UK the different operational departments do not engage in open discussion, as they are keen on maintaining their separate ways of working. However, Sweden is not uniform either as each municipality follows a different asset management strategy or have an uneven distribution of funding. An important observation is that there is no competition for funding between the rich and poor municipalities in Sweden. Since the municipalities acquire most of the funding by taxing local inhabitants, the poor municipalities are not able to afford building primary flood defenses. In the United Kingdom in the past, there had been competition between urban and rural areas. However, they could have this competition because the funding was provided by the national government. Sweden could change this by having one leading asset management authority, but this may be difficult because of the self-governance system which is difficult to change, and they are also unwilling to change it. In Sweden, if there is competition, it is more about different industries using the same area.

Opportunities to overcome

For the most part, the countries do not have very many ideas about how to overcome the conflicts of interest barrier. The EA in the United Kingdom mentions that they need more positive incentives to motivate the operational departments to reduce their conflicts over funding by working in a more unified way. At the moment the only incentive is meeting the deadline proposed by the government to achieve the ISO 55000 standards, otherwise the amount of funding will be reduced.

Inequality

Inequality refers to the large differences between states or municipalities in the level of flood risk and asset management policies. This barrier is significant for Sweden and Norway according to the results of chapter 4. Germany has a similar situation but according to the LSBG, it does not face major consequences because of this, therefore it was not identified as a significant barrier. In Germany the inequality lies in the design criteria and

safety standards for the primary flood defenses, because each federal state makes its own calculations.

In Denmark there are differences between the west-coast and the rest of the country, in that the DCA is the national operating authority responsible for asset management but only on the west-coast of the country, while in the rest of the country the private landowners and municipalities are responsible. This difference has more to do with the level of flood risk, since the west-coast is considered to be more at risk of flooding and so more coordination and funding is provided there. This barrier is not considered significant in Denmark.

Opportunities to overcome

In Norway, since the level of flood risk and population distribution varies so much, the NVE proposes that the construction and maintenance of the primary flood defenses be prioritized for the most hazardous areas, but of course, more knowledge of climate change scenarios will be required.

Unclear division of roles and responsibilities

Unclear division of roles and responsibilities is significant for all asset owners that have identified it (table 15). The NVE in Norway does not help the municipalities enough to maintain and finance their structures. The NVE typically stops their function after the design and construction phase. After that, the municipalities are left to their own devices to do the maintenance. But the NVE is also a permitting authority, so the municipalities can appeal to it for extra funding if needed, and depending on what they prioritize, the NVE could respond to the appeals. Unlike in Norway, Swedish municipalities do not really have a higher authority to which they can appeal to for help. The County Boards do not have an asset management authority and they also have limited funding. They are only able to advise the municipalities and facilitate democratic discussion between them and provide a link between the municipalities and the Swedish government. Like in Norway, Sweden is a large and varied country, and the types of natural disasters it faces depend on location. Because of this, it is difficult to have one authority with one standardized procedure for the whole country.

In Denmark, the problem is very similar to that of Norway and Sweden in that the responsibilities are mismatched and diffused. The only clear role, like in Norway, is that of the individual landowners who have to protect their assets. So the similarities between Sweden, Norway and Denmark is probably because of the fact that they are all democratic and have the self-governing system. This is most extreme in Sweden.

Opportunities to overcome

In the UK, to improve the funding responsibility, the EA has not proposed a concrete solution, but mentioned that the rules of the way the treasury allocates the costs would have to be changed, and this would depend on political willingness. In Sweden, the County Board of Skåne and Helsingborg municipality both agree that it would be easier to have one responsible authority for asset management at national level. It would be difficult to

achieve fully, due to the large differences between municipalities and the Swedish self-governing system, as the municipalities all govern differently and would like to preserve their autonomy, but they believe it would still be achievable to a large extent, to improve the facilitation of proactive asset management implementation. How a leading asset management authority could come to be is so far undefined, but for now, the national government could increase its role in helping the municipalities. It could be persuaded via an open democratic discussion between the counties, the national government and the municipalities.

5.3.3 Resource barriers

The most commonly occurring resource barriers across all NSR countries in terms of frequency are *funding and rising costs, time-consuming process, lack of staff* and *lack of space*, according to table 16. No LCC calculations is not discussed in this section as that only takes place and is significant for HHSK water board in the Netherlands, and has already been discussed in chapter 4.

Table 16: Number of countries with each resource barrier

Resource barriers	Frequency (# of countries)	Countries
Funding and rising costs	6	BE, DE, UK, DK, SE, NO, NL
Time-consuming process	5	NL, BE, UK, NO, SE
Lack of staff	4	NL, BE, NO, SE
Lack of space	3	BE, NL, SE
No LCC calculation tool	1	NL

Funding and rising costs

Funding and rising costs is considered significant by the asset owners in all countries except the Netherlands, where the asset owners have declared that they have already resolved the main issues pertaining to it. The Netherlands has reached an adequate level of budget allocation, but the next step for it is to think more in risks if something unexpected will occur and the water boards are not able to afford it. The Netherlands is no longer experiencing a funding barrier in a way that negatively impacts its efficient implementation of projects, because it has solved the problem a while back. Unfortunately not much information has been collected on how that has been done. However, what can be said, is that the HHSK water board is now implementing its projects in phases, and at the start of each phase they receive a fixed budget from Rijkswaterstaat and only for that phase. If it happens that additional budget is needed, they can apply for more, provided they have proper argumentation, but at the same time, the reason they are doing LCC calculations more and more is so that they can determine the cost in advance and know which measure would be best to choose that would fall within that amount.

A lot of data has been collected from the Coastal Division in Belgium on this barrier. It does not have a lack of funding, but the problem is more to do with budget allocation, especially if a project demands greater investments. They would have to demand more funding from the Flemish government which also takes a lot of time. The

problem is that with a limited budget they also have a limited amount of projects they can work on. Unlike the Netherlands, where the money for flood protection comes from the Delta Fund, in Belgium there is only one source of money for all the public works. In UK, extra funding can only be given if expectations are met, and with the condition that they achieve the ISO55000 accreditation. It is an incentive. Funding has not been prioritized very well or spent fairly, but based more on personal preference and opinion. The Coastal Division in Belgium has considered splitting its budget into phases as in the Netherlands, but for them this would be a problem because it would mean having a different contractor for each phase and they want to avoid that. This has to do with the internal administration and it would have to change and that this time it is not known how that can be done. The MDK at the moment carries out CBA calculations and it considers doing LCC into the future, but at the moment this is not a priority. The LSBG in Germany is considering LCC more than the MDK as a solution to reduce cost for maintenance.

In Norway the municipalities lack funding for maintenance and they turn to the NVE for help. In Sweden, despite many similarities to Norway, municipalities have to fund everything themselves, they cannot turn to the national government or county. The richer municipalities may be able to do this, but not the poorer municipalities. There will be a problem in the future when they reach the operational level and they have to actually implement a project. In Germany the problem is similar to Sweden in that there isn't enough to do maintenance in a very effective way due to debt breaks. In Denmark, the main problem of funding is due to a lack of a long-term vision, because they have to apply for finances a few years in advance, but they don't know how much they will need so they wait to do crisis management instead at the last moment. An important remark for Sweden is to be aware before implementing crisis management as it is not a proactive approach and it is very expensive. It is better to have a plan and think in advance, and neither Sweden nor Denmark has it yet.

Opportunities to overcome

Every NSR country had an opportunity in mind to overcome this barrier. In Norway the municipalities are supposed to be able to fund their own projects, but the NVE has the responsibility to help with funding. When they are unable to do so however, they can appeal to the Ministry of Petroleum and Energy for additional funding. Swedish municipalities face a similar problem in that they are responsible for their own funding, however there is no national operating authority in Sweden to help them with funding, other than the County Administrative Boards. According to a respondent from the County Administrative Board of Skåne, they will attempt to find a solution after analyzing the reports they have acquired from the municipalities that participated in their survey. Furthermore, they claim that a national system for funding would be a solution, but that would mean there needs to be an asset management at national level. According to the UK, a total expenditure approach would be the ultimate solution, because it would be helpful in estimating the funding for more years into the future. The EA is currently working on this and they have made some advancements. In the workshop discussion (**Appendix C**) the other asset owners also agreed on this solution. The LSBG in Hamburg, Germany have proposed that LCC is the best solution to overcome the funding for maintenance problem as it would improve cost-effectiveness by estimating future costs. This technique was also agreed upon during the workshop, although not all countries can prioritize this opportunity yet because they are at that level of asset management where this can be done. Many other opportunities for overcoming the funding barrier have been identified in the workshop in Rye, which can be

read in **Appendix C.** The one that was most focused upon in the discussion was adapting the way funds are used so that the quality of asset is taken more into consideration and not simply acquiring more and more funding. Funding must be spent wisely and where it is needed.

Lack of staff

According to chapter 4, this barrier is significant for the Netherlands (particularly at Rijkswaterstaat), Norway and Sweden.

At Rijkswaterstaat they now have more staff members than in the past, but improvement is happening very slowly and it is difficult to influence national decisions due to the rigid, top-down procedures. At the moment they don't have concrete solutions. The NVE in Norway proposes that Norwegian municipalities need to hire more people, especially more technical experts, but first they must acquire the right competencies to be able to hire the right people, which include recruitment staff with sufficient experience. The other countries did not propose solutions for this barrier. Swedish municipalities are in more need of climate change experts and asset management specialists, as currently there are not enough people working on these topics.

Interestingly, this barrier is not considered significant for Belgium even though the Coastal Division, the only asset management operating authority for the whole country, consists of only about six people. Despite the fact that staff numbers have been reduced over the years, they claim to still be able to manage quite well, and for them in fact, having fewer staff members is viewed as more of an opportunity than a barrier, as there is closer and open communication between them.

Opportunities to overcome

The Coastal Division in Belgium is the only asset owner that mentioned an opportunity to overcome this barrier. Mainly they believe that they have to learn to live with this and adapt to it. They have a common information server in which new staff members or old staff members who have to replace a leaving colleague can learn and update themselves on new skills. It is a time-consuming process but they say that they can manage.

Time-consuming processes

There is no asset owner, according to the results in chapter 4 that considers this barrier significant. Big projects in general require a huge investment of time, especially if they take place in an environment with a lot of people. This can especially be observed in Belgium where it is very important that all relevant stakeholders are contacted before starting a project, otherwise the Coastal Division cannot acquire a permit to build, which also results in time delays. In the Netherlands, implementation of projects take longer time than they had in the past. This is because a higher level of detail and precision is required. This should apply to all countries due to increasing amounts of uncertainty and complexity. UK does not compare to the other countries on this barrier because it seems that people within the Environment Agency (EA) do not want to spend so much time completing a project but want to see instant results. They do not accept the fact that the efficiencies they

ought to seek are long-term, because then they cannot observe instant results. Contrary to spending too much time, it can also happen that there isn't enough time to carry out a project as planned. For example, the Netherlands is experimenting with more innovative techniques and there is more uncertainty about the outcome or there is lack of knowledge about how to handle the components. A failure could suddenly occur and there would be little time to repair. In Norway, many of the projects are delayed because it takes time for the NVE to do both the design and construction stages because they are short on technical staff.

Opportunities to overcome

They did not provide explicit opportunities to overcome. The NVE in Norway came closest. They associate more staff with less time spent. In contrast, according to the municipality of Helsingborg, it would be more efficient if there was a national authority in charge of asset management decisions in Sweden. However this alone does not determine the efficiency, but also the number of staff, as mentioned earlier. As can be seen in Belgium, where there is a national asset management authority, they still have some issues with time, although not significant ones. It may be an idea to not view time consuming processes as a barrier but more like an indicator of what should be prioritized to make the process more efficient. Because no asset owner considered time to be a significant barrier for their country.

Lack of primary flood defenses

This barrier is only visible in Sweden and Norway, where the ones that are existent are also very old. It will be a long road until then, but the first step for Swedish municipalities is to improve their adaptive plan including more research into climate change scenarios, and determine the most effective way for choosing the most optimum design and measure to construct these assets. In Norway, currently the focus is on building new and resistant buildings that would be protected from floods, and since the general mindset is to live with floods, it is highly likely that they do not intend to build very many primary flood defenses, but focus instead on nature-based solutions, as has been pointed out by the respondent from NVE.

5.3.4 Cognitive barriers

Cognitive barriers seem to be the most important and frequently occurring type of barrier in most countries and also the cause of other types of barriers. The most significant cognitive barriers across all NSR countries in terms of frequency are *conservative methods* and *lack of knowledge and expertise* (table 17). These are the barriers that are elaborated in this section.

Table 17: Number of countries with each cognitive barrier

Cognitive barriers	Frequency (# of countries)	Countries
Conservative methods	5	NL, BE, DE, UK, DK
Lack of knowledge and expertise	5	NL, BE, DE, SE
Too much complexity	2	DE, NL
Lack of a long-term vision	2	BE, DK
No sense of urgency	2	NL, SE
Unclear credibility to decisions	1	NL
Lack of competence	1	NO
Lack of attention	1	NL
Wait until it fails attitude	1	DK

Conservative methods

Conservative methods is the most prevalent cognitive barrier across the NSR countries. It is shared by all except Sweden and Norway. According to the chapter 4 results, the countries that consider it a significant barrier are Germany, Denmark and the UK. At Rijkswaterstaat in the Netherlands they consider their techniques to be slightly conservative as they are a bit hesitant to adopt new techniques since different methods and technologies were used to make them, and today's existing infrastructure was built with the technologies of the 1960s and 1980s. Furthermore, the safety standards have been changed, and it is difficult for people to percept it and adapt. However, this barrier is not considered significant in the Netherlands. Life-cycle costing (LCC) is an indicator that innovative techniques are being used. The Netherlands is performing LCC the most. Before starting a project, it is obliged to calculate LCC in the Netherlands, but in Belgium, for instance, it's not, and they do not do that for every project. In UK, the operational departments of the EA are also fairly conservative, as they are unwilling to change and become more uniform. People generally cannot adapt too quickly to fast-paced technology.

