Governance of Adaptive Delta Management in the Netherlands

Exploring how the institutional and instrumental governance of ADM in the Netherlands enhance adaptation to sea-level rise

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By

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Preface

Adaptive approaches have a broad range of applications and are used in many different fields; adaptive delta management is only one of them. For me, being adaptable was also required to complete this research. When I started, my topic was Solar Radiation Management, and I had different supervisors than I have today. After a month, I changed to Adaptive Delta Management because this topic had more added value for the company where I was doing my thesis: The Scientific Council for Government Policy *(De Wetenschappelijke Raad voor het Regeringsbeleid)*. Changing the topic was a leap in the dark for me; I was not familiar with delta management and I had no idea what I was getting myself into. The goal back then was to develop a framework for evaluating ADM, and my primary research method was performing a case study on the Maeslantkering. Throughout the research, new insights taught me that changing the goal and the primary research method would yield more valuable results. Getting into an entirely new topic has been challenging but also highly educational. Over the past six months, I have taken a deep dive into the delta management sector. I went from barely knowing anything about delta management to being comfortable with having one-on-one interviews with leading individuals in the delta management sector. Looking back at the past six months, I am happy that I leaped.

I would like to take this opportunity to thank my first supervisor, Gerdien de Vries, for her guidance and support during this research. Also, I would like to thank Jos Timmermans, who was always available to answer all my delta management-related questions. Furthermore, my gratitude goes out to Hans de Bruijn, my graduation committee's chair, who was valuable in aligning all perspectives in the committee meetings.

A word of thanks goes to my project team at the Scientific Council for Government Policy ('Wetenschappelijke Raad voor het Regeringsbeleid'). Annick and Suzanne provided me with helpful feedback and helped me delineate my research.

Finally, I would like to thank my family and friends for their endless support and patience, not only during this research but over the entire course of my studies.

My objective for this thesis was to conduct research relevant to delta management's current practice and simultaneously relevant to scientific research. I believe I succeeded in reaching this goal, and I hope you enjoy reading the final result.

Anne-Marie de Jong
26th of April 2021

Executive summary

One of the biggest challenges for delta management is the uncertainty of sea-level rise. In the Netherlands, the policy development method Adaptive Delta Management (ADM) is used to incorporate uncertainty in decision making transparently and minimize the risk of overinvesting or underinvesting. ADM aims to achieve this by an adaptive approach, which means to be able to speed up or temporize efforts or change strategy if climatic and socio-economic developments indicate this might be necessary.

Four long-term (LT) coastal adaptation strategies for the Dutch coast are identified to protect the Netherlands against sea-level rise in the long term. The strategies considered are Protect-Closed, Protect-Open, Seaward and Accommodate. Due to deep uncertainty around sea-level rise, it is impossible to eliminate one of the LT-coastal adaptation strategies or choose one above the others. Which LT-coastal adaptation strategy will be pursued in the future will be influenced by external developments or the occurrence of an external event with an enormous impact. Hence, Dutch policymakers aim to keep all LT-coastal adaptation strategies open in the Netherlands until external developments occur that make one or more strategies less viable.

Purpose of the research

Little research is done into the governance dimension of ADM, while governance is key to its success. Also, signs are present indicating that the link between ADM in practice and theory has vanished. Therefore, this research aims to address these knowledge gaps by exploring how ADM is governed in practice and whether this is coherent with ADM's scientific foundation. Also, this research aims to explore if ADM's governance in practice enhances adaptation to sea-level rise by analyzing the previous findings. The main research question of this research is:

"Is the governance of ADM in the Netherlands coherent with its scientific foundation, and does the governance of ADM enhance adaptation to sea-level rise?"

Research approach

The research is split into four phases. Phase I consists of an integrative literature review to explore how the governance of ADM should be shaped theoretically. Phase I results in a theoretical governance framework containing the institutional and instrumental governance elements of ADM. At the end of Phase I, the relative importance of the elements for enhancing adaptation is assessed. In Phase II, empirical research is performed to explore how ADM's institutional and instrumental governance is shaped in practice and if this is coherent with theory. The information sources of Phase II are interviews, policy documents and advisory reports. The interviews are performed with key actors of ADM and a few additional actors expected to have valuable knowledge. The first part of Phase II explores how the institutional governance of ADM in practice is shaped and if this is consistent with theory. The second part of the empirical research explores how the instrumental governance of ADM is shaped in practice. Again, the findings will be compared with the the theoretical governance framework to analyze the similarities and differences between the instrumental governance in practice and theory. Phase III analyzes the previous phases' results to determine if the governance of ADM in practice is appropriate for enhancing adaptation to sea-level rise. If it turns out that adaptation to sea-level rise is not enhanced at this moment, the analysis of the relative importance indicates on which governance elements should be focused first. Based on this analysis, recommendations will be provided to enhance adaptation to sea-level rise in the Netherlands. Finally, phase IV reflects on the findings, discusses the implications and limitations of this research and concludes on the main findings.

Results Phase I – Literature Research

The findings of the literature review (Phase I) show that several institutional and instrumental governance elements are essential for ADM. Institutional governance describes how the organizational structure of the actors involved in ADM should be shaped. The instrumental governance describes the methods and tools (instruments) that can be used for applying ADM. The institutional and instrumental governance combined form the theoretical governance framework of ADM.

Institutional governance elements	Instrumental governance elements
Clear agreements on roles and responsibilities	Scenarios – Static scenarios or transient scenarios outline the major uncertainties that play a role in decision making
Transparent information management	Adaptation pathways – Outline the possible strategies, the signposts that should be monitored and the transfer stations on which can be switched to another strategy
Engagement of multiple actors at various levels in monitoring	Adaptation tipping points – Indicate the endpoint of a strategy, which is when a strategy no longer meets the predefined objectives
Engagement of multiple actors at various levels in evaluation	Monitoring system – Keep track of the external developments that may lead to adjusting choices and strategies continuously
Coordination at a higher level than implementation	Evaluation system – Evaluate if pursuing current strategies will lead to reaching the predefined objectives in time considering the external developments and recalibrating strategies whenever new monitoring information comes available

The theoretical governance framework of ADM

The analysis of the elements' relative importance for enhancing adaptation to sea-level rise show that the institutional governance elements are requirements for applying ADM. Only if all institutional governance elements are present in practice, a proper foundation for applying the instruments of ADM is in place. Regarding the instrumental elements, scenarios were identified as the most critical instrument for applying ADM. Thereafter come adaptation pathways, the monitoring system and the evaluation system. Finally, adaptation tipping points were assessed to have the lowest relative importance for enhancing adaptation. It is important to note that if an element has low relative importance, this does not mean the element is not important for applying ADM. All the elements included in the theoretical governance framework of ADM have been identified as essential for the governance of ADM.

Results Phase II – Empirical Research

The results of the empirical research into the institutional governance in practice (Phase II) show that the actors that play a role in developing adaptive strategies are the Signal Group, the Knowledge Network, Research Program Sea-Level Rise, (Staff) Delta Commissioner, the Delta Program Sub-Programs, and various knowledge institutions. The actors responsible for the adaptive implementation of the strategies are regional water authorities, municipalities and drinking water utilities. Based on the empirical research into the institutional governance of ADM in practice, the conclusion is drawn that all theoretic institutional governance elements are present in practice.

The results of the empirical research into the instrumental governance of ADM in practice (Phase II) show differences between practice and theory and between the strategy level and the implementation level. The application of the greater part of the instruments is not coherent with how they should be applied according to theory. Hence, the results confirm that the link between ADM in practice and its scientific foundation has vanished.

On the strategy level, the application of scenarios and the monitoring system are in line with how they should be shaped according to theory. For adaptation pathways, differences between theory and practice were observed; the adaptation pathway maps used in practice only contain the preferential strategy instead of multiple strategies, and no signposts and transfer stations are defined. Another finding is that adaptation tipping points in practice are more flexible than in theory. Furthermore, evaluation and adjustment of strategies do not happen whenever new information comes available, as is prescribed in theory, but has a fixed rhythm in practice. The most important implication of these differences is that ADM in practice provides less guidance on when and which adjustments are needed than in theory.

On the implementation level, the majority of instrumental governance elements is not applied. Scenarios and adaptation pathways are hardly ever used by the actors at the implementation level. Also, no concrete adaptation tipping points have been identified at the implementation level. Finally, it was not possible to generalize the findings on the monitoring and the evaluation system because no rules or arrangements are in place on how monitoring and evaluation should be shaped in practice. Therefore, the monitoring and evaluation system is unique for every implementing actor.

Results Phase III - Analysis

The results of the analysis of the previous findings to determine if the governance of ADM in practice enhances adaptation to sea-level rise (Phase III) show that the organizational structure in the Netherlands is appropriate for enhancing adaptation to sea-level rise. However, the results show room for improvement in how the ADM methods and tools are applied in practice.

An important finding from the institutional analysis is that to enhance adaptation to sea-level rise on the implementation level, it is required that the implementing actors take into account the measures considered on the strategy level. The explanation for this is that the consequences of sea-level rise for the implementation level depend on the amount of sea-level rise combined with the national coastal adaptation strategy. For example, which flood protection measures are taken along the Dutch coast by the actors on the strategy level determine which areas will remain safe in the future for new housing developments for municipalities. Furthermore, the actors of ADM identified in Phase II are also the actors responsible for ensuring adaptation to sea-level rise. Therefore, the results of the empirical research into the institutional governance of the actors of ADM are still valid, meaning that the theoretical requirements for institutional governance are all met in practice. Hence, the organizational structure of the actors of ADM is appropriate for enhancing adaptation to sea-level rise.

Regarding the instrumental governance at the strategy level, the current application of scenarios, the monitoring system and the evaluation system enhance adaptation to sea-level rise. However, no adaptation pathways towards the national LT-coastal adaptation strategies to cope with sea-level rise have been defined. The result is that it is more challenging for policymakers to identify the short-term actions needed to keep the LT-coastal adaptation strategies open. Also, the absence of adaptation pathways could result in path-dependency and lock-ins. Finally, defining concrete adaptation tipping points is challenging; this makes it more difficult for policymakers to determine when a strategy should be adjusted.

On the implementation level, most instruments of ADM are not applied in practice. The absence of scenarios at the implementation level means that uncertainty is not incorporated in decision making, while uncertainty around the consequences of sea-level rise for implementing actors is high. Furthermore, the lack of adaptation pathways and adaptation tipping points results in policymakers not having insight into the possible adaptation options, path dependencies and lock-ins. Therefore, adaptation to sea-level rise is not enhanced on the implementation level.

Recommendations

Concludingly, the current application of the instruments does not enhance adaptation to sea-level rise. However, it is vital for the Netherlands that action is taken. If no action is taken, the risk of overinvestment or underinvestment in flood protection measures exists. Overinvestment in flood protection measures comes with extremely high sunk costs at the expense of society. On the other hand,

underinvestment may result in major flooding with enormous consequences for the Dutch living environment, economy, and risking the safety of citizens. Four recommendations have been proposed to enhance adaptation to sea-level rise in the Netherlands. The Staff Delta Commissioner should be responsible for taking the lead in implementing the proposed recommendations.

- Develop adaptation pathways to the LT-coastal adaptation strategies. The adaptation pathways shall be developed for the LT-coastal adaptation strategies considered in the Netherlands (Protect-Open, Protect-Closed, Seaward and Accommodate). The development of adaptation pathways will provide policymakers insight into the possible adaptation options, lock-ins and path dependencies. Furthermore, it will help policymakers identify short-term measures that have to be taken to keep the LT-strategies open.
- Develop area-specific consequence scenarios. These area-specific scenarios should outline the plausible consequences of sea-level rise for a specific area based on the amount of sea-level rise combined with the national LT-coastal adaptation strategies. Insights into the possible range consequences of sea-level rise are crucial for implementing actors to make an informed decision on appropriate measures and actions. Furthermore, these scenarios are the basis for applying the other instruments of ADM on the implementation level.
- Formulate policy objectives more precisely. Policy objectives should be defined as clear and explicit as possible, preferably with measurable indicators. Clearly defined goals make it easier to determine if a strategy is successful or not (and an adaptation tipping point occurs). Resulting in that policymakers have insight into when adjustment of a strategy is needed.
- Provide workshops on the application of the instruments of ADM. Workshops and training should be provided to teach the actors of ADM how to apply the instruments because using the instruments of ADM in the prescribed manner is challenging.