Opportunities to overcome

The LSBG in Germany proposed a systems-engineering (like in the Netherlands) and holistic approach (like in Denmark). The respondents did not specify how they intend to use these approaches.

Lack of knowledge and expertise

This barrier is considered significant according to chapter 4 results in Sweden and Norway. In Sweden, the reason why they haven't yet developed a detailed asset management plan is because they do not have the technical expertise; aka the people specializing in climate change research and flood protection. Because of this they do not know which primary flood defenses would be most optimal to have, and so this is why they do not have very many primary flood defenses. It is difficult to analyze the situation in Sweden very well because of the large differences between municipalities. Some municipalities have the knowledge and others do not. In the Netherlands, the main barrier when it comes to

knowledge is determining with sufficient certainty whether the available knowledge leads to the right decision. This is difficult because acquiring precise knowledge is difficult due to the subjectivity of the people and probabilistic calculations. Although only Dutch respondents mentioned this explicitly, it likely applies to all other countries as well, but many of them have only recently begun to think long-term and have not even started to make probabilistic calculations yet. Asset owners in the Netherlands are the first to adopt a whole systems approach to combine different solutions. According to both German and Dutch respondents, the challenge when it comes to knowledge is how to preserve it for the young generation and how to attract young people to this field of work. For innovative techniques there is a lot of knowledge that is required to make it work and many asset owners are afraid to try it because they lack the knowledge.

Opportunities to overcome

During the interactive workshop the asset owners shared insights with each other regarding different possible opportunities they could take to overcome this knowledge barrier. A relevant opportunity that was discussed during the interactive workshop between asset owners is to create awareness by, for example, making a simulation of storm-surge barriers, as this would help to visualize what would actually happen in a real-life situation. Another opportunity discussed in the workshop is to create a flood website where all the knowledge related to flood risk is put all together for easy access for the asset owners.

5.3.5 Information and communication barriers

Surprisingly, information and communication barriers have not been mentioned that much during the interviews, but the most frequently mentioned ones are *unavailability of information* and *unstructured communication,* according to table 18. This finding is surprising because information and communication is among the first barriers to identify, after resource barriers, according to previous studies. *Unstructured information* will also be discussed in this section, because even though it was mentioned by fewer countries, it seems important to discuss and could be applicable to the other countries as take-away information.

Table 18: Number of countries with each information and communication barrier

Information & Communication barriers	Frequency (# of countries)	Countries
Unavailability of information	4	NL,SE, UK
Unstructured communication	3	NL, DE, DK
Unstructured information	2	NL, DE
Outdated information	2	BE, NO
Lack of transparency	1	NL
Lack of data	1	UK, NO
Abstract information	1	NL

Unavailability of information

Shared between the Netherlands, Sweden and United Kingdom. In the Netherlands, this barrier is related to the unclear *credibility to AM decisions* barrier, because there is not enough information on how some of the new primary flood defenses have been built, so it cannot be certain that the decisions made for the maintenance of those assets are the right ones. In Helsingborg municipality in Sweden they are still in the investigation phase for the primary flood defenses, so they do not have almost any primary flood defenses yet, and because of this, no information on them. In similar lines, the EA in the United Kingdom do not have information available regarding the ageing primary flood defenses, because they were built a long time ago, and thus there are no digital archives for them.

Opportunities to overcome

The NVE in Norway suggested that Norwegian municipalities should make their own central register of all the assets that they have built, just as the NVE has already done. This register should be made available to the NVE as well, so that it would be able to expand its role beyond the design and construct stage in order to better help the municipalities with the maintenance of the assets as well, which is deemed to be much more important for the long-term.

Unstructured communication

Unstructured communication refers to the communication between the two levels of strategic and operational asset management. It is significant for the Netherlands, Germany and Denmark. Usually the tactical handshake remains invisible until a crisis happens. Most asset owners agreed that it is a significant problem. The DCA from Denmark was quite explicit about this problem in their country. The two levels are not in harmony and often the operational level just runs by itself without consulting the strategic level often enough. In all countries except for Sweden and Norway, the focus is more on the operational level while the strategic level is not well-developed. In Norway and Sweden the authorities are still working to develop a long-term strategy and are far from implementing it. The Netherlands is the most advanced in terms of balancing the two levels, although asset owners need to be more consistently aware of the tactical handshake, because according to respondents from Rijkswaterstaat, it is usually only taking place during an emergency. But since the long-term plan is more precise in the Netherlands due to the risk management approach and established safety levels, it can be concluded that this is not such a big barrier as it is in the other countries.

Opportunities to overcome

According to Rijkswaterstaat in the Netherlands, the most optimum way to overcome this barrier is by improving the assessment of the performance of system and assets. To do this, more project managers and more attention at national and regional levels will be needed. The Coastal Division in Belgium proposed more holistic strategies at national level, hinting

at a whole-systems approach as that already starting to be used at the HHSK water board in the Netherlands.

Unstructured information

Unstructured information was most explicitly mentioned for the Netherlands and Germany, but this does not mean that the other countries do not or will not experience this barrier. They are probably not aware of it or have other priorities concerning the level of proactive asset management. It is significant for the Netherlands and Germany. In the Netherlands a more unified system of reporting is needed so that the information becomes easily accessible. In Germany it's the same problem of not having a consistent documentation system.

Opportunities to overcome

The HHSK in the Netherlands suggested that they should make a unified system of reporting so that all water boards have access to it, because right now all the information on all the primary flood defenses are spread out throughout the organizations. Someone needs to be assigned responsibility to filter the information and give it to the right person. Also, the geo-information system and document system need to be linked. Speaking of the geo-information and documentation system, the LSBG in Germany want to make such a system where data needed can easily be accessed. They mentioned that they hope to receive input on how to do that based on the results of the FAIR project.

5.3.6 Participation barriers

The only participation barriers mentioned are *public dilemma* and *engagement with stakeholders*.

Table 19: Number of countries with each participation barrier

Participation barriers	Frequency (# of countries)	Countries
Public dilemma	4	NL, BE, DE, SE
Lack of stakeholder engagement	2	BE, UK

Public dilemma

The downside of the Scandinavian democratic system is that the people protest more due to their unlimited liberty. Public dilemma is most relevant for the Coastal Division in Belgium and the HHSK in the Netherlands. A balance is needed between authority and freedom of expression. In the Netherlands and Belgium the operational authorities hire landscape architects to satisfy the people's aesthetic desires. In Hamburg, Germany, the problem is when the people are asked to sell their land to be used for flood protection, otherwise they understand why primary flood defenses have to be built. The people also protest when their view of the sea is blocked by highly built flood gates.

Opportunities to overcome

At HHSK they have already started hiring landscape architects to help reduce public protests and it thus far appears to have effect, although it does not eliminate the complaints entirely. The Coastal Division in Belgium also hires landscape architects, but the people living on the coast have to pay for them themselves, as it is considered an extra outside of the project budget established at the start. Another opportunity the Coastal Division have begun following is to share and explain the design plan to the public and involve them in earlier stages of the decision-making progress. Even though this may be time-consuming in the short-term, it has an added value for the long-term as it prepares the people better for future major floods.

Lack of stakeholder engagement

In Belgium this barrier is a cause for the time delays of projects, but it's a trade-off that must be made. The difficult thing for them is to get everyone on the same line and to have everyone agree with the plans of the MDK. In the Netherlands the water boards and Rijkswaterstaat make an effort to involve as many stakeholders as possible in their plans including NGOs, but it's also possible to involve people too much that it interferes with the implementation of projects too much. Compared to the Scandinavian countries, Belgium and the Netherlands have more rigid procedures and have to make a conscious effort to engage stakeholders in the decision-making process as much as possible.

Opportunities to overcome

The Coastal Division in Belgium noted that it is important to involve all stakeholders and shareholders early on, in order to acquire a building permit. In UK, the EA would like to form more external partnerships, with universities for instance, in order to help spread the knowledge and awareness of flood management, especially to the younger generation. During the interactive workshop (Appendix C), the asset owners suggested to do a stakeholder analysis before a project starts, by engaging stakeholders to find a solution together to move towards a proactive asset management approach. The fact that all the asset owners agree on engaging stakeholder is a positive sign, because it means that more governance is desirable (involving different types of stakeholders) to facilitate the implementation of proactive asset management.

5.3.7 Conclusion

Overall, the results show that there are both similarities and differences between countries when it comes to their asset management and that the national context plays a large part. Different countries consider different barriers significant, that other countries might not deem significant at all, or might even view them as an opportunity, as was observed with the *lack of staff* in Belgium. It was important to compare countries because in order to see how the asset management strategies differ between countries and why, to discern what proactive asset management means for each country, and to identify the barriers they are currently facing towards improving their strategies, as well as the opportunities they are considering to apply in overcoming those barriers.

6. Discussion and Reflection

In part 1 chapter the empirical comparison and their implications are discussed in light of the theoretical background introduced in chapter 2. The goal of the discussion is to identify in what ways the empirical results differ from theory and how they can contribute to theory. This is done first for the asset management strategies and then for the governance barriers. For the governance barriers any barriers that have emerged from practice are briefly discussed in light of their contribution to the literature on governance barriers and asset management that contains discussion of barriers. The second part of the chapter is a reflection on the research methodology, limitations, and implications for theory and policy.

6.1 Discussion

6.1.1 Asset Management Strategies

In this section the asset management strategies are examined holistically, and not looking at each stage in part, as has been done in chapters 4 and 5. In line with Gersonius et al. (2015), this thesis contributes to the claim that more strategic planning is needed, which should take the uncertain and changing nature of floods into account as "future conditions may change from those that currently exist" (Gersonius et al., 2015: pg. 16). For the context of the NSR countries, the proactive AM framework has demonstrated to be instrumental for the asset owners in better understanding how the two levels of AM are interlinked and how they are supposed to communicate with each other. Moreover, this framework aimed to help them understand why long-term planning is necessary and get them to reflect on how this framework could be useful to them in their country, considering their national contexts and what they want to achieve in their current AM strategies. The application of this framework to the NSR context has demonstrated that this framework can be well-implemented via inter-country collaboration, so that they can share best practices and together create a much more practical framework. The comparison of the strategic level across countries has demonstrated that each country is at a different stage of implementation of AM.

The following sub-sections reflect on the guidelines of the proactive asset management framework presented in table 3 in chapter 2, and how they emerged in practice.

Strategic level

According to the asset management literature, a *risk-based approach* is the very definition of proactive asset management (Gersonius et al., 2015; Sayers et al., 2002). The HHSK water board in the Netherlands refers to it as a 'whole-systems approach' because it takes into account other elements in the environment, for example tourism and the landscape. It is a holistic approach for dealing with risks. This *risk-based approach* originates in stage 3 of the proactive asset management framework, which is about choosing measures for the network, to be identified up until 2050 (medium term). The proactive asset management framework is based off the Dutch Adaptive Delta Management (ADM) model and also the British sound flood risk management model that was discussed in chapter 2 (Sayers et al., 2002). According to Sayers et al. (2002), the United Kingdom is evolving from a

traditional, reactive strategy based on design standards for the primary flood defenses to a risk-based, towards proactive strategy that takes into account many other factors. The risk-based approach is now being adopted in all areas of the United Kingdom, but according to the English scientific team. The UK still has a long way to go before it fully adopts it. Results show that thus far, only the Netherlands, Belgium and the United Kingdom are employing a risk-based approach, but even they claim they can refine it and improve it further by applying it to other contexts. Unfortunately, there is currently very little data on the British current asset management strategy aside from what could be discerned from the questionnaire, that being because the Environment Agency (EA) is not a FAIR project partner, so they had no obligation to provide the data. In the Netherlands, the Delta Programme has developed the ADM framework in such a way as to be flexible and robust. However, thus far this framework has only been applied to the Island of Dordrecht, and in order to guarantee its validity it is necessary to apply it to other contexts.

According to the literature (Sayers et al., 2015; Haasnoot et al., 2012), coming up with *safety standards* and design criteria for the network of primary flood defenses is also very important for the strategic level. It takes place in stage 2 of the proactive AM framework. Here it is important that a leading authority sets the legal safety standards for the primary flood defenses (Willows and Connells, 2003). The NSR countries differ quite a lot on this because of their different national contexts and different patterns of allocations of responsibilities. Germany's federal states each have their own *safety standards,* and Sweden and Norway also due to highly varied external factors, and so different priorities have to be set for different regions. These countries can be compared further because in Germany having different safety standards is not considered to be a very big problem unless there are many disagreements between federal states, rendering the implementation process inefficient. As for Norway, it is not possible to have the same safety standards because the level of flood risk differs throughout the country and areas to build should also be prioritized in accordance with the population distribution, because in those areas where population is scarce people should just learn to live with floods. In Sweden it's a different matter because it has not yet reached the operational level of its AM. Moreover, Sweden does not have a leading asset management authority, although the municipalities would like to have. The proactive AM framework may serve as an appropriate guide for Sweden on this matter. Sweden is interesting because it has more of a top-down approach, starting first with the strategic level and moving down to the operational level. Regarding the long-term adaptive plan, all countries have at least a partially completed plan with the exception of Denmark, which is just starting to develop a strategic level of AM.

Tactical handshake

The tactical handshake, as is explained in chapter 3, is supposed to facilitate implementation of AM by maintaining proactive communication between the strategic level and the operational level. According to Van der Velde (2013), the asset manager is responsible to relay information from the strategic level to the operational level and then report back to the strategic level. The HHSK water board in the Netherlands has reported that they plan to include the asset manager earlier in the decision-making process so that he or she is aware on time about the requirements for design and safety, and also has enough time to share his or her own opinion. As has been mentioned in chapter 5, the Netherlands is considered a forerunner in asset management implementation and many opportunities mentioned by Rijkswaterstaat and the HHSK could also be applicable to the other countries. This example comes to show that, empirically, the Netherlands is already attempting to pragmatically implement the tactical handshake, thus closing the gap further

between theory and practice. It is a recurring pattern across the NSR countries not to have a developed tactical handshake. Denmark appears to be the most extreme example, because, as a respondent claimed, there is almost no communication between the strategic and operational levels. This is because in Denmark, on the west coast, the focus is on short-term plans and the operation of individual sluices. A conclusion that is drawn from the results is that the presence of long-term planning at the strategic level contributes to the strength of the tactical handshake. However, this observation is not found in the literature. In fact, not much is explicitly mentioned in the literature regarding the tactical handshake.