Implications of the results

Based on the recommendations that have been proposed in this research, the following implications for policymakers have been identified:

- A more future-oriented mindset is required for policymakers to explore the long-term strategies to cope with sea-level rise and connect short-term decisions with long-term objectives.
- More alignment between the actors at different levels is needed. Only then, actors on the implementation level can obtain insight into the possible consequences of sea-level rise for their region and explore the accurate measures to protect the area and its residents from the consequences.
- Policymaking at the implementation level will become more complex and time-consuming than it is today.

Although the primary focus of the research was exploring if the governance of ADM enhances adaptation to sea-level rise, also two lessons learned for further developing the theory of ADM based upon practical experience have been identified:

- Adaptation tipping points are more flexible in practice than in theory. Even when the proposed recommendation to formulate policy objectives more precisely is followed up, it will not be possible to define concrete adaptation tipping points in practice. As technical feasibility and financial or societal acceptability of solutions change over time, policymakers cannot define in advance when a strategy will be no longer viable, and an adaptation tipping points occurs. Further research is suggested on how adaptation tipping points can be defined when precise policy objectives are absent.
- The pace at which the evaluation of strategies in practice has a fixed rhythm, while in theory, continuous evaluation should happen continuously whenever new information comes available. The fixed rhythm is expected to be positive for the application of the ADM method in practice. Therefore, further research is suggested into the effectiveness and the implications of a fixed evaluation rhythm for the ADM method.

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List of abbreviations

ADM	Adaptive Delta Management
AM	Adaptive Management
APM	Adaptive Policymaking
APP	Adaptive Policy Pathways
CBS	The Netherlands' Central Statistical Agency (*Centraal Bureau voor de Statistiek*)
CPB	The Netherlands' Central Planning Agency (*Centraal Planbureau*)
DAPP	Dynamic Adaptive Policy Pathways
DP	Delta Program
HWBP	The Netherlands' Flood Protection Program (*Hoogwatersbeschermingsprogramma*)
KNMI	Royal Netherlands Meteorological Institute (*Koninklijk Nederlands Meteorologisch Instituut*)
LT	Long-Term
M&E	Monitoring & Evaluation
MAA	Monitoring, Analysing and Acting (*Meten, Weten, Handelen)*
OECD	Organisation for Economic Co-operation and Development
PBL	The Netherlands' environmental assessment agency (*Planbureau voor de Leefomgeving*)
RCP	Representative Concentration Pathway
SQ	Sub-Question
RQ	Research Question
RWS	National water authority (*Rijkswaterstaat*)
WUR	Wageningen University & Research

1 Introduction

This chapter provides an introduction to this thesis. The first section introduces the policy method of Adaptive Delta Management and the knowledge gap addressed in this research. Thereafter, the research approach, the scientific and societal value, and a reading guide for this thesis are presented.

1.1. Context

The Dutch Delta Program's objective is to maintain citizens' safety and health and enhance the living environment and economy of the Netherlands. Nearly 60% of the country lies in flood-prone areas; this makes delta management an existential issue for the Netherlands (Bloemen et al., 2019). The Delta Program comprises the areas of flood risk management, freshwater availability, and spatial planning (Appendix B).

The main challenge of delta management and long-term policymaking is uncertainty. The two main types of uncertainty that determine future delta challenges are climate change and socio-economic conditions (Bloemen et al., 2019). The Dutch weather and climate in general are expected to show more erratic patterns: more often periods of intense rainfall are expected, which will pressure cities and their infrastructure and potential droughts leading to shortages of fresh water (Slob & Bloemen, 2014). Also, temperature rise and changing air circulation patterns decrease summer and increase winter discharges of the Dutch rivers (DP2011, 2010). Recently, the speed and severity of sea-level rise have been the main topic of discussion. The most recent IPCC projections estimate a sea-level rise in 2300 between 2.3 and 5.4 meters in the highest scenario and a sea-level rise of 1 meter in the lowest scenario (Oppenheimer et al., 2019). The high level of uncertainty makes it hard to evaluate the risk, leading to a possible outcome that insufficient measures are taken or implemented too late to protect the Netherlands against sea-level rise. Simultaneously, the possibility exists that the measures taken are over-dimensioned, which leads to unnecessary expenses for society.

Furthermore, the impact of climate change depends on uncertain socio-economic developments. Uncertainty around socio-economic conditions is caused by variations in socio-economic developments such as demographic trends, economic growth or crises, or construction in flood-prone areas (Dewulf & Termeer, 2015). Also, uncertainty around future government policies and actions plays a role. The deep uncertainty about climate change in general in combination with uncertainty around the socio-economic impact, makes climate change a key challenge for bringing analytical insight into policy decisions (Marchau et al., 2019). Doing nothing is not an option because the consequences of climate change can cause major inconveniences, economic damage, and the safety of citizens is at stake. Delta management has to act now, and therewith formulating policy under uncertainty is unavoidable.

Adaptive Delta Management (ADM) was introduced in the Dutch Delta Program as a policy development method. ADM aims to incorporate uncertainty about future external developments in decision making transparently and minimize the risk of overinvesting or underinvesting in measures (DP2012, 2011). The rationale behind ADM is coping with uncertain future climate change through a flexible approach to achieve robust performance of strategies. Robust policy means that policy performs satisfactorily under a wide variety of future scenarios (Walker et al.,

2013). Flexibility is defined as having the ability to adjust the pace of the current strategy, to switch to another strategy or add another strategy (Haasnoot et al., 2013). The combination of these two gives us *adaptive strategies*, which entails having the ability to speed up or temporize efforts or to change strategy if the actual or expected rate of climatic and socio-economic developments indicate this might be necessary (Bloemen et al., 2019).

In the ADM-method, an instrument that is used to achieve adaptiveness of strategies are adaptation pathways. Adaptation pathways or strategies are a concetanation of actions that can be implemented so that a system will continue to meet the predefined policy objectives (Haasnoot & Van ‘t Klooster, 2018). The objectives formulated are in the areas of flood risk management, freshwater availability, and spatial planning. Adaptation pathway maps are used to outline the possible adaptation pathways and give policymakers insight into the possible adaptation options. Within adaptation pathway maps, uncertainty around changing conditions is included in the form of scenarios. The application of adaptation pathways enables policymakers to connect short-term decisions with long-term challenges while incorporating uncertainty.

1.2. Knowledge gap

In March 2021, a search on 'adaptive delta management' on Scopus and Web of Science yielded 22 scientific articles on ADM. On the same day, the same search term on Google generated 14.400.000 hits. The significant difference gives the impression that ADM is mainly grounded on policy documents and advisory reports but that ADM's embedding in scientific literature is limited. The same conclusion was drawn by Timmermans et al. (2015), who also derived from this that the link between ADM in practice and its scientific foundation has vanished. They argue for further research focusing on the reintegration of ADM's scientific foundation into ADM in practice. Also, limited attention is being paid to ADM's governance dimension, while the governance challenges are considerable (Van der Brugge & Roosjen, 2015). The few scientific articles on ADM have a theoretical focus primarily. These studies cover topics such as the optimization of adaptation pathways or if scenarios and adaptation pathways are incorporated into policy agendas. However, how scenarios and adaptation pathways are incorporated and if this is coherent with its scientific foundation has not been explored. Focusing on the governance dimension is important because the success of flexible approaches depends on how the organizational landscape is shaped (Metzger et al., 2021). Furthermore, ADM is a policy method under development, therefore, learning from practice is valuable to further develop the ADM method. Concludingly, little is known over ADM's functioning in practice, while this is key to its success.

1.3. Research objective and scope

The goal of this research is to explore how ADM is governed in practice and whether this is coherent with ADM’s scientific foundation. Also, this research aims to explore if ADM's governance in practice enhances adaptation to sea-level rise by analyzing the previous findings.

The first decision that defines this research's scope is that the focus is on the governance of ADM in the Netherlands. ADM is a policy development method that was introduced in the Dutch Delta Program in 2011. Therefore, ADM had sufficient time to land and now is an appropriate moment to study how the governance has taken shape. Furthermore, delta management is organized at the national level, therefore it makes sense to leave the international context out of the scope. The second research choice that affects the scope is to only focus on the uncertainty of sea-level rise. The uncertainty around the speed and severity of sea-level rise is significant, and the consequences for the Netherlands are tremendous.

1.4. Research approach

This section will explain the research approach, including the research questions, the research methods and activities, and the research flow diagram.

1.4.1. Research questions

Based on the knowledge gap and the objective of this research, the following main research question was established:

"Is the governance of ADM in the Netherlands coherent with its scientific foundation, and does the governance of ADM enhance adaptation to sea-level rise?"

In this research, the distinction is made between institutional and instrumental governance. Institutional governance describes the organizational structure of ADM. The instrumental governance describes the methods and tools ('instruments') of ADM. Based on the distinction, the following sub-questions were established to answer the main research question:

[1] What does ADM entail, where lies the scientific foundation of ADM and how is ADM used to cope with the uncertainty of sea-level rise in the Netherlands?
[2] How should the institutional and instrumental governance of ADM be shaped theoretically?
[3] Is the institutional governance of ADM in practice in the Netherlands coherent with theory?
[4] Is the instrumental governance of ADM in practice in the Netherlands coherent with theory?
[5] Does the governance of ADM in the Netherlands enhance adaptation to sea-level rise?

1.4.2. Research methods and activities

Figure 1 shows a schematic overview of the research. The first step to answer the main research question is desk research into what ADM entails, where the scientific foundation of ADM lays and what the approach is to cope with the uncertainty of sea-level rise in the Netherlands (SQ1). An integrative literature review will then be performed to develop a framework consisting of the institutional and instrumental governance elements essential for ADM based on scientific research (SQ2). Subsequently, empirical research will be performed to explore how ADM's governance is currently shaped in practice. For the empirical research phase, information will be gathered through conducting interviews and studying policy documents and advisory reports. The institutional governance of ADM will be explored through analyzing the roles, responsibilities and interactions of the actors involved in ADM. Then, the institutional governance of ADM in practice is compared with the theoretical framework's institutional elements to determine whether they are coherent (SQ3). The second part of the empirical research entails exploring how the instrumental governance of ADM is shaped in practice. Again, the findings will be compared with the theoretical framework's instrumental elements to examine the coherency between practice and theory (SQ4). Next, the results of SQ1-SQ4 will be analyzed to explore if the current institutional and instrumental governance of ADM enhance adaptation to sea-level rise (SQ5). Also, for the improvement areas identified, recommendations for improving adaptation to sea-level rise will be given. Finally, the last activity is reflecting on the findings, discussing the implications and limitations of this research and concluding on the main findings (Main RQ).