Operational level

According to the literature, the process of *selecting the best measure* for implementation is crucial, and various factors that take different elements in the environment into account need to be considered to make sure that the right decisions are made. Life-cycle costing (LCC) and Cost-benefit-analysis (CBA) are recommended in order to choose the right approach, but are not mandatory (Van der Velde, 2013). The first stage of the operational level is to identify all the possible measures for the individual primary flood defenses and then select the most cost-effective solution. The *innovative techniques* are supposed to be a solution for this cost-effectiveness problem (Van der Velde, 2013; Sayers et al., 2012). The reason why many asset owners hesitate to invest in it is because it is expensive in the short-term and the long-term is highly uncertain. There is also lack of knowledgeZ on the performance of innovative techniques due to this long-term uncertainty (Gersonius et al., 2015). This is why it is difficult to follow a *risk-based approach*, as explained for the strategic level.

Most countries have the operational level well put in place, but because the strategic level is not that developed yet, it could be optimized much more. Being able to perform them requires sufficient funding and knowledge, and not all NSR countries can prioritize these right now. Also, LCC is not appropriate in all contexts, for example the NVE in Norway does not believe LCC is necessary, because it is already employing advanced CBA. It is yet to be determined whether LCC will be a useful resource to Norway or not.

6.1.2 Governance Barriers

The governance barriers literature was introduced in chapter 3 from which five categories of barriers were derived that could potentially encompass a wide-range of specific governance barriers. It is important to recall that governance barriers have been investigated because they are specific barriers to implementation and that is where the added value of this research lies: what are the governing barriers that are preventing policy (in this case asset management) to be implemented in a proactive and sustainable way. A lot of connections can be made between the identified governance barriers and the steps of asset management in which they take place, how they are manifested, and opportunities for overcoming them. Particularly regarding the opportunities for overcoming them, there are many lessons learnt from the empirical results, but also from theory.

An interesting observation from practice is that barriers are cross-cutting across different categories of barriers, and this is perhaps a contribution that can be made to theory. In addition, some barriers do not directly seem to fit within the chosen categories and instead appear to be specific for a country only. However, they have been placed within the most appropriate categories in order to be able to compare them with other countries.

In the following paragraphs each barrier category is briefly discussed and the empirical results compared to the literature.

Institutional

According to Sayers et al. (2014), to be effective, AM strategies must be implemented across different sectors of society, from national to regional to local. All sectors must be integrated and the responsibilities of stakeholders divided equally.

Many good plans have failed due to the *lack of clear roles and responsibilities*, according to the literature. Appropriate division of roles and responsibilities are precisely what should bridge the gap between science, policy and implementation. The lack of clear roles and responsibilities is an important barrier discussed in the literature. Rule # 7 from Sayers et al. (2014) directly addresses unclear division of roles and responsibilities. It says: "be clear on responsibilities for governance and action". The empirical results of this thesis show that the lack of clear roles and responsibilities is a significant and common barrier for many of the NSR countries. It was described by asset owners in all seven NSR countries and appears to be the most significant for Sweden because there the national level does not carry any AM responsibility, which defies the rule from theory suggesting there should be a leading asset management authority (Willows and Connells, 2003). This may partly explain why in Sweden it is very difficult to implement their asset management plans, since only the municipalities are responsible for developing long-term strategy, to acquire funding, to collect all the asset information and data, and the fact that there is no leading national asset management authority makes it that much more difficult to implement policy, because it is not uniform throughout the whole country. Interestingly enough, the LSBG in Hamburg, Germany, didn't mention anything about unclear roles and responsibilities, since asset management policies differ across federal states there as well. However, they do discuss *conflicts of interest* which also springs from this lack of uniformity. On the other end, the Netherlands has very clearly defined roles and responsibilities because of its hierarchical governance system for AM. This may be why policy is implemented more efficiently there than in other countries.

The *lack of political will* is another popular barrier from theory. There has been political resistance against keeping options for measures open. This can be due to several reasons (Gersonius et al., 2015): (1) It is often unclear to decision-makers whether the options are realistic and whether they will be realized; (2) keeping options open can put constraints on available land; (3) most decision-makers have the desire and habit to take decisions for visible short-term actions rather than focusing on future action for the long-term. In practice, this barrier is shared between Belgium and UK. In Belgium politicians base their decisions and prioritize asset management issues for primary flood defenses in function of whether the people are happy or not, so in terms of their reputation. In the United Kingdom it is the same. Politics is short-term and if politicians feel that their reputation is challenged because of public complaints, they can remove primary flood defenses that are considered by the public to cause disruption or prevent construction of new ones. During the workshop, the asset owners agreed that less-dependence on politics to comply with AM policy would be a solution. This opportunity would also possibly be useful for the Netherlands which has the *rigid procedures* barrier, but again, may be difficult to adopt. The *lack of enforcement* barrier is similar to the *lack of political will* and is shared between Sweden and Denmark. However, no description of it was found in the literature.

Lastly, the *loss of warranty barrier* is only visible at LSBG in Germany (see **Appendix B.4** for a brief explanation). No information was provided in the literature regarding this barrier.

Some new barriers emerged in practice that were not found in the literature. These are: *lack of enforcement*, *lack of EU certification* and *loss of warranty. The institutional void* barrier was mentioned in the literature but not explicitly in practice. However, Sweden could be considered to come closest to this *institutional void*, in that it does not have a leading asset management authority or a national authority in charge of asset management. In Sweden it is definitely considered a barrier, but in other countries, the Netherlands for example, it would be considered an opportunity to overcome the rigid procedures at the level of the Ministry. It was even mentioned during the interactive workshop that gaining an independence from politics may prove beneficial (**See Appendix C**). The *institutional crowdedness* barrier on the other hand, was observed in the Netherlands with a plethora of actors and institutions which can impede decision-making. This is a cause of the *rigid procedures* barrier outlined in practice. Overall, these emerging barriers could contribute to the literature on governance barriers by showing that there are many more barriers that exist in different contexts, which contributes to validating what Biesbroek (2014) affirmed that it is difficult to make on generalizable analytical framework for governance barriers to adaptation.

Table 20: Comparing theoretical and practical institutional barriers

Barriers from literature	Barriers from practice
- Institutional void - Fragmentation - Ineffective leadership - Lack of clear roles and responsibilities - Lack of political will	- Conflicts of interest - Inequality - Unclear division of - responsibilities and ownership - Lack of enforcement - Lack of EU certification - Lack of political will - Rigid procedures - Loss of warranty

Resources

In the literature, resource barriers are considered to be a main cause for lack of policy implementation (Ekstrom and Moser, 2010). Financial resources have been discussed the most in the literature as being among the most important barrier to implementation, because without money other necessary resources including knowledge and staff would not be affordable to make a project happen. In recent literature a desire to minimize investments is discussed, but also that because of the ongoing economic crisis, there will be less funding for AM (Gersonius et al., 2015). Indeed, the results of this thesis show that all seven NSR countries mentioned funding barriers. However, all asset owners agree that more funding is not the solution necessarily, at least not a sustainable solution. Rather the way it is spent and distributed, and the way the funding roles are allocated, is a determining factor for the effectiveness of funding in carrying a project to its completion and desired outcomes. According to Gersonius et al. (2015), there is also a risk of over and under-investment which must be prevented. Over-investment occurs when more funding is accumulated at the start of a project than needed, and then it is more difficult to finish the project on time, because all the funding has to be spent. In practice this occurs in Norway, as explained by

the NVE. In Norway, this over-investment results is a time-consuming process. Under-investment is when too little funding is provided at the start of a project because of some unforeseen future events and if it is a huge-investment project it cannot be completed without additional funding. Belgium is a good example of this, as it sometimes happens that the Coastal Division must complete a major project but receive too little funding for it in the beginning.

The lack of technical staff is another important resource barrier that is described in the literature and supported by the empirical results. The literature also mentions lack of space to build as an important resource barrier (Sayers et al., 2013; Gersonius et al., 2015; Sayers et al., 2002), due to intensive land use in very little space and increasing coastal urbanization. However, empirically, this was not frequently mentioned by the NSR countries, as it cannot be avoided. The only problem with this barrier is that it often leads to public protests.

There was no barrier mentioned in the literature regarding *LCC calculation tool*, only that LCC calculations are beneficial to adopt in order to improve cost-effectiveness of constructing and maintaining primary flood defenses (Van der Velde, 2013). All the other barriers mentioned in the literature review have also emerged in practice.

Table 21: Comparing theoretical and practical resource barriers

Barriers from literature	Barriers from practice
- Lack of funding - Lack of staff - Lack of time - Lack of space	- Funding and rising costs - Time-consuming processes - Lack of staff - Lack of space - No LCC calculation tool

Cognitive

According to the literature, cognitive barriers are the core barriers that prevents real transformation from taking place, because it is said that change first begins in the mind (Shu and Bazerman, 2010). Interestingly, the cognitive barriers are the most frequently identified in this research and many of them are also considered significant for some asset owners. Gersonius et al. (2015) explains that lack of knowledge is a main barrier to adopting a risk-based approach, which prevents a proactive asset management from taking place at the strategic level. According to Gersonius et al. (2015), the focus of decision-making on the status quo combined with risk and uncertainty aversion can be a barrier to the development of a proactive AM strategy. Interestingly, the *lack of knowledge* and *conservative methods* are the most frequently occurring cognitive barriers in the NSR countries. The *wait until it fails attitude* barrier that emerged in practice can be considered to be similar to *conservative methods*. According to table 17 in chapter 5, *conservative methods* and *lack of knowledge* occur in five of the NSR countries. *Conservative methods* is the main reason why countries like Germany and Denmark do not follow a risk-based approach at the strategic level. On the operational level the effect seems to be different, as was observed in the United Kingdom. It has been determined that the UK follows a risk-based approach, however one of the barriers present in the EA is in fact *conservative methods*. However, this barrier is found at the operational level in the UK and is responsible for fragmentation between the various departments. It can be speculated that this prevents

a full risk-based approach from taking place, as respondents from the EA have claimed that staff members are afraid to take risks because they want to see immediate short-term results. However, this is something that needs to be investigated further.

Several new barriers emerged in practice that were not mentioned in the theory. These are *lack of competence*, *too much complexity*, *and wait until it fails attitude*, and *lack of long-term vision*. However, *wait until it fails attitude* is similar to *conservative methods*, and *lack of long-term vision* is mentioned implicitly. These emerging barriers occurred in only two countries with the exception of *lack of competence*, which only occurred in Sweden. These emerging barriers are likely not found in the literature on governance barriers because they emerged in the context of asset management specifically. This indicates that different governance barriers emerge in different policy situations. These barriers were also not explicitly discussed in the asset management literature because mostly the significant and frequently occurring barriers to proactive asset management were discussed, *conservative methods* among them.

Table 22: Comparing theoretical and practical cognitive barriers

Barriers from literature	Barriers from practice
- Lack of knowledge and expertise - Willingness to change - Conservative methods - Lack of attention - No sense of urgency - Unclear credibility to decision-making	- Conservative methods - Lack of knowledge and expertise - Too much complexity - Lack of a long-term vision - No sense of urgency - Unclear credibility to decisions - Lack of competence - Lack of attention - Wait until it fails attitude

Information and communication

This category of barriers refers both to information and data regarding the primary flood defenses and also to the communication between the strategic and operational levels and across different disciplines. According to Biesbroek (2014), communication refers also to that between science and policy which can lead to lack of awareness, skepticism and denial (all cognitive barriers). Lack of awareness is the only result observed in this thesis out of these three. Information and communication barriers can be considered crucial barriers that prevent implementation of policy next to cognitive barriers. This affirmation could challenge the claim by Ekstrom and Moser (2010) that resource barriers are the first to be acknowledged. Perhaps funding is among the first to be mentioned, and it definitely was in this thesis study, but it was also noticed during the interview process that as asset owners began to elaborate more on other barriers rather than just funding, they begun to go in more depth regarding information and communication barriers.

Abstract information, *lack of transparency* and *outdated information* are barriers that emerged in practice and were not identified in neither the governance nor the asset

management literature. This is likely because these barriers were also not considered significant by any asset owner and were also not frequent across the NSR countries.

Table 23: Comparing theoretical and practical information & communication barriers

Barriers from literature	Barriers from practice
- Lack of available data - Lack of information on assets - Lack of communication between stakeholders	- Unavailability of information - Unstructured communication - Unstructured information - Outdated information - Lack of transparency - Lack of data - Abstract information

Participation

Sayers et al. (2014) suggest to encourage more stakeholder participation in the decision-making process because the public are directly impacted by the AM decisions made on their behalf which aim to protect them from flooding. Thus it makes sense that they should be involved more in the decision-making. Some NSR countries have more public participation than others. For example, in the Netherlands NGOs are involved, and according to the roles and responsibilities tables in **Appendix B.2**, no other country has NGOs involved in the decision-making, or private landowners for that matter. Denmark is an exception, because there the private landowners are the asset owners. The DCA asset owner in Denmark only owns one sluice. There are sluice boards and the private landowners are involved. The NVE in Norway proposed that private landowners should be involved alongside municipalities to help with the operation of the primary flood defenses. The problem with public participation, determined empirically, is that if people are involved too much they start to complain and make difficult demands. The opposite also happens, so a middle-way is needed, a balance between too little and too much public involvement. As mentioned under the resource barriers, public dilemmas often occur due to lack of space in intensely used industrial areas. In Belgium, for instance, having such a short coastline, the tourist industry is affected by the construction of sea walls. Innovative solutions such as multi-functional sea walls with an aesthetic touch are often useful in mitigating public protests.

Lack of collaborative governance was not identified empirically and public dilemma was not identified in the literature. Usually the governance and asset management literature mention *lack of public involvement* and *public dilemma* as the main participation barriers, and this was backed up empirically in this thesis.

Table 22: Comparing theoretical and practical participation barriers

Barriers from literature	Barriers from practice
- Lack of collaborative governance - Lack of public involvement	- Public dilemma - Lack of stakeholder engagement

6.2 Reflection

6.2.1 Credibility of the research

Regarding the research methodology more specifically, the results were validated by sending key notes to the interviewees and asking them to make any necessary corrections or additions. Most of the interviewees have replied back with useful information and suggestions which have afterwards been incorporated into the analysis. Moreover, I have had the opportunity to share my results with the scientific team which has also provided solid feedback. The validity was overall addressed sufficiently, but the reliability could have been addressed better. This research was performed only in the North Sea context, and the results of this research cannot be generalized to other regions or countries that border various coastlines. Therefore there is no way that the reliability can be confirmed unless future research uses this same proactive asset management and analytical framework to other conflict areas, and afterwards the results would need to be compared. Regarding the interviews more specifically, more questions regarding the specific examples of barriers from the literature could have been asked, as well as the current asset management strategies in order to fill in the blanks from the questionnaires.

For the analysis, relationship between barriers was touched upon, however this could have been explored in further detail by looking at which barriers might be the cause of other barriers and why. Furthermore, determining how a barrier came about would also be interesting, to know more about how to prevent it, rather than just overcoming it.

6.2.2 Limitations

There are several key limitations of this research. The first is that it is not known to what extent this research is generalizable to other contexts. Only one or two asset owners at most have been researched, with only a maximum of three interviewees per asset owner organizations. During the interviews the respondents mainly described the barriers that take place in their specific organizations and only sometimes generalizing to the rest of the country. The same can be said about the questionnaires and current asset management strategies, although, for the most part, the current asset management strategies presented in **Appendix A** represent the national level, with a few exceptions. The proactive asset management framework introduced in chapter 2 has not yet been tested on the NSR countries, only proposed. It remains to be seen whether it could actually serve as a benchmark in practice.

Furthermore, it may be useful to complement this research and pursue additional lines of inquiry with regards to the research question posed in this thesis by means of other research analytical lenses, including for example perspectives on governance with relation to resilience (Rijke et al., 2013) and critical political ecological perspectives (e.g. Swyngedouw, 2015). Also the analytical lenses for governance barriers articulated by Biesbroek (2013, 2014) could prove insightful. These perspectives are deemed crucial areas for further research as barriers, as articulated by theoretical scholarship and incumbent governmental actors and thus need to be critically reflected upon in a constructive manner.

6.2.3 Implications for Theory

The derived proactive asset management framework introduced in chapter 2 was intended to be flexible and robust, and not fitted to one particular context. Each NSR should, then ultimately be able to apply it to their own situation, and use it as a benchmark to evaluate their current asset management strategies and figure out what can be done in order to optimize them and inch closer to a full proactive strategy. As mentioned in chapter 2 and 3, the asset owners also contributed to designing the framework, but it was still very much based on the Dutch and British models introduced in the literature. The empirical results show that each country is at a different stage of asset management implementation, and also each country implements asset management differently, depending on its national context, external factors such as climate change, and also the general cultural climate of each country. Therefore, it is difficult to prescribe one guideline of asset management that all North Sea Region (NSR) countries should follow.

6.2.4 Implications for Policy

In the introduction the contribution of this thesis to policy was briefly explained. Now that the empirical part of the research is completed, more can be said about the actual added value of this research to theory and to policy. The aim of this thesis is to contribute to helping the asset owners in all seven North Sea Region countries improve their asset management strategies for their primary flood defenses, by identifying the governance barriers that they face in the implementation process. Recent governance literature was consulted for this in order to place the empirical results in a scientific context. The principal added value of this research lies in bridging the gap between theory and practice, which is very important. Academic research tends to remain in the theoretical realm, and practitioners are too keen on achieving desired short-term results as quickly as possible. Theory is supposed to give a glimpse into the future, and to help practitioners take the long-term into account in their short-term strategies. By investigating the governance barriers and challenging the asset owners to think of possible practical opportunities for how to overcome these barriers, they are helped to create their own practical asset management framework, so to speak.

7. Conclusions and Recommendations for Future Research

The main aim of this thesis has been to identify the significant governance barriers to proactive asset management implementation faced by asset owners in each of the seven North Sea Region (NSR) countries: the Netherlands, Belgium, Germany, United Kingdom, Denmark, Sweden and Norway. In order to do this, the specific case study of each asset owner was introduced which provides hints as to the external factors. Then the national context consisting of the roles and responsibilities, as well as relevant policies and plans were introduced for each country. Afterwards, the current asset management strategies of each country were discussed, in order to set the context for the research on governance barriers. This chapter provides a conclusion to the thesis and possible recommendations for future research.

7.1 Conclusions

The central research question that this thesis sought to answer is:

What are the significant governance barriers that asset owners in the North Sea Region face to proactive asset management implementation for primary flood defenses and what are practical opportunities to overcome them?

This question has been addressed indirectly throughout the research with the help of 6 sub-questions. Some of these sub-questions are conceptual and are answered in chapter 2 when discussing the literature. The rest of the sub-questions are empirical and have been addressed in chapter 4 for each asset owner in each of the seven North Sea Region country and then in comparison between countries in chapter 5. The answers to these sub-questions are summarized below.

1. *What is proactive asset management for primary flood defenses?*

The literature review in chapter has provided a definition of what is meant with proactive asset management. The framework that was derived was meant to be a guideline for the NSR countries to improve their current asset management strategies. However, the empirical results show that each country views proactive asset management slightly different, and not everything that is done in one country can necessarily be applied in another. The proactive asset management framework derived in chapter 2 is mostly based on the Dutch and British literature, whose current strategies are in line with what is being said in the literature. However it would be biased to claim that the Dutch strategy is the one to be followed. Instead, asset owners from the other countries should study the Dutch strategy in an objective way as to determine which aspects would apply and which ones would not.

2. *What is the national context of each NSR country?*

The national context has been determined empirically by analyzing secondary data in the form of a questionnaire. The comparison shows that there are many similarities between countries regarding the distribution of roles and responsibilities and policies and plans for asset management, but despite the close geographic and cultural proximity of these countries, there are also wide differences. The countries can be grouped based on certain characteristics. Sweden, Denmark and Norway can be grouped together because they are all Scandinavian countries and thus share similar democratic political systems. However, even they have differences. Each NSR country experiences the barriers differently, despite many similarities. Sweden has absolutely no asset management authority at national level, only representatives at regional level, due to the self-governance system of the municipalities. In Norway the municipalities are also autonomous, but the NVE is an operating asset management authority at national level, similar to Rijkswaterstaat in the Netherlands. Thus there are many links and intricate connections between countries with different cultures and political systems, and differences exist between countries which are otherwise very similar.

3. *What is the current asset management strategy for primary flood defenses in each country of the North Sea Region?*

As mentioned in answer to the first research question, each NSR country has slightly different asset management strategies. Moreover, they are in different stages of implementation. With the exception of Norway and Sweden, all the other countries are focused on the operational level. The Netherlands is a good example of what needs to be done at the strategic level regarding the development of a long-term perspective, adopting a risk-based approach and a whole-systems perspective. It is followed closely by Belgium, which imitates the Dutch strategy and the UK which is also focusing on fully implementing a risk-based approach.

4. *What are governance barriers and which governance barriers to proactive asset management for primary flood defenses have been identified in the asset management literature?*

The governance literature outlines different types of governance barriers to adaptation and asset management implementation specifically, and from this literature five categories of barriers have been derived. In the literature governance barriers have been defined as those which inhibit or slow down the process of policy implementation. Empirical results fitted well within this framework and no barriers were found that belong to a different category other than the ones used in this framework. Even many of the specific barriers were similar to the ones identified in the literature. This was because the asset owners were specifically asked whether they experienced some of the barriers identified in the literature. However, there were also some additional barriers which the asset owners have identified of their own accord but which were not also identified in the literature. Examples are lack of primary flood defenses and loss of warranty. The former was identified in Sweden and Norway; while the latter was identified in Germany.

5. *Which governance barriers are significant for the asset owners to overcome in order to implement proactive asset management for primary flood defenses?*

This question was answered in chapter 4 in which the significant barriers for each country were described, along with a visual portrayal showing in which stage of asset management the barriers occur. Patterns in frequency and significance of barriers was analyzed across the seven NSR countries in chapter 5.

6. *What ideas do the asset owners have for overcoming the significant governance barriers?*

The NSR countries had very many similar barriers but they manifested differently, affecting different stages of asset management, and more importantly, the barriers had different relevance for each country. For some it was a priority to overcome, for others not.

In conclusion, to answer the first part of the central research question, an interesting observation made here is that not all North Sea Region countries consider the same governance barriers to be relevant. To answer the second part of the central research question, the asset owners have been asked during the interview whether they had any idea for how to overcome their significant barriers. During the workshop opportunities were elaborated upon further with the asset owners sharing insights with each other. This shows that one visible benefit of this Interreg project and the identification of barriers part in particular, was that the asset owners really did collaborate and share insights with each other. It is possible that many of the opportunities can be applicable to all or at least most of the countries, but this can only be speculated in this thesis; it cannot be known for sure without actual interventions in practice. As a recap, some of the main opportunities to overcome that were identified include adopting a systems-engineering approach in order to improve communication between the strategic and operational asset management levels, doing life-cycle costing (LCC) calculations in order select the most cost-effective measure, and communicating clearly with the public in order to reduce public protests. Future research could investigate further how these specific opportunities to overcome can be translated into practical interventions.

7.2 Recommendations for future research

According to Biesbroek (2013), opportunities to overcome barriers have not been covered extensively in empirical research. This thesis has tried to also investigate the possible opportunities that the asset owners could take by asking them to think about it, and by engaging them in a workshop in which they had the chance to share ideas with each other. However, the investigation of these opportunities has not been completed, and it should be taken one step further by researching in more depth the relationship between the opportunities identified and corresponding barriers and asset management steps. The question that future research should ask is *how* the opportunities mentioned can be translated into action for intervention. This could be done by adjusting the proactive AM framework using the results of this thesis and possibly by creating a framework for opportunities.
Future research should apply this analytical framework for barriers and the ideal proactive asset management framework in other contexts by investigating other types of stakeholders such as the ones mentioned in the national context description, other regions and even other

types of assets. Afterwards, the results of those studies should be compared with the results of this thesis in order to confirm or disprove the frameworks and make suggestions for improvement.

Lastly, as mentioned under reflection, the investigation of complementary approaches for adaptation such as political ecology and resilience could prove fruitful for future research. Governance can be viewed from a variety of different analytical lenses, and to be able to increase the validity of the research, a plethora of these would have to be investigated in different studies to inch closer to a common analytical framework for governance barriers.

References

Adger, W. N., S. Agrawala, M. Mirza, C. Conde, K. O'Brien, J, Pulhin, R. Pulwarty, B. Smit, and K. Takahashi. (2007). *Assessment of adaptation practices, options, constraints and capacity.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

Biermann, F. (2014). *Earth System Governance. World Politics in the Anthropocene.* The MIT Press.

Biesbroek, G.R., Swart, R.J., Van der knap, W.G.M. (2009). The mitigation-adaptation dichotomy and the role of spatial planning. *Habitat International, Vol.33, 230-237*.

Biesbroek, G.R., Klostermann, J.E.M., Termeer, C.J.A.M., and Kabat, P. (2013). On the nature of barriers to climate change adaptation. *Regional Environmental Change, Vol.13, 1119-1129.*

Biesbroek, G.R. (2014). Challenging Barriers in the Governance of Climate Change Adaptation. *Wageningen University.*

CIRIA (2013). *The International Levee Handbook.* CIRIA, Griffin Court, London, UK.

De Klerk, W.J., and Den Heijer, F. (2016). *Deltares, Delft, Netherlands.*

Ekstrom, Julia A., Susanne C. Moser, and Margaret Torn. (2010). *Barriers to Climate Change Adaptation: A Diagnostic Framework.* California Energy Commission. Publication Number: CEC-500-2011-004.

Eriksen, S., and Lind, J. (2009). Adaptation as a political process: adjusting to drought and conflict in Kenya's drylands. *Environmental Management, Vol.43, No.5, 817-35.*

Fabricius, C., and Currie, B. (2015). *Ch. 9 Adaptive Co-Management from Adaptive Management of Social-Ecological Systems*. Springer.

Gersonius, B. (2012). The resilience approach to climate adaptation applied for flood risk. *CRC Press/Balkema.*

Gersonius, B., Rijke, J., Ashley, R., Bloemen, P., Kelder, E., and Zevenbergen, C. (2015). Adaptive Delta Management for flood risk and resilience in Dordrecht, The Netherlands. *Journal of Natural Hazards.*

Gilroy, K. Ray, P., Kucharski, J., Haasnoot, M., Ollszweski, J., Brown, C., Olsen, R., Stakhiv, E., and Mauroner, A. (2015). Water Resources Planning and Design for Future Uncertainties. Collaborative Risk Informed Decision Analysis (CRIDA). *ICIWaRM Publication.*

Hamin, E.M., Gurran, N., and Emlinger, A.M. (2014). Barriers to Municipal Climate Adaptation: Examples from Coastal Massachussets' Smaller Cities and Towns. *Journal of the American Planning Association, Vol.80, No.2, 110-122.*

Haasnoot, M., Kwakkel, J.H., Walker, W.E., and Maat, J.T. (2012). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Global Environmental Change (23), pg.485-498.*

Haasnoot, M., Walker, W.E., and Kwakkel, J.H. (2013). Adapt or Perish: A Review of Planning Approaches for Adaptation under Deep Uncertainty. *Sustainability, Vol.5, 955-979.*

Herk, S. (2014). Delivering Integrated Flood Risk Management. Governance for collaboration, learning and adaptation. *CRC Press/Balkema.*

Interreg North Sea Region Programme. (2016). Flood infrastructure Asset management and investment in Renovation, adaptation, optimization, and maintenance-FAIR. Action Plan.