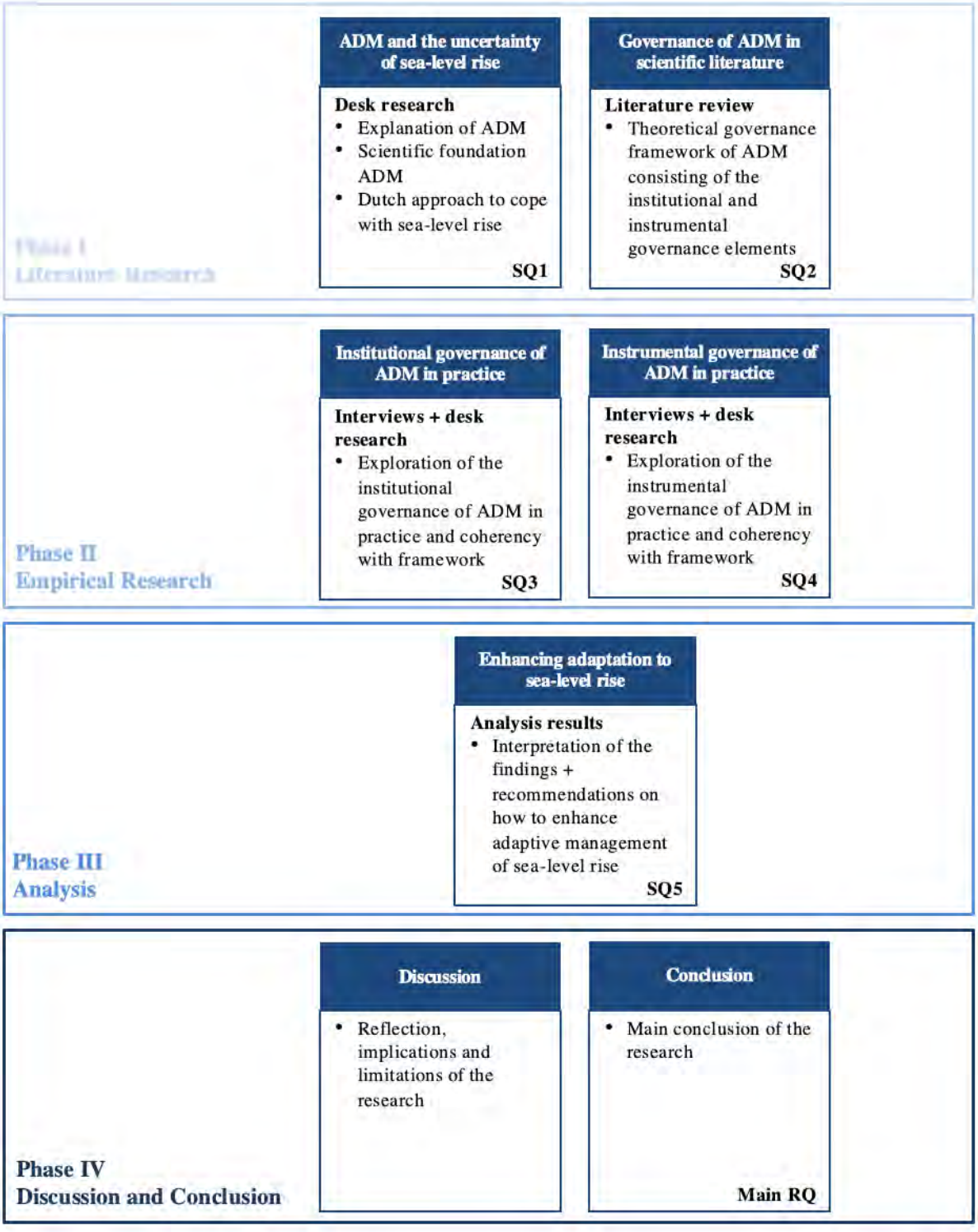

Figure 1: Research flow diagram

1.5. Scientific and societal relevance

This section explains the scientific and societal value of the study. The first section describes the scientific relevance. After that, the societal relevance is explained.

1.5.1. Scientific relevance

The first scientific contribution of this study is that the theory behind ADM will be enriched with lessons learned from practice. ADM is a policy method under development, meaning that the theory behind ADM is altered based on practical experience and the other way around. Therefore, comparing theory and practice is critical for the further development of the ADM method. A knowledge gap exists on how ADM in practice is applied and how this relates to its scientific foundation. This study aims to fill this knowledge gap by performing both literature research and empirical research into the ADM method and comparing the results. The lessons learned from this comparison are valuable for determining which elements of ADM are successful for enhancing adaptation and which need further research.

Secondly, no theoretical framework to evaluate the application of ADM in practice exists yet. This research aims to take the first step towards establishing such a framework. First, the theoretical governance framework containing the institutional and instrumental governance elements essential for applying ADM in practice will be composed based on scientific literature. After that, the framework will be tested by using the framework to explore how the governance of ADM has taken shape in the Netherlands.

1.5.2. Societal relevance

First of all, the relevance of this study lies in gaining insight into how ADM's governance in practice is shaped and if this enhances coping with the uncertainty of sea-level rise adaptively. For a relatively new approach such as ADM with the vital function of protecting the Netherlands against climate change, it is critical that its functioning is assessed. If the ADM method does not function properly in practice, the risk of overinvestment or underinvestment exists. Overinvestment in flood protection measures comes with extremely high sunk costs at the expense of society. On the other hand, underinvestment risks the Dutch living environment, economy, and citizens' safety. Furthermore, insight into the functioning of ADM in practice is not only relevant for determining if ADM is an appropriate policy development method to cope with sea-level rise but also if ADM is appropriate for addressing other climatic or socio-economic uncertainties.

Secondly, the lessons learned in this research are valuable for other delta countries worldwide. These delta countries face similar challenges in coping with uncertainty around climate change and socio-economic developments, therefore introducing an ADM system comparable to the Netherlands might also be considered in these countries. The theoretical governance framework can guide them in shaping their organizational structure, and they can identify best practices from the governance of ADM in the Netherlands.

Thirdly, the lessons learned from this research may be valuable for other policy areas dealing with uncertainty. For example, during the COVID-19 pandemic, deep uncertainty is encountered on how fast the coronavirus will spread and how contagious the variants will be. This makes predicting the capacity within intensive care units challenging. Therefore, an adaptive approach could be helpful in transparently incorporating uncertainty in decision making. Hence, adaptation pathways for the possible strategies for expanding the intensive care units' total capacity in the Netherlands could be developed. Important signposts could be the number of contaminations, the contagiousness of variants in the Netherlands, and the intensive care units' current occupancy rate.

1.6. Reading guide

Table 1 outlines the reading guide of this thesis, showing the content and objectives of each chapter. Additionally, which chapter answers which research question.

Chapter	Content	Objective	SQ
1	Introduction	Introduce problem, research objective, research approach and scientific relevance	-
2	ADM and sea-level rise in the Netherlands	Explain what ADM entails and its importance for the uncertainty of sea-level rise	SQ1
3	Theoretical governance framework ADM	Identify how the institutional and instrumental governance of ADM should be shaped according to the scientific literature	SQ2
4	Institutional governance of ADM	Explore the institutional governance of the actors involved in ADM + examine coherency with theory	SQ3
5	Instrumental governance of ADM	Explore how the instrumental elements of ADM are shaped in practice + examine coherency with theory	SQ4
7	Enhancing adaptation to sea-level rise	Analyze if the institutional and instrumental governance enhance adaptation to sea-level rise, and provide recommendations for improvement areas	SQ5
8	Discussion	Reflect on the results, the implications, the limitations and recommendations for future research	-
9	Conclusion	Present main conclusions of the research	Main RQ

Table 1: Reading guide

I

Literature Research

2

ADM and sea-level rise in the Netherlands

This chapter aims to provide the important background information required for the rest of this research. First, the ADM approach in the Netherlands and its scientific foundation will be explored. Then, the uncertainty of sea-level rise and the strategy to protect the Netherlands against sea-level rise will be explored.

2.1. Approach for the desk research

Desk research is performed to explore ADM and sea-level rise in the Netherlands. For this desk research, the consulted sources are a combination of policy documents, advisory reports, scientific literature and books obtained via the TU Delft library. The scientific publications are obtained by searching on Scopus, Web of Science and Google Scholar. Additionally, backwards snowballing is used to identify new relevant sources based on an article's reference list.