Klerk, W.J., and Den Heijer, F. (2016). A framework for life-cycle management of public infrastructure. *Deltares, Delft, the Netherlands.*

Klijn F., and Schweckendiek, T. (2013). *Comprehensive Flood Risk Management. Research for Policy and Practice.* Taylor & Francis Group.

Klijn, F., Kreibisch, H., de Moel, H., and Penning-Rowsell, E. (2015). Adaptive flood risk management planning based on a comprehensive flood risk conceptualization. *Mitigation Adaptation Strategy Global Change (20), pg. 845-864.* DOI 10.1007/s11027-015-9638-z.

OECD (2015). Towards a Framework for the Governance of Infrastructure. *Directorate for Public Governance and Territorial Development.*

Oonk-Abrahams, N. (2015). Project Applications: Flood Infrastructure Asset Management and Investment in Renovation, Adaptation and Maintenance. *Rijkswaterstaat.*

Rijke, J., Brown, R., Zevenbergen, C., Ashley, R., Farrelly, M., Morison, P., Van Herk, S. (2012). Fit-for-purpose governance: A framework to make adaptive governance operational. *Environmental Science & Policy, Vol.22, 73-84.*

Rijke, J., Farrelly, M., Brown, R., Zevenbergen, C. (2013). Configuring transformative governance to enhance resilient urban water systems. *Environmental Science Policy, Vol.25, 62-72.*

Runhaar, H., Mees, H., Wardekker, A., Sluijs, J., and Driessen, P. (2012). Adaptation to climate change-related risks in Dutch urban areas: stimuli and barriers. *Regional Environmental Change, Vol. 12, 777-790.*

Sayers, P.B., Hall, J.W., and Meadowcroft, I.C. (2002). Towards risk-based flood hazard management in the UK. *Civil Engineering 150, paper 12803, 36-42.*

Sayers, P., Galloway, G., Penning-Rowsell, E., Yuanyuan, L., Fuxin, S., Yiwei, C., Kang, W., Le Quesne, T., Wang, L., and Guan, Y. (2014). Strategic flood management: ten 'golden rules' to guide a sound approach. *International Journal of River Basin Management.*

Schanze, J. (2006). Flood Risk Management-A Basic Framework. *Flood Risk Management: Hazards, Vulnerability and Mitigation Measures, 1-20.*

Shu, L.L., and Bazerman, M.H. Cognitive Barriers to Environmental Action: Problems and Solutions. *Harvard University.*

Swyngedouw, E. (2015). *Liquid Power: Contested Hydro-Modernities in Twentieth Century Spain.* MIT Press.

Van der Velde, J., Klatter, L, and Bakker, J. (2013). A Holistic Approach to Asset Management in the Netherlands. *Structure and Infrastructure Engineering, Vol.9, No.4, 340-348.*

Van Rijswick, H.F.M.W., and Edelenbos, J. (2014). Ten building blocks for sustainable water governance: an integrated method to assess the governance of water. *International Water Resources Associaiton, Vol.39, No.5, 725-742.*

Wijnia, Y.C., and Herder, P.M. (2010). The State of Asset Management in the Netherlands. *Next Generation Infrastructure Foundation.*

Willows, R.I., and Connells, R.K. (Eds.). (2003). *Climate Adaptation: Risk, uncertainty and decision-making.* UKCIP Technical Report. UKCIP, Oxford.

World Economic Forum. (2014). Strategic Infrastructure Steps to Operate and Maintain Infrastructure Efficiently and Effectively. Accessed June 21st 2016 from: http://www3.weforum.org/docs/WEF_IU_StrategicInfrastructureSteps_Report_2014.pdf

Appendices

A. Current Asset Management strategies

A.1 The Netherlands

Strategic level of AM in the Netherlands

Proactive Asset Management Stages	Current Asset Management Strategy
Stage 1: Threats and Opportunities	Threats and opportunities are being identified more and more. The most prominent threats are: sea level rise and peak discharges. These ultimately affect the socio-economic factors as well. The most prominent opportunities are: new knowledge to better determine the strength of the dikes and to better determine the course and consequences of flooding.
Stage 2: Objectives and Requirements	The objectives and requirements are set at the strategic management level. There is also a legal safety standard already determined which is a requirement to achieve proactive asset management. The Water Act (2010) defines standards for the primary flood defense system in the Netherlands for protection from flooding. It lays down the safety standard for each dike ring taking account of the relevant failure mechanisms that could occur. The safety standard is specified as the "annual probability of flooding of the area protected by the dike ring as a result of the breach of a primary flood defense structure.
Stage 3: Measures for System	The National Water Plan 2016-2021 introduces the new standards for the primary flood defense system. The new standards are set in the Water Act.
Stage 4: Adaptive Plan	The adaptive plan is illustrated in the Delta Programme. The new approach centers around 'adaptive delta management': "looking into the future and using that insight to put in place cost-effective measures in good time and remaining flexible to be able to act on new opportunities (Delta Programme, 2015)."
Stage 5: Performance of Network	See p 4 Advice Rhine Estuary Drechtsteden

Operational level of AM in the Netherlands

Proactive Asset Management Stages	Current Asset Management Strategy
Stage A: Measures for assets	For each individual project life cycle costing is done to determine which measure will be chosen. This is to optimize between design live, maintenance and construction costs. In general flood defences were built for a 50 years design life (dikes) or 100 years hydraulic structures. Design life can freely be chosen with this new approach.
Stage B: Design and Construct	The Flood Protection Programme is the implementation programme of the Delta Programme. It contains measures for improving primary flood defences that failed the (extended) third assessment. Section 5.5 of the Water Act (2010) details the regulations for how a project plan is to be implemented.
Stage C: Monitor and Maintain	Duty of care (zorplicht) principle is followed, which implies that the asset owner has the legal duty to comply with the safety requirements and to provide for necessary preventive management and maintenance. The primary flood defenses are continuously inspected to see whether the physical condition is in line with the design requirements. The asset manager is responsible for the implementation of the duty of care. It is now the rule that monitoring and maintaining must be done continuously.
Stage D: Performance of assets	The evaluation of the performance of assets used to be every 12 years but now it is every 6 years. Statutory Assessment tools. A report on the general structural condition of a primary flood defense structure is submitted by the water authorities to the Provincial Executive every 6 years.

A.2 Belgium

Strategic level for Belgium

Proactive Asset Management Stages	Current Asset Management Strategy
Stage 1: Threats and Opportunities	Some threats have been identified, for example it was noticed that the existing sea walls were already damaged by light storms in certain places. No information on opportunities.
Stage 2: Objectives and Requirements	The policy document for long-term planning is the Vlaamse Baaien, looking at a time horizon until 2100. It signifies that there is a need to revisit and modify the national approach to water management. The Maritime Access Division (a branch of the Ministry of Public Works and Mobility) is responsible for leading these long-term decisions. The Coastal Safety Masterplan outlines the safety standards and flood protection measures that need to be met. These safety

	measures are provided to upgrade the safety level of this area to the Flemish protection standard.
Stage 3: Measures for System	The whole Flemish coast was assessed with the design storms (e.g. weak spots, flood maps, etc.). A cost/benefit analysis (CBA) was performed for these spots to determine the necessary measures for the system and the required investments that will need to be made. It is not sure whether maintenance was included in this CBA. There could be other criteria included to optimize this stage.
Stage 4: Adaptive Plan	In 2011 the Coastal Safety Masterplan was approved by the Flemish government. It is a plan with measures based on CBA calculations and input from local governments. Measures need to be integrated as much as possible in the local areas, and where possible, soft measures (e.g. sand nourishment). Prioritization is based on an annual budget and the way of the least resistance.
Stage 5: Performance of Network	An analysis is done every five years based on the initial analysis of the Coastal Safety Masterplan, but updated with the most recent scientific developments and based on the conditions of the primary flood defenses (e.g. erosion of beaches, degradation of the existing sea walls, sluices, locks, etc.), combination of overtopping limits and failure probability. The assessment could be improved and made more precise, by adopting the Dutch method of probabilistic failure assessment.

Operational level for Belgium

Proactive Asset Management Stages	**Current Asset Management Strategy**
Stage A: Measures for assets	The selection of measures for primary flood defenses is done during the cost/benefit analysis at system level, where different alternatives were compared together with the costs. Local councils could chose for another more costly alternative if they are willing to co-invest. Life-cycle costing (LCC) is also sometimes used to choose optimum decision, but not for every project, but not to a sufficient extent. The flood measures that are included in the Coastal Safety Masterplan are mostly the result of a cost-benefit analysis (risk versus investment and maintenance costs). The next step would be to include the LCC more.
Stage B: Design and Construct	Once the preferred measure for primary flood defenses is selected, consultants are asked to make a design for urban areas (4-5 designs to choose from during tendering phase) in order to ensure maximal integration with the environment. In the design and construct stage there is a fixed budget for coastal protection, which can be a drawback when big investments are needed, because this means that additional funding is difficult to come by.

Stage C: Monitor and Maintain	All the primary flood defenses and beaches are inspected yearly (or at least every two years). Beaches are monitored ad-hoc (due to severe storms), and degrading infrastructure is reported to top management within the Coastal Division (MDK) for the consideration of renewal. This stage can be improved as it is very subjective now and based on engineering judgment.
Stage D: Performance of assets	Primary flood defenses and beaches are analyzed based on the data acquired from stage C in a one to two year cycle-inspection reports. This can be improved by making an official procedure and report.

A.3 Germany

Strategic level in Hamburg

Proactive Asset Management Stages	**Current Asset Management Strategy**
Stage 1: Threats and Opportunities	Threats include the construction practice that excludes maintenance and the high construction costs. Also, the analysis of critical points of the primary flood defenses is incomplete and the documentation about the primary flood defenses themselves is incomplete. Opportunities include optimizing knowledge transfer, critical analysis system, and it is possible to create a risk and maintenance-management system that is target-oriented, adaptable to change, and innovative. It seems that both the threats and opportunities are sufficiently addressed, and that there is awareness of both.
Stage 2: Objectives and Requirements	Federal state defines design water level (including climate change related effects) in consultation with neighbors and states. No safety levels and allowable risks defined and there are no specific national requirements when it comes to primary flood defenses. This means that this stage is addressed incompletely and there is potential for improvement.
Stage 3: Measures for System	The overarching goal of flood protection is the main requirement. The influence of tourism, urban planning and development is also taken into consideration. The defense line is more or less defined and fixed and realignments are considered from an environmental protection point of view. For the flood protection gates specifically, there are possible cost reductions by simplifying the design of structures. No mention of the actors involved.
Stage 4: Adaptive Plan	There is no real adaptive plan yet. There is a monitoring plan that say the design level must be checked every ten years. Water protection plans should be periodically surveyed.
Stage 5: Performance of Network	The performance of the network is assessed using the following criteria: -Protection of the population and goods -Uniform security

	-Technically high quality -Sustainability -Economics Clear indicators given and results of the assessment show that the network performs adequately.

Operational level in Hamburg

Proactive Asset Management Stages	**Current Asset Management Strategy**
Stage A: Measures for assets	Life-cycle costing (LCC) is rarely taken into consideration when choosing between different options. The planning is based on conservative, state-of-the-art techniques. Like in the Netherlands, the construction is determined by safety laws; in addition there are available plots of land, acceptance by citizens, and funding. When selecting the most optimum measure, federal states define the criteria in stage 2 (objectives and requirements) and the local authorities priority lists depending on actual status of assets. A complete defense line will be adapted to the defined criteria (e.g. design water level, construction condition, and special urgency). As mentioned in the strategic level, the adaptive plan is not yet formed rendering this stage incomplete. There is potential for improvement, but it must first take place at the strategic level.
Stage B: Design and Construct	Design and construction are based on the requirements, the relevant engineering standards, and the design specifications of the asset owner. This stage is performed appropriately, since the design plan is specified.
Stage C: Monitor and Maintain	There is regular monitoring of the flood protection gates. For the Regular flood protection gates this is done weekly. Inspections are performed in different time spans and intensity depending on the specific primary flood defense. Maintenance is done twice a year for the flood protection gates and if necessary once a week. Missing information on specific criteria. This stage might be affected by the fact that bearing expenses in Germany is often variable among states, meaning that some states get more funding for maintenance than others, which ultimately affects the quality of their maintenance. Hamburg, which is the case study in question, the only cost bearer is the federal state itself with some support from the Federal government, whereas in other states the funding is distributed between water boards and the federal government.
Stage D: Performance of assets	The assessment of individual assets is performed using the following criteria: -Functionality -Operational safety and security for employees -Legally compliant -Economically -User-friendly maintenance

	-Well-documented Again, well-specified criteria. Results show that performance is acceptable but there is still a lot of room for improvement.

A.4 Denmark

Strategic level on the West-coast of Denmark

Proactive Asset Management Stages	Current Asset Management Strategy
Stage 1: Threats and Opportunities	The threats and opportunities to the system are identified in the National Assembly by the Danish Coastal Authority (DCA), and also during the national implementation of EU Floods Directive (6 year intervals). This is considered to be adequately addressed.
Stage 2: Objectives and Requirements	There are no national or state requirements. However, climate adaptation is now part of the Local Planning process. Some major primary flood defenses are coordinated by a Sluice Board consisting of national and local professional members that make decisions together regarding what needs to be done, who should pay, etc. Once the FAIR project is further developed, other public stakeholders will be more engaged in this stage. Since there are no specific requirements and no safety levels set, it is concluded that this stage does not meet the requirements of proactive asset management.
Stage 3: Measures for System	Denmark has already started to consider the multi-functional use of existing primary flood defenses. Additional assets are also considered, as for example pumps, in case sea levels cause the sluice to no longer function. The availability of land is also starting to be considered, such as changing farm practices. The stage is progressing and more measures to choose from will be needed in the future.
Stage 4: Adaptive Plan	Climate triggers and city development plans all drive the need for an adaptive strategy. The sources and outcomes of climate change are typically monitored and included in the adaptive plan. A longer-term view is needed to challenge and change the status quo. The adaptive plan lacks information on how to monitor the 'real performance' of the measures and set 'smart' triggers to incorporate within the strategy. There is an adaptive plan, but there is not detailed information regarding every step in the implementation process, therefore there is potential for improvement in this stage.
Stage 5: Performance of Network	No specific system performance criteria assessed, so this stage has not yet been addressed.