Section 2.2 explores what ADM as a policy method in the Netherlands entails. Next, Section 2.3 discusses the development of adaptive approaches into ADM through consulting scientific literature. Finally, Section 2.4 elaborates on the latest research into the uncertainty of sea-level rise, and the Dutch strategy to cope with sea-level rise. Finally, Section 2.5 ends with the conclusion of this chapter.

2.2. ADM in the Netherlands

Adaptive Delta Management (ADM) is introduced in the Delta Program of 2012 (DP2012, 2011). ADM aims to help policymakers to identify the short-term measures that fit the long-term strategy. These short-term measures shall increase the flexibility and robustness of delta policy at the same time. Flexibility means having the ability to adjust the pace of the current strategy, to switch to another strategy or add another strategy (Haasnoot et al., 2013). A robust policy is a policy that performs well on the predefined objectives in all plausible future scenarios. ADM aims to make delta management easily adjustable to external developments on the one hand and less sensitive to political changes on the other hand (Hermans et al., 2016).

ADM is used in the Delta Program as the guiding principle in formulating delta decisions and strategies. ADM follows an adaptive and integrated approach: *adaptive* to be able to speed up or temporize efforts or to change strategy if climatic and socio-economic developments indicate this might be necessary, and *integrated* to address the highly interconnected fields of delta management and physical developments that characterize dynamic and densely populated deltas (Bloemen et al., 2019). ADM applied in the Delta Program can best be explained by its four key elements:

- Developing adaptation pathways
- Connecting short-term decisions in the field of spatial planning with long-term delta management objectives
- Looking for flexibility
- Linking Delta Program measures to other investment agendas

Developing adaptation pathways

Figure 2 shows an example of an adaptation pathway map for the decision of remaining the Meuse as a commercial shipping river. The adaptation pathways show the possible future policy pathways for a specific area, based on the bandwidth of the plausible future scenarios and the technology available. The adaptation pathways start in the current situation by mapping out the possibilities for the subsequent actions. From that point is assessed what the possible adaptation strategies are further in time. Also, the conditions are defined when switching from one strategy to another one is advised (DP2013, 2012). The adaptation map helps the decisionmaker understand what preparatory measures need to be taken to roll out a specific plan of action. Adaptation pathways make transparent how different policy decisions can be combined; some decisions can be expanded or adjusted to other pathways, while other choices are mutually exclusive. A policymaker can make an informed decision for a particular policy pathway by analyzing the successive dependency of different policy options and the related costs and benefits.

The basic idea behind the adaptation pathways approach is to generate a wide array of pathways (consisting of a concatenation of measures) through which policy objectives are achieved under changing climate and socio-economic conditions (Deltares, 2014). Adaptation pathways aim to place current strategical choices on a long-term horizon while considering possible adjustments over time. The time horizon often stretches until 2050 with a forward view to 2100 (DP2012, 2011). This enables delta managers to make important policy decisions today while taking into account uncertainty, without limiting the possibility of changing policy course whenever developments make this necessary. The application of adaptation pathways enables policymakers to understand how short-term decisions contribute to reaching long-term objectives.

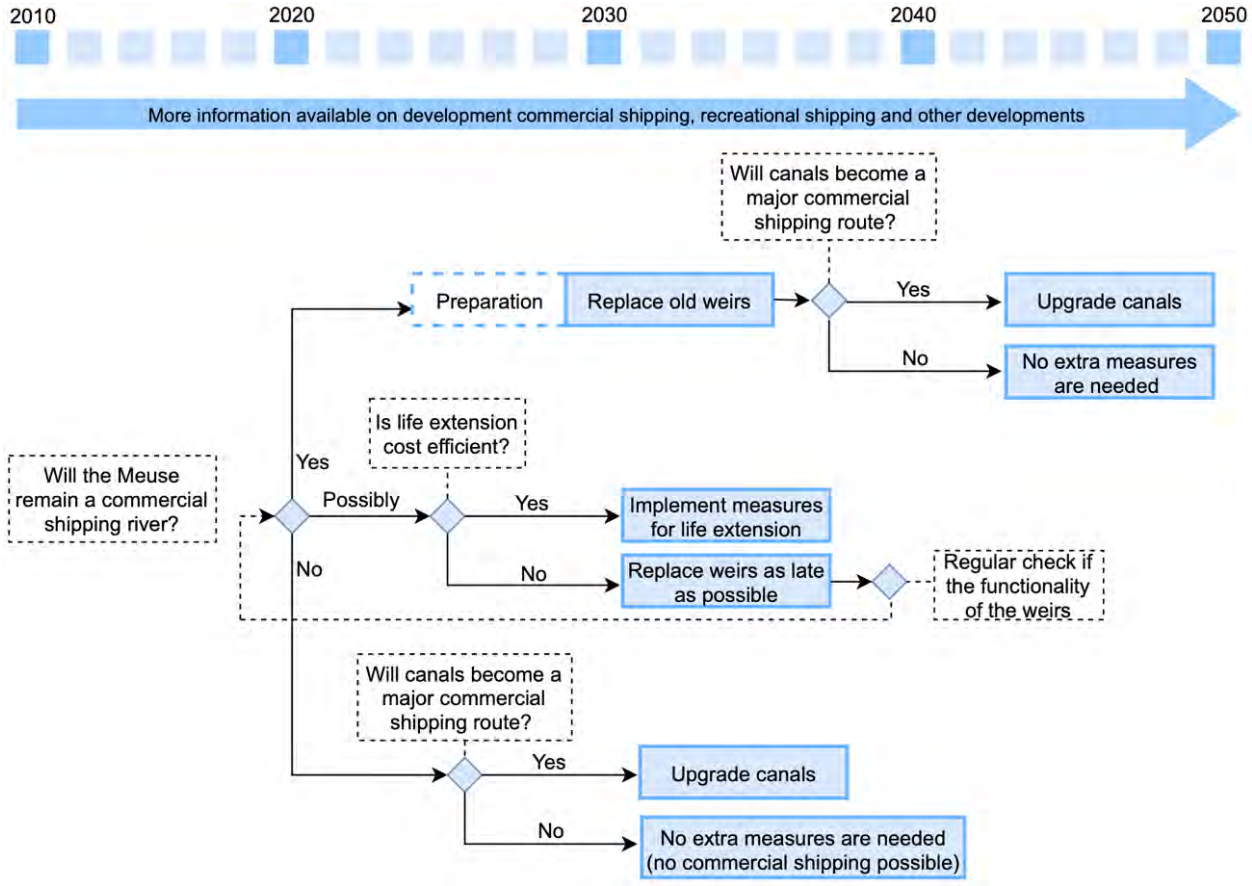

Figure 2: Adaptation pathway map designed for the Delta Program Adapted from DP2012 (2011)