Operational level on the West-Coast of Denmark

Proactive Asset Management Stages	Current Asset Management Strategy
Stage A: Measures for assets	As mentioned previously, aside from the west coast, it is up to the individual land owners to protect themselves from flooding. Thus, it is the responsibility of private landowners, including the municipalities, to decide on and to prioritize mitigation measures. According to the 22 risk management plans from the recent planning period of the EU Floods Directive, municipalities generally do not prioritize the implementation of measures. They use a more **ad-hoc method** in which mitigation measures are implemented at random. So cost-benefit analysis is not performed. In general, there is a lack of cross-cutting and holistic solutions. If mitigation has broader benefits they are not prioritized. Often mitigation measures are non-structural, in the form of assessments, so that informed decision-making can be made. By making such informed decisions the investments can hopefully be optimized. In this case, this stage is different than the one described in the proactive approach, but it could potentially work better for Denmark.
Stage B: Design and Construct	Land use and planning are taken into consideration when choosing the design. The funding responsibility to implement and build structural coastal protection is divided between the national government and municipalities. For the Danish west coast both the government and municipalities pay to establish and maintain the protection. Regarding the rest of the country, it is the decision of local land owners whether or not they are interested in protecting themselves from flooding. Therefore they also have an obligation to finance such a project. The self-funding principal often leads to implementation of the cheapest coastal protection monetarily but it is often not the best solution. A better structure of funding could benefit and improve the available holistic solutions.
Stage C: Monitor and Maintain	The DCA is responsible for the primary flood defenses on the west coast of Denmark. Typically plans and budgets do not cover the monitoring and maintenance of existing primary flood defenses because there are no legal requirements for older assets. For newer assets, the DCA requires detailed monitoring and maintaining report, but it is currently lacking this.
Stage D: Performance of assets	The performance of individual primary flood defenses are assessed post event by the asset owner to determine whether they have met the 'owner set' requirements, since Denmark does not have national set requirements for asset management for primary flood defenses. This stage could be improved by including an explanation of the decision to decommission, and by making an assessment report.

A.5 Sweden

Strategic level for Sweden

Proactive Asset Management Stages	Current Asset Management Strategy
Stage 1: Threats and Opportunities	Strategic department of municipality determines this.
Stage 2: Objectives and Requirements	No requirements yet. Helsingborg, including all Swedish municipalities, is supposed to follow the Planning and Building Act. They have the responsibility to ensure safety and health for all of their inhabitants. Recently there has been a new addition to the Planning and Building Act concerning risk of flooding, landslides, and erosion. Other than that, there is no really clear criteria, and no set safety levels. This is because asset management is not governed uniformly in Sweden, but each municipality adapts as it suits them. The County Administrative Board has to examine the physical planning in the Comprehensive detailed Plan so that it avoids and minimizes the risk of flooding. The County has the right to cancel the Detailed Comprehensive Plan if there is a risk to people's lives. This stage needs to be improved because there are no clearly identified criteria.
Stage 3: Measures for System	To be decided by the city council
Stage 4: Adaptive Plan	Comprehensive Plan and detailed comprehensive plan
Stage 5: Performance of Network	Responsibilities are shared (municipality as well as railway station)

Operational level for Sweden

Proactive Asset Management Stages	Current Asset Management Strategy
Stage A: Measures for assets	Regarding investment planning, they are still in the exploration phase, so not much can be said about how they choose the measures for their assets. This is so far determined in the long term investment plan.

Stage B: Design and Construct	Paid from long term budget. Hope to share costs.
Stage C: Monitor and Maintain	Responsibility of the maintenance department of each municipality (potentially a knowledge gap). Potentially the safety department Each municipality is responsible for its own funding, maintenance and capital investment. There is a growing discussion whether the municipalities will get more governmental support for funding in the future. The problem is that there is currently no leading asset management authority in Sweden that is in charge of all these questions and many municipalities wish for someone to take the lead.
Stage D: Performance of assets	Responsibility of the maintenance department.

B. Governance Barriers

B.1 Coding

Name	Description
Institutional barriers	Institutional barriers refer to the established governing processes that restrict individuals from stepping over boundaries that are out of the reach of certain actors. Institutions are societal arrangements that are context-specific (Biesbroek et al., 2013).
• Conflicts of interest	This refers to competing interests and opinions about what is important and what needs to be prioritized when it comes to flood protection between different relevant stakeholders.
• Inequality	This refers to large differences between regions, states, or municipalities instead of having one uniform asset management strategy throughout the entire country.
• Lack of enforcement	Sometimes authorities are not able to enforce a law due to self-governing processes and liberal democratic governments.
• Lack of political will	This refers to when there is a lack of political will to put flood protection on the political agenda to other competing issues.

Name	Description
• Rigid procedures	This refers to rigid national government proceedings that are difficult to influence from below. This is typically present in hierarchical modes of governance.
• Unclear division of roles and responsibilities	Sometimes the division of roles and responsibilities between different authorities when it comes to asset management for flood protection is missing something or is not divided evenly or fairly, making implementation of projects difficult.
• Loss of warranty	This is not a typical barrier but there is a risk of not receiving a warranty for the primary flood defences from the producer in case there is damage.
Resource barriers	A resource barrier is a lack of those assets that are necessary to achieve the desired goal. This type of barrier can occur at almost any stage of the asset management process, but especially at the operational management level where the technically-intensive processes take place (Ekstrom and Moser, 2010).
• Funding and rising costs	Includes lack of funding for project implementation or maintenance, or unequal division of funding between different departments/industries.
• Lack of primary flood defences	Refers to a shortage of primary flood defences or really ageing infrastructure.
• Lack of space to build	Refers to the dense space in which primary flood defences have to be built, but are forced to share space with other industries and inhabitants.
• Lack of staff	Refers to a shortage of staff (e.g. project managers or technical experts)
• Time-consuming processes	Can include project delays, not enough time to do inspection, especially when using innovative techniques for which the outcomes are not known.
Resource barriers	A resource barrier is a lack of those assets that are necessary to achieve the desired goal. This type of barrier can occur at almost any stage of the asset management process, but especially at the operational management level where the

Name	Description
	technically-intensive processes take place (Ekstrom and Moser, 2010).
• Funding and rising costs	Includes lack of funding for project implementation or maintenance, or unequal division of funding between different departments/industries.
• Lack of primary flood defences	Refers to a shortage of primary flood defences or really ageing infrastructure.
• Lack of space to build	Refers to the dense space in which primary flood defences have to be built, but are forced to share space with other industries and inhabitants.
• Lack of staff	Refers to a shortage of staff (e.g. project managers or technical experts)
• Time-consuming processes	Can include project delays, not enough time to do inspection, especially when using innovative techniques for which the outcomes are not known.
Cognitive barriers	Cognitive barriers refer to people's ideology, values, or beliefs, as well as education and cultural backgrounds that prevent real transformation from taking place in the desired orientation. They are what "cloud" decision-making (Shu and Bazerman, 2010).
• Conservative methods	Refers to "state-of-the-art" traditional techniques as opposed to more innovative solutions.
• Credibility to decisions unclear	It is difficult to prove that a certain decision is going to work out as planned.
• Lack of competence	This refers to skills needed to complete a task adequately.
• Lack of attention	This refers to the lack of attention for flood protection, because there are other competing issues. It is more to do with prioritization.

Name	Description
• Lack of awareness	This refers typically to the local inhabitants who are not that much aware of flood issues and why flood protection measures must be taken.
• Lack of knowledge or expertise	Sometimes there is lack of technical knowledge or expertise on some issues such as climate change or specific modelling techniques that needs to be known in order to approach the subject the right way.
• Lack of long-term vision	Sometimes there is a lack of a strategic plan or a long-term vision of climate change in relation to the primary flood defences.
• No sense of urgency	Sometimes there is a cultural barrier of having no sense of urgency about flood protection due to the fact that there were no severe natural disasters happening lately.
• Conservative methods	Some asset owners are resistant to change for various reasons, including that it is easier to continue on the same path as before instead of restructuring the whole process, or because they are afraid of what will happen due to uncertainty.
• Too much complexity	This refers to incorporating too many complicated technical elements into the design so that there is a risk that it cannot be repeated for future assets or that it might be too difficult or expensive to maintain.
• Wait until it fails attitude	Some asset owners wait until an asset fails to do maintenance, and most of the time they have to make reinforcements which are even more expensive. This is usually because they were unable to get support beforehand on their plans, or because they have no sense of urgency, or because they simply do not have a plan or know what to do.
Information and communication barriers	Information barriers refer to fundamental and applied research on asset management, data availability for monitoring and assessing performance of assets and credibility and legitimacy of information. A lack of communication between science, policy, and society in long-term adaptation and maintenance of flood protection infrastructure assets can result in a low level of awareness, skepticism, and denial (Biesbroek, 2014). Throughout the

Name	Description
	asset management cycle, information and communication is a frequently occurring and critical process (Ekstrom and Moser, 2010).
• Abstract information	This refers to the fact that sometimes strategic plans can be too abstract for operational authorities to actually know how to implement them.
• Lack of data	This refers to lack of data on the current conditions of the assets, of the different technical components, and other data on climate change for instance.
• Lack of transparency	This refers to a lack of openness when it comes to information, and to whom it is available for.
• Outdated information	Sometimes information about plans, the assets, or technical knowledge is not updated frequently enough within the organization and this may interfere with the efficiency and delivery of projects.
• Unavailability of information	Sometimes there isn't sufficient information available on some aspects of asset management within the organization that are deemed important, and this results in some gaps in knowledge.
• Unstructured communication	There is incoherent communication between the strategic and the operational asset management levels.
• Unstructured information	Sometimes the information is spread out throughout the organization and it isn't all in one place or with the people that it should be with.
Participation barriers	Participation barriers typically occur in the design and construct stage of the operational level, because that is where the outcome of asset management for primary flood defenses is made visible, and if the public is not consulted beforehand in the decision-making process, they often oppose the new developments.
• Lack of stakeholder engagement	Sometimes it occurs that not all relevant stakeholders are involved early in the decision-making process, and this leads to various other problems such as lack of communication, inefficiencies, project delays, etc.

Name	Description
• Public dilemma	This refers to protests coming from the local inhabitants in relation to the construction of primary flood defences in the vicinity of where they live.

B.2 The Netherlands

Rijkswaterstaat

Barrier categories	Barriers to Asset Management Implementation
Institutional	1. **Rigid procedures:** There are rigid procedures because of the top-down governing approach to asset management. These procedures are difficult to influence.
Resources	1. **Lack of staff:** It is very difficult to find project managers for the assessment phase at Rijkswaterstaat because there is a limited amount of staff. Capacity is the main problem at Rijkswaterstaat at the moment. In addition, each year there is a political discussion about how many people are working for the Ministry and there needs to be a reduction of 10%. These decisions at top management are difficult to influence from below because they are top-down and rigid.
Cognitive	1. **Conservative methods:** There is always some hesitation about using new and innovative technologies due to the uncertainty and risk that they pose. Current technologies are from the 1860s and 1980s and a lot of design elements are based on these technologies. New technologies require new methodologies and they can affect the system because the methodologies are different and they should be related to the same design rules as the old technologies. At HHSK water board they are currently investigating innovative techniques by looking at a combination of different solutions (whole systems approach). 2. **Lack of knowledge or expertise:** The expertise is an issue in the Netherlands because they cannot be sure that they are making the right decisions. There is some lack of specific knowledge on the assessment and inspection of assets, and also the specific standards. This is important in order to prove that a certain decision is the right one, in order to be efficient but also to avoid conflict with other stakeholders. There is also some lack of knowledge regarding new technologies because some unexpected failure can occur and they might not be able to handle it, and they might also have little time to repair it. More knowledge is needed on new components and how to replace them. The most important knowledge barrier in the Netherlands is how to pass on the knowledge of asset management and primary flood defences to the younger generations and keep it sustainable. 3. **Lack of attention:** There are many different types of national assets competing for the attention of the Dutch national government, besides the primary flood defences. There is also a problem of attention within Rijkswaterstaat for the primary flood defences because they are not only responsible for those, but also for roads, the main shipping lanes and the primary water system. The primary flood protection standards are just a

	minor part of what Rijkswaterstaat is doing, so it's a matter of prioritization. It takes a lot of effort for the organization as a whole to get enough attention from the national government to achieve the new safety standards. 7. **Credibility to decision-making unclear:** It is difficult to prove that the right decisions are taken. It is also difficult to explain and prove to people who are not involved in the decision-making. The Minister has to be convinced that the projects will generate the desired results because she is investing a lot of money to actually have them implemented. 8. **Too much complexity:** For some structures, like the storm surge barriers, the design is very complicated and includes all kinds of elements and components. It might be difficult to replicate or repair if sudden damage occurs. This is especially true if there is lack of expertise on knowledge on the matter, as explained earlier.
Information & Communication	1.**Unstructured communication:** There is a lack of communication between the strategic and operational levels, especially now with the new rule of thumb for the failure mechanisms, which doesn't fit with the old design methods. This could be improved after assessing the performance of the new innovative assets and with systems engineering. 2. **Lack of transparency:** Language needs to be made more transparent in the decision-making process in order to engage more stakeholders and make it more understandable to everyone and thus be able to convince everyone better of the decisions being made. 3. **Abstract information:** This is a barrier for the regional asset owners (water boards) because they cannot really relate to what is happening and what is being decided at the strategic level. It may be a challenge to get proper data and transfer information from the strategic level to the operational level.
Participation	1. **Lack of stakeholder engagement:** Rijkswaterstaat involves public organizations quite a lot but at some point it is enough, and there is a threshold, that when crossed, has the potential to interfere with the realization of the projects. There is also a problem that sometimes they do not find a public organization willing to be involved with their projects and they really need more partnerships.

HHSK

Barrier categories	**Barriers to Asset Management Implementation**
Institutional	1. **Conflicts of interest:** Conflict of interest between different asset owners regarding what they want to achieve with the levees and how much money they want to make with that, and there is also an issue of maintaining reputation-competing priorities. They had to lobby for the dikes that they were going to reinforce. There are many personal and water board synergies when assessing the performance of a network, it's not black and white.
Resources	1. **Lack of space:** There is little space to build their flood protection infrastructure, because they are in the Randstad, the most economical area of the Netherlands, and a lot of people are living there along the coast. Ideally everyone should move to the east, but that is not likely to happen. 2. **Time-consuming process:** It's a very time-consuming process to implement projects now compared to how it used to be, because they have to pay attention to a lot more detail than before with innovative techniques,

	so that things do not go wrong unexpectedly. Now it takes about 10 years to implement a project, and before it took 5/6 years. 3. **Funding and rising costs:** Limited budget for project Kijk. The construction work would have to be redistributed.
Cognitive	1. **Conservative methods:** There is always some hesitation about using new and innovative technologies due to the uncertainty and risk that they pose. Current technologies are from the 1860s and 1980s and a lot of design elements are based on these technologies. New technologies require new methodologies and they can affect the system because the methodologies are different and they should be related to the same design rules as the old technologies. At HHSK water board they are currently investigating innovative techniques by looking at a combination of different solutions (whole systems approach). 2. **Lack of knowledge and expertise:** There is some lack of knowledge on the failure mechanisms (especially piping) as now there are also new design rules and safety standards which are at the moment difficult to implement in practice because they are so abstract and new. In addition, there are a lot of local people who are not aware that new dikes are needed to protect the safety of the people working and living in those vulnerable areas. 3. **No sense of urgency:** There is no sense of urgency and ultimately no focus on what must be done regarding innovative assets. 4. **Credibility to decision-making unclear:** This is especially difficult for innovative solutions because it is difficult to prove to the maintenance department that it will work and maybe they will not accept the proposals.
Information & Communication	1. **Unavailability of information:** It is difficult to be sure that the right information is acquired every time a problem occurs with the system. Since the information is somewhat disorganized, it can be difficult to ensure that it is always at hand in times of urgency. It is especially a problem for old technologies because it is difficult to ensure tht the right information is provided if the technologies are not validated for the last 100-150 years. This barrier is related to the credibility to decision-making is unclear barrier, because if there is an absence of the right information then it is difficult to make the right predictions and to prove that they are the right ones. The problem in the Netherlands is that there are many authorities coordinating asset management activities and for this reason information is not equally shared. 4. **Unstructured information**: There is not a unified system of reporting and it is often spread out in the organizations, for example the water boards. The information regarding the status of the assets is only with the asset owner at the Delta Programme or the Ministry of I and E, but not with the other water authorities even though they have the right to this information because they contributed financially to these projects. The geo-information and document management systems are not linked and they should be linked.
Participation	1. **Public dilemma:** Sometimes people complain because they do not like the aesthetic view of the dikes, and the HHSK water board hires landscape architects to satisfy the demands of the people.

B.3 Belgium

Barrier categories	Barriers to Asset Management Implementation
Institutional	1. **Lack of political will:** The main concern of politicians is that the people are happy. So if the people complain about the construction works, the politicians might not support the projects unless the people can be convinced that they are necessary.
Resources	1. **Lack of staff:** The MDK is a very small organization; only 6 people are doing all the activities related to flood protection at both the strategic and operational levels. Now it's not a very big problem because they have learnt to manage it, but it was a problem in the past, 4 years ago. Some persons who were involved in the technical side left the organization, and some new people came who didn't initially have the know-how and expertise of those that left, so it was very time-consuming and challenging to learn the technical know-how in order to replace the knowledge that was missing. Currently they are a few persons short which means a lot of work but they have learnt to manage. 2. **Lack of space:** This is especially a problem at the Belgian coast because it has only 67 km, making it an exception in comparison to the other NSR countries. Half of the coast is very dense with a lot of houses, and it is especially crowded in the summer with the tourists. This is a problem if the MDK wants to start some construction projects involving high walls for example, because they need to take over parking spaces which can bring them in conflict with the restaurant owners and the tourists for example. 3. **Time-consuming process:** A lot of time needs to be invested, especially in big projects, because there are a lot of shareholders involved, so a lot of time needs to be invested in the planning phase to convince all the stakeholders and shareholders why a project needs to be done, and to eventually acquire a building permit. 4. **Funding and rising costs:** The budget is a limiting factor because the MDK has a maximum annual budget that they can use to complete the projects. Because of this, there is also a maximum number of projects that they can do, and this can e problematic especially if there is a project that is more expensive. In Belgium there is the same budget for all types of infrastructure. Thus there is little money allocated to flood protection only, even though the total budget for all public works is quite large.
Cognitive	1. **Lacks long-term vision:** At the moment they are mostly doing reactive maintenance, because it has been only 10 years since they discovered that storm surges are becoming more and more frequent and that the sea level is rising higher and higher. 2. **Lack of knowledge and expertise**: There is always a lack of knowledge on the part of the people, because they feel that flood protection is not their problem. It becomes their problem when it is too late and there is a storm, and this is another reason why the MDK does reactive maintenance-because the people cannot be easily convinced that certain measures are necessary until a natural disaster actually occurs. 3. **Conservative methods:** Currently in Belgium they are only looking at the investment and not at the total cost of ownership. They are not calculating LCC for every project because it is not a requirement, but this is a drawback because sometimes they are not sure whether to undergo some specific construction because they cannot determine whether it would require a lot of

	maintenance or not, and performing LCC helps with the decision-making of that.
Information & Communication	1. **Outdated information:** The current plans (adaptive plans) are 80/90 years old and the old plans are more than 120 years old and they are not documented very well. The old primary flood defenses are built on structures that are deep into the ground and it is difficult to look deep into the ground. This is something that cannot be changed.
Participation	1. **Public dilemma:** There are, especially in the past, a lot of protests from the coastal inhabitants regarding the sea walls that were being built along the coast. For instance, the MDK had to close a lot of public areas, parking spaces, and this disrupts certain industries, such as the tourism industry. Also, the people do not like when their view of the sea is blocked. The people just need to be involved sooner in the projects so that they better understand what they are doing and that it is in their benefit. 2. **Engagement with stakeholders:** It is challenging to get everyone on the same line and agree with the construction plans. It is a barrier to project implementation to have to convince each organization, the public, the local governments of their plans, because they are not easily convinced.

B.4 Germany

Barrier categories	**Barriers to Asset Management Implementation**
Institutional	1. **Inequality:** The large differences between states can sometimes be a problem in Germany but it is not a huge problem. An example: there are 4 federal states situated on the North Sea coast (Schleswig-Holstein, Lower Saxony, Hamburg, and another one). All these states come up with their own design levels that fit the situation on the coast. The problem is that this location is shared between the 4 states but they have different design levels so there are some conflicts over the height of the dikes, for instance. The only thing they can do is discuss between them but these discussions can be very difficult and inefficient. It would be more efficient if the national government made one calculation of the design level for all 4 states. 2. **Conflicts of interest:** This barrier is related to the one previously discussed. Sometimes there is resistance inside authorities over what to prioritize. There are different views between authorities over things like the necessity of building a new flood wall for instance. For example, the Port Authority has private high water protection plans, and from their point of view it is not necessary to make a very high protection level. The LSBG on the other hand believes it is necessary to make a higher one because they have to protect a lot of inhabitants in Hamburg and the inner city which houses a lot of culture and economic buildings. So there is a lot of discussion going on inside Hamburg and there is a lot of resistance inside the city as well. 3. **Lack of EU certification:** This barrier refers particularly to a lack of certification for the LSBG plans from the European Union (CEE) because they do not have the staff and the knowledge to do this. It is not easy to find someone that can do this. This barrier is in addition to the lack of good structured documentation discussed under the information and communication category.

	4. **Loss of warranty:** This barrier is unique for Germany. There is a risk that if they do not follow the instructions of the producer they might lose their warranty for a specific asset.
Resources	1.**Funding and rising costs:** The problem in Germany (especially in Hamburg) is that there is not enough money to do maintenance in a very effective way. In some states in Germany, the money for the maintenance is obtained from the taxes of people. In Germany there is also the problem of tax debts to the federal government. Because of these tax debts the states do not have enough money to do maintenance as well. So they try to do reduce their tax debts so that the federal republic and each federal state will decrease their debts in the next years.
Cognitive	1. **Too much complexity:** The flood protection gates are built in a very complicated manner and this makes them more complicated to maintain and also more expensive. At LSBG, for instance, they have a lot of different electric facilities to measure and to steer the motors in order to operate the whole gate. There is information in the documentation and even on the internet about the current status of the gates but this is not available for all the gates because some are built in this highly complicated manner and there is no available information on their status because it is undetermined probably. They need a concept for the best technique in relation to the safety requirements. The complex plans are not very necessary to build the flood gates because they could be simplified. 2. **Lack of knowledge and expertise:** Sometimes there is a lack of expert knowledge on maintenance due to outsourcing. The LSBG for instance sometimes hires external expertise to replace the ones that have already left from their organization, but if they only depend on external expertise they lose their own knowledge and they want to avoid that. 3. **Conservative methods:** In Germany they are using state-of-the-art or traditional techniques. The tradition is to look at the design level for the dikes at the maximum water level. Then they construct their infrastructure in the way they, the engineers, think it is best, and it is usually done the same way as it was always done.
Information & Communication	1.**Unstructured information:** The problem is that each plan has its own documentation. Sometimes the documentation for the assets are very good and sometimes they are very poor, so there is a lot of inconsistency. This is especially relevant for the maintenance department and they need to have a structure document all their plans in the same way. 2.**Unstructured communication:** The missing tactical handshake is a big problem in Germany. The operational level is sometimes not in harmony with the strategic level. The LSBG considers this important to develop in order to have a prominent discussion, to change strategy and to adapt the operational level in accordance with the plans made at the strategic level.
Participation	1. **Public dilemma:** Sometimes there is resistance from the inhabitants. Normally the inhabitants are happy with the flood protection plans because they are aware that they are built for their protection. However, there is some resistance when operating authorities want to build their land to use to build primary flood defenses. Another case is when the operating authorities need to build higher and the people complain because their view is blocked.

B.5 Denmark

Barrier categories	Barriers to Asset Management Implementation
Institutional	1. **Unclear division of roles and responsibilities:** Roles and responsibilities are mismatched and diffused. As it is now, the only clearly defined role is that of the private landowners because they are responsible for protecting their own houses from the sea. This is a problem because it puts constraints on how the DCA operates the sluices since it might be difficult to influence the private landowners not to build in low-lying areas, for example. They cannot force them to move. 2. **Lack of enforcement:** Not all the municipalities obey the Planning and Building Act which prohibits the construction of houses in low-lying areas. The Act should be enforced by the Business and Growth Ministry, but they hesitate to put that problem on the agenda because now the liberal government is in power in Denmark and they do not like to put constraints on how the business can develop. So the problem is to do with the elections as well. 3. **Lack of political will:** In Denmark there is rapidly changing political agendas, due to the fact that politics is short-term, and with every new election the regulations for flood management change, so it is not sustainable.
Resources	1. **Funding and rising costs:** The problem with funding in Denmark is that operating authorities such as the DCA have to apply for finances for major works one or more years in advance. They have to be well in front of the actual investment in order to raise the money to adapt to climate change when doing larger innovation projects, but they are not at that stage yet because they do not have a long-term strategic plan to be able to make predictions and calculate future scenarios. Paradoxically, this lack of funding is one reason there is no long-term strategic plan.
Cognitive	1. **Lacks a long-term vision:** It is not that common in Denmark to look very far into the future. Currently climate change is not that much taken into account in Denmark when doing planning. This is one of the things the DCA hopes to gain input from the FAIR project. 2. **Wait until it fails attitude:** It is usually the case in Denmark, with any type of asset that the asset owners wait until something fails to do maintenance. For example, there was a municipality who was the asset owner of the sluice in Ribe, and they waited until the sluice was close to collapse before they started to actually renovate it. This was very expensive for them. This is a general cultural barrier in Denmark and it is visible in different industries not just flood protection. 3. **Conservative methods:** In Denmark they are used to doing things like they've always done them. This is mostly because of the cultural barrier in Denmark of not looking very far into the future.
Information & Communication	1.**Unstructured communication:** The tactical handshake is missing in Denmark. What happens is that the strategic level typically just runs once at the start of a project, and then the operational level just runs by itself without any sort of communication with the strategic level. There is a blind spot at the tactical level that prevents good communication from taking place.
Participation	1. **Lack of stakeholder engagement:** Might be good to include private landowners in the decision-making.