Connecting short-term decisions with long-term objectives

The beforementioned adaptation pathways contain short-term measures that are directly related to long-term objectives. The short-term measures considered might be on the agenda to implement in the upcoming years. However, simultaneously, decisions are taken in other policy areas than delta management that can result in other spatial developments (e.g. housing or infrastructure). These measures in other fields might affect the flexibility of a strategy. Therefore, assessment is needed to determine how these plans affect long-term objectives. The outcome of this assessment may lead to adjustments in design, location or timing of short-term measures. An example is the construction of a river bypass near Nijmegen. The bypass is not needed at this moment but is expected to be needed in the future to accommodate the expected increase in peak river discharges due to climate change. Despite the river bypass is not needed today, it is constructed now. In this way, it is ensured that no future urban developments will sprawl over the assigned area.

Looking for flexibility

The Delta Program positions ADM as an approach that has clearly defined long-term objectives but is flexible in how these objectives will be reached (Van der Brugge et al., 2012). Flood risk management and freshwater availability is constantly worked on to achieve the long-term objectives. Flexibility in how these objectives can be achieved means that different strategies can be pursued to achieve the long-term objectives. Adaptation pathways explore the possible strategies. It is not fixed upfront which strategy or combination of strategies will be pursued. Also the timing of implementation of measures is flexible; the next action or measurement is chosen when more information on the speed and severity of climate change and socio-economic conditions becomes available over time. Flexibility in the timing of measures depends on external factors such as climate change and other spatial developments in the area. When looking at adaptation pathways, flexibility can be rated by opting for a strategy with a wide array of follow-up actions instead of opting for a strategy with only one possible follow-up action. Also, wherever possible, high investments are postponed. In this way, time is bought in which knowledge development can take place to reduce the amount of uncertainty (Hekman & Booister, 2020).

Ensuring flexibility helps to minimize the risk of overinvesting or underinvesting in measures (Van Rhee, 2012). Underinvestment occurs when measures turn out to be insufficient to meet the predefined objectives. Overinvestment happens when, in hindsight, measures are over-dimensioned. The possibility of speeding up or delaying the implementation of measures helps to align actions with the actual rate of climate change or socio-economic developments. Innovation in technologies and new knowledge obtained can be incorporated in deciding on the pace of implementation and the dimensioning of measures. An example of looking for flexibility is the flood protection mean in the coastal town of Katwijk aan Zee. In 2008, the regional water authority of Rijnland found that additional measures were needed to meet the predefined objectives and keep the coastal town safe from flooding. Instead of choosing for the standard measure of raising the dikes, the choice was made to build a sandy dike clad with stone within the existing dunes (called ‘Dijk-in-Duin’). The dyke absorbs the waves in the area, resulting in that less beach nourishment is needed to reinforce the dunes. In case the sea-level rises, it is relatively easy to reinforce the dike and dunes to keep Katwijk aan Zee safe. Because the flood protection measures are relatively easy to adapt the approach is called flexible.

Linking Delta Program measures to other investment agendas

The last key element of ADM entails connecting investment agendas from delta management with other policy areas (such as infrastructure, urban development, nature, and recreation). Connecting investment agendas can result in financial benefits or societal added value. You can think of combining construction works to reduce the amount of inconvenience for the area or save construction costs (Van Rhee, 2012). An example is the Prins Hendrik dike constructed in Texel. The design of the dike was adjusted so that it also met the ambitions in nature conservation; for which the ancillary expenses were paid by the Wadden fund (Bloemen et al., 2019).

2.3. Tracing the scientific foundation of ADM within adaptive approaches

Early applications of adaptive approaches can be found a few decades ago when the notion of Adaptive Management (AM) was introduced within environmental sciences (Holling, 1978). Due to our incomplete understanding of dynamic natural systems, the traditional static management approaches were falling short for dealing with natural resources. AM has emerged to support natural resource management policy by confronting uncertainty. AM approaches acknowledge that changes in the managed resources due to human intervention will always occur, that surprises are unavoidable and that new uncertainties will continue occurring. AM entails a systematic process of active learning from the outcomes of management actions, accommodating change and thereby improving management (Gunderson, 1999).

A more recent development of adaptive approaches is the introduction of Adaptive Policy-Making (APM). The rationale behind APM corresponds with AM since they share the rationale that it is impossible to have one single static strategy that performs well under all possible futures. An essential difference in APM in comparison to AM is the source of uncertainty. In APM, the primary source of uncertainty is external developments outside the control of policymakers. The research in AM considers uncertainties arising out of the system's complexity that the policymaker is trying to manage as the primary source of uncertainty (Kwakkel et al., 2010). The difference in the source of uncertainty in both fields makes that the approach for coping with uncertainty in both areas is also different; AM acknowledges uncertainty and therefore plans to adapt the strategy when the conditions change. APM goes a step further; this policy method already explores the possible futures and tries to identify the adaptive strategy that performs best over all possible futures. Thus, AM learns from the past and APM learns by exploring the future.

APM advocates for a systematic approach that explores the range of plausible future scenarios for the key uncertainties. Subsequently, the performance of the considered adaptive strategies should be tested over the scenarios (Lempert et al., 2003). The policymaker may already start implementing the best performing short-term measures but plan to adjust them in specific ways when new information comes available that make some scenarios more likely and others improbable. Instead of trying to predict the future and finding measures that fit this envisioned future, policymakers can now gain a systematic understanding of the best short-term measures that keep several long-term options open while considering several plausible future scenarios (Lempert et al., 2010). This helps policymakers identify short-term adaptive measures that are robust over an extensive range of plausible futures. APM not only prescribes the development of scenarios but also a monitoring system and predefined responses when specific trigger values are reached (Walker et al., 2001).

In 2012, a new adaptive approach named Adaptation Pathways was introduced (Haasnoot et al., 2012). The Adaptation Pathways approach shows which measures are needed, when they should be implemented, and how long-term objectives influence short-term decisions. The adaptation pathways were combined with APM into the Dynamic Adaptive Policy Pathways (DAPP) approach (Haasnoot et al., 2013). The ADM approach developed in the Netherlands is based on the DAPP approach (Bloemen et al., 2019).