B.6 United Kingdom

Barrier categories	Barriers to Asset Management Implementation
Institutional	1. **Conflicts of interest:** There is some friction between certain operational teams. Some of the teams have worked in competition for funding because they think their need is greater than that of other departments. This is due to the fragmented organizational culture which will be discussed. However now, the system of allocating budgets is based on a nationally-consistent set of rules rather than various departments bidding for money. It is also looking at longer-term as well, so 5/6 years rather than an annual round of bidding and funding. So this competition for funding was more a problem in the past but it is important to still acknowledge it. In the past, the urban areas have attracted funding because that's where the greatest benefits are achieved for the money. However some of the departments are in very rural areas. This is still a problem. Some parts of the country feel a little bit left out and under-funded compared to some other areas, and that is where some of the competition arises from. It has also happened that sometimes people have cheated to get additional funding at the expense of other parts of the country. The new budget allocation system is based purely on economics and the bidding process is being replaced by IT based upon economic justification rather than opinion. 2. **Lack political will:** Politics is short-term and politicians are not looking further than the next election which is why they lack political will for improving flood protection strategies. As soon as politicians feel their reputation is challenged because of public complaints over the primary flood defenses, they remove flood walls. But this is something that the EA does have influence over by improving their organizational culture. 3. **Lack of EU certification** Like in Germany, the EA lacks EU certification (CEE) for their plans.
Resources	1.**Funding and rising costs:** The Environment Agency (EA) has some pressure with the funding because if they do not meet the ISO 55000 by the deadline this can affect their funding. They had received extra funding following the recent flooding but it came with conditions. If they do not demonstrate improvements in their asset management they will not receive funding anymore from the national government. So far there are not many positive incentives for people, only the precaution that they might lose their funding. This may be due to the resistance to change barrier and wait until it fails attitude (reactive). 2.**Time-consuming process:** At the EA people working in the operational departments want to see efficiencies immediately but some of the desired goals cannot be achieved right away or the outcome cannot be visible right away.
Cognitive	1. **Conservative methods:** The challenge is changing people's behaviour and the organizational culture and moving away from doing things the way they have always been done. The problem with the organizational culture in UK is the fragmentation between different departments, like in the EA for instance. The operational part of the EA is split into 14 areas and they each have autonomy with their own custom, their own practice and their own way of working. A more nationally-consistent way of working is needed. There are many people that are resistant to change and want to continue working the way they have been working the past 30 years. They are also quite risk-

	adverse, so it is important for them to try not to manage the risks so much. This resistance to change makes them inefficient. In addition, people have trouble keeping up with the pace of technology and the pace of innovation. That is an issue-technology is moving ahead so quickly that they have trouble adapting to it. 2. **Wait until it fails attitude:** At the moment the EA has a reactive approach when it comes to flood management. They do not have consistency in their strategies and in their level of flooding.
Information & Communication	1.**Lack of data:** There have been instances when decision-making has not been based on good data but rather on opinion and personal preference. The data is not reviewed regularly and is not regularly updated. Also risk data is missing meaning that they don't have particularly good ways of predicting failure.
Participation	1. **Insufficient engagement with stakeholders (Owen):** There is not much public involvement but now they are starting to form partnerships with universities for instance in order to pass on the knowledge to future generations.

B.7 Norway

Barrier categories	Barriers to Asset Management Implementation
Institutional	1. **Inequality:** Every municipality has different priorities because they do not have the same level of flood risk or the same geography and population distribution. 2.**Unclear division of roles and responsibilities:** If the municipalities do not inspect their structures (sometimes they can't because they do not have the technical expertise), the NVE has no possibility of functioning. Then the NVE has to wait until something happens before intervening.
Resources	1.**Time-consuming process:** Sometimes projects are delayed for the NVE because it is time-consuming to do both the design processes and construction and building because during that stage they are short on staff for some of the processes. 2.**Lack of staff:** The NVE especially finds it difficult to find geotechnical engineers. Some of the municipalities lack the right competencies to hire the right people which causes delays in their projects and this ultimately impacts the NVE as well, like in a domino effect. 3.**Funding and rising costs:** Sometimes the municipalities lack funding and competences.
Cognitive	1. **Lack of competence:** Some of the municipalities lack the right competences, so they make mistakes in hiring consultants and that causes problems. In addition, municipalities are not that attractive especially when the oil business is good, so geotechnical engineers prefer to work in the private sector because the pay is better. 2. **Wait until it fails attitude:** Sometimes municipalities wait too long to take action until it's too late and they have to make reinforcements which are much more expensive than just maintenance. However, this is not a major problem because many municipalities do their job quite well. The question is: 'when is it critical enough to actually go and reinforce a structure?'

Information & Communication	1.**Outdated information:** Some of the information on asset condition is really old and the information for the ageing assets are put into archives and not digitalized. 2.**Unavailability of information:** There is no central register of everything that is built because some of the municipalities do not share information on all of their assets. It is better if the municipalities make a database for all the assets that are built and place all the plans for the security measures they have into this database.
Participation	1. **Lack of stakeholder engagement:** Might be good to include private landowners in the decision-making.

B.8 Sweden

Barrier categories	**Barriers to Asset Management Implementation**
Institutional	1. **Unclear division of roles and responsibilities:** There is a lack of a leading asset management authority at national level to coordinate and take charge of asset management for primary flood defenses across all municipalities. There should be one uniform policy for all of Sweden, more or less, although it's different because there are large differences across municipalities, but it could still be better than it is now. 2. **Inequality:** There are large differences between municipalities. Sometimes it is unfair because some municipalities are poorer than others. A more regional or national perspective is preferred which would it make it safer and more equal for the inhabitants. 3**. Conflicts of interest:** There are problems all the time between the municipalities and what the County Boards suggest, and this is normally not a problem but it could make processes more inefficient. 4. **Lack of enforcement:** There should be more enforcement in Sweden, for example when it comes to implementing crisis management.
Resources	1.**Funding and rising costs:** There is no national funding for asset management for primary flood defenses, so the municipalities have to pay for everything themselves. This is a problem because some municipalities are rich and some are poorer, so the budget is not allocated evenly. It is important to note that this barrier is not prominent yet, because Sweden is not yet at the operational level. Not many municipalities are at that level yet. 2.**Lack of space:** Some municipalities, like Helsingborg, are very crowded and populated with different industries and inhabitants and they want to densify the city in order to save the agricultural land. 3.**Time-consuming process:** Planning and designing takes a lot of time because municipalities are coping with problems in such different ways and each one uses a different method because there are no standards or guidelines from the national government. 4.**Lack of staff:** Municipalities lack personnel dealing specifically with climate-change related issues. 5.**Lack of primary flood defenses:** Sweden does not really have primary flood defenses yet, and the ones they have (e.g. storm-runoff pipe) are quite old and information is lacking on them.
Cognitive	1. **Lack of knowledge and expertise:** There is no department in the municipalities working specifically with climate change and primary flood

	defences. There are only about one or two people working part time on this topic and they are not specialized. In addition, since there are large differences between municipalities, the knowledge also greatly differs between municipalities because some of them have the required expert staff and some do not. This difference also depends on the size of the municipalities. Furthermore, people are starting to become more aware of flood issues, but they are not really being considered yet in the projects that are currently under way. 2. **No sense of urgency:** Due to Sweden's long passive history of not being at war for a long time and not being susceptible to a massive natural catastrophe, people have become more comfortable and lazy, and this is a barrier to implementing measures in an efficient way.
Information & Communication	1.**Unavailability of information:** There is lack of documentation like the Water Act. With such documentation the municipalities would be better off in preparing for flooding and approaching the operational level of management.
Participation	1**. Public dilemma:** When people complain they can stop the plans for a really long-time.

C. General opportunities to overcome barriers from the Workshop

The following opportunities have been identified during an interactive discussion amongst the asset owners in the workshop.

Institutional barriers
▪ Less dependence on politics to comply with regulation

Resource barriers
▪ Adopt LCC within organization ▪ Adapt the way funds are used (based on what is needed, not only fixed budget costs) ▪ Towards Total Cost of Ownership (total expenditure) ▪ Adopt long-term strategy ▪ Whole-system approach (look to risk and not money when developing the new safety standard) ▪ Make funding more transparent (can be sensitive in terms of politics) ▪ Stable funding stream and accommodation

Cognitive barriers
▪ From 'photo to film' mentality (Look at multiple futures and think about how to communicate) ▪ Awareness (make simulation of storm-surge barriers and communicate with press/community, and also discuss what happens if dikes break) ▪ Make a flood website

- Create urgency, awareness (creates a better funding profile to programme projects-convince politicians)-continuous either top/down or the correct stakeholders (e.g. major), (high impact/high influence)
- Improve ability to respond to events in order to attract funding
- Being proactive instead of reactive
- Do a stakeholder analysis before a project starts, and engage stakeholders to take part in finding the solution to narrow the resistance to change- find the correct target groups and make sure they use the tools available

Information and communication barriers

- Communication of uncertainty needs to be done a bit more, and communication should be kept simple, but in terms of long-term scenarios, and done more in ranges as opposed to fixed years
- Risk communication: showing GIS maps with flooding statistics, and look for examples in other countries
- Communicate with influential people (network)
- Both tool and programming needed

Participation barriers

- Communication to public
- Communicate with influential people (network)
- Network with regular meetings and discussions

D. Respondents

Country	Name	Organization	Position
The Netherlands	Remco Schrijver	RWS	Program Manager
	Jenne van der Velde	RWS	Top advisor for asset management
	Manon de Vries	HHSK Water Board	Project Manager
	Marco Weijland	HHSK Water Board	Technical Manager
Belgium Belgium	Niels van Massenhove	Coastal Division	Operational role to build the primary flood defenses
	Daphne Thoon	Coastal Division	Strategic role with a focus on safety
Hamburg, Germany	Michael Schaper	LSBG	Engineer in Maintenance for dikes and sea walls
	Jan	LSBG	Engineer-maintenance for flood protection gates
Denmark	Ulf Radu Ciocan	DCA	Coastal Engineer
	Per Sørensen	DCA	Head of Coastal Research
United Kingdom	Owen Tarrant	EA	Principal Scientist
	Kevin Woodley	EA	Strategic role of developing policy
	Malin Rizell	Helsingborg municipality	Architect; making the adaptive plan
Norway	Camille Nestegard	NVE	Coordinator of security measures for natural hazards

Sweden	Jorgen Dehlin	County Board of Skåne	Development of EU-funded projects
	Emilie Bjorling	Helsingborg municipality	Water quality specialist; recently started doing climate change research
	Malin Rizell	Helsingborg municipality	Architect; making the adaptive plan

E. Interview Guide

Introduction:
Nice to meet you again! Thank you for making time to discuss with me. With this interview I seek to identify the main barriers to the implementation of specific asset management objectives, and how they can be overcome. So I would like to discuss one by one the main improvement potentials (or challenges) that your organization faces in its asset management for flood protection infrastructure, the main barriers that prevent these improvements from taking place, how these barriers developed (or what caused them), an what potential solutions there are to overcome them.

Do you have any questions before we begin?

1. What is your motivation for taking part in the FAIR project?
2. What is your asset management role?
3. Are there any changes you would like to see to the A.M. framework?
4. What are the current asset management priorities at the moment?
5. What is the first (second, third) improvement you would like to see?
6. What are the barriers that prevent this from happening, and how did those barriers develop? At what stage of asset management?
7. What do you think are potential solutions to overcome these barriers? What do you need in order to do/acquire that?
8. Which of these do you consider the main barrier (s)? Perhaps it has caused other barriers to be developed. What other solutions might there be to overcome it?
9. Are there any other points of improvement challenges or barriers you would like to discuss?

Conclusion:
Thank you for your time, it was an interesting discussion! I will make some preliminary notes on this interview and send to you for validation. Afterwards I will undergo more detailed analysis and comparison.

F. Questionnaire Template

Only part A-the country context is provided, as that is deemed to be most relevant for this thesis. Part B is about the specific primary flood defenses.

1 Introduction

This template sets outs the questions to be reviewed and completed by the Asset Owners. The responses will then form the basis of a comparison of methods across the North Sea Region and, importantly, common challenges identified and best practice shared. The results from the questionnaire will be taken forward in WP3 and WP5.

The questionnaire is structured in two main parts. This first part of the questionnaire explores the context within which asset management policy is made, strategies development and plans delivered. The aim is to provide a rich understanding of the approaches in each partner country that forms the background to the case studies. The second part of the questionnaire focuses on the specific challenges and approaches at the case study site. By including these two strands an in-depth understanding of the reasons why different approaches are used will be developed and, in doing so, enable best practice to be shared in the most meaningful way.

Note: The responses to the questionnaire should be provided as a standalone report and set out using the question headings given here.

2. Part A National context

Question 2.1: Context within which asset management takes place

2.1a – Roles and responsibilities

2.1b - Relevant policy, plans and codes

Discuss the policies, plans and codes that specifically influence the delivery of asset management. These should include both flood related and non-flood related (for example, broader development plans).

2.1c- Planning timescales of interest

Discuss the timescale over which asset management activities are assessed and planned and how each influences AM decisions. Consider the multiple timescales within which assessments takes place (national policy cycles, regional planning cycles, maintenance cycles, others).

2.1d - Requirements of performance

Discuss what kind of performance requirements have to be met, who defines these and how these are determined.

- Required criteria **(i.e.** What criteria must be met regardless of cost)

- Desired criteria? What criteria might be met? If (broad) benefits outweigh (broad) costs
-

2.1e- Governance and other aspects

Funding
Who pays, the asset management plan to be developed, for maintenance, capital investment and how secure is this funding stream into the future?

Question 2.2-Challenges and barriers to be overcome

Questions 2.2a to 2.2d -seek to tease out the issues in our understanding of asset performance over time and the availability of supporting data.

2.2a- Barriers in the understanding of the current system
Physical understanding

Socio-economic understanding

2.2b -Future change
We would like to understand how future change is accounted for. In particular:
In climate
In socio-economics

In land levels

Regional soil subsidence (i.e groundwater management related consolidation) – If yes, what assumptions are made
Isostatic rebound – If yes, what assumptions are made

2.2c -Funding barriers

Everyone has a finite pot of money – but is the structure of funding or payment a barrier to optimal / best asset management (compensation for example).
2.2d -How successful is asset management

Is it known whether the asset management is being delivered successfully?

Consider issues of delivering:

The required process – assets been managed through the process set out
The performance criteria (see Question 2.1d) – have required and desired performance been met.
The efficiency of achieving these – minimizing whole life costs for the outcomes achieved

If so, how is it measured? (e.g. required and desired performance requirement (if present) is met?

Question 2.3:
Overview of tools and data used (where this is known)
2.3a- Reliability
Overview
What approaches do you typically use to support policy analysis and design?

Do you have data to support these methods? If so, who collects it, who collates it and can access it and is it t openly available, if so where? Is uncertainty in the data considered?
Specific challenges and gaps in understanding
What are you particularly grappling with?

2.3b -Deterioration
With and without management….

Question 2.4: Decision process

The following question explore the aspects that shape the choices made.
2.4a- Investment planning and prioritization

Opportunities for enhancing the return on investment

2.4b- Social justice
How are the three principles of justice considered?

Equality – Are all citizens treated equally in the FRM process? If no, why not? If so, how is this ensured?
Are the most vulnerable members of society prioritized? If no, why not? If so, how is this ensured?
Utility – Is it a required to ensure the best return for each euro spent? If no, why not? If so, how is this ensured?