2.4. Sea-level rise in the Netherlands

This section describes the latest findings on the speed and severity of sea-level rise. Thereafter, the current status of coping with sea-level rise in the Netherlands is explained, and is emphasized on why using an adaptive approach is essential.

2.4.1. The uncertainty of sea-level rise

The most recent IPCC report indicates that the global mean sea level is rising, and most likely, the rise of the sea level is accelerating. The IPCC projections indicate a global mean sea-level rise of 0.29 to 1.1 meter in 2100 for the RCP2.6 and RCP8.5 scenarios (Oppenheimer et al., 2019). The RCP2.6 and RCP8.5 are the best- and worst-case scenario used by the IPCC on how fast global emissions are mitigated. Beyond 2100, the sea-level rise will continue due to continuing deep-ocean heat uptake and mass loss of the Greenland and Antarctic ice sheets. The projections of the IPCC in 2019 are visible in figure 3.

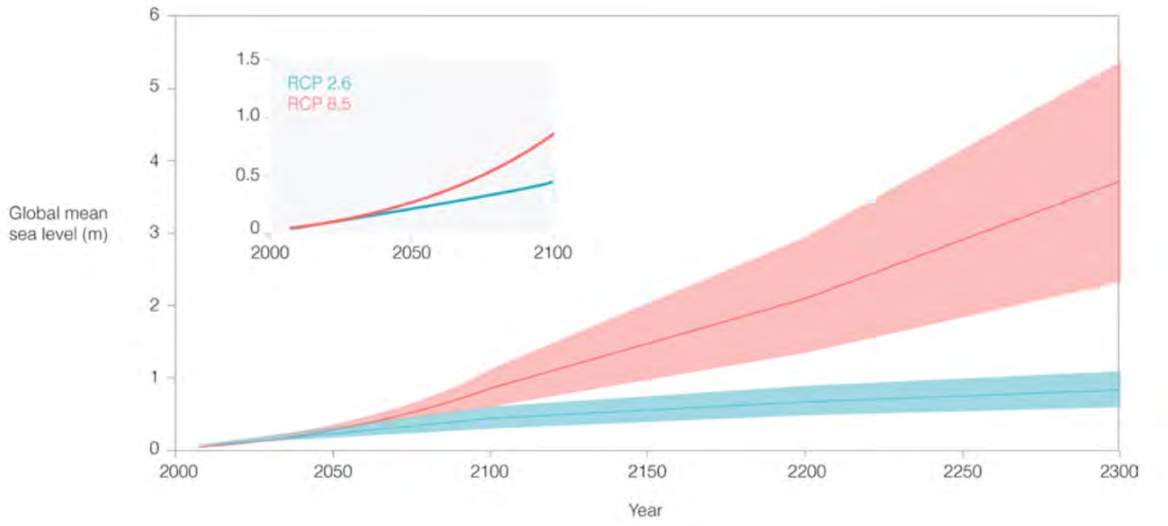

Figure 3: IPCC's projections of global sea-level rise (Opperheim et al., 2019) Visualization retrieved from Swinkels (2020)

In addition to the IPCC's projections discussed above, potential ice mass loss from Antarctica could lead to a more rapid increase of sea-level rise. The potential ice mass loss could result in a sea-level rise of 2 meters before 2100, even if we manage to keep global warming below 2 °C (Le Bars et al., 2017). However, no consensus has been reached in the scientific community about the probabilities that such extreme sea-level rise scenarios can be reached before the end of this century (Haasnoot et al., 2020).

Besides the uncertainty around sea-level rise on the global level, additional uncertainty is encountered on the effects of sea-level rise on a regional level. The amount of sea-level rise will not rise homogenous over the globe. Differences up to 30% can be expected between different regions due to thermal expansion, ocean dynamics and land ice loss (Oppenheimer et al., 2019).

The rising sea levels represent a growing threat to urbanized deltas all over the world, including the Netherlands. The consequences are enormous for a low-lying country like the Netherlands. Haasnoot et al. (2020) researched the consequences for the Netherlands of a sea-level rise along the Dutch coast of 2 meters. The outcomes are that the volume of sand needed for beach nourishment of the Dutch coast may be 20 times larger than today. Also, storm surge barriers will have to close more and more often until they need to be closed permanently, blocking shipping

business to the port of Rotterdam. Also, the increase in sea-level rise will cause intensified saltwater intrusion via the rivers, while the expectation is that the demand for fresh surface water will rise because of salt intrusion in the groundwater. The question is not whether sea-level rise will occur but when this will occur (Haasnoot et al., 2020).

2.4.2. Strategies to cope with sea-level rise in the Netherlands

The large uncertainty about the speed and severity of sea-level rise challenges decision making. The uncertainty comes with the risk of either underestimating or overestimating the effects of sea-level rise. Underestimation of the risks may lead to underinvestment in coastal measures, which may result in that policy objectives (such as water safety norms) cannot be met. Overestimation of the risks leads to overinvestment, leading to unnecessary expenses for society. Therefore, an adaptive approach is chosen to deal with uncertainty about future sea-level rise and minimize regret about investment decisions (Haasnoot et al., 2020).

The expectation is that the Dutch coast's current strategy can be maintained until at least 2050 (DP2021, 2020). The current strategy called 'soft where possible, solid where needed' is flexible. The soft measures are beach nourishment, which can flexibly grow apace with the rise of the sea level. To explore the strategies in the long-term, the Delta Commissioner has asked Deltares to explore possible strategies for the Netherlands to cope with extreme sea-level rise. Extreme sea-level rise is defined as a rise of the sea level of 2 to 4 meters along the Dutch coast. Deltares' exploration aimed to identify the short-term measures needed to keep all strategies for the long-term open. Short-term is defined as the period of the upcoming 20 years, and long-term is the period beyond 2080 (Haasnoot et al., 2019). The rationale is that the LT strategies identified can protect the Netherlands against extreme sea-level rise over the next 100 to 200 years. The exploration identified four LT-coastal adaptation strategies covering the entire solution space to cope with extreme sea-level rise in the Netherlands. These LT strategies are derived from IPCC's proposed adaptation strategies for coastal systems and low-lying areas (Wong et al., 2014). The four LT-coastal adaptation strategies comprise:

- Protect-Closed: Protecting the Dutch coast against flooding using solid or soft measures such as barriers, beach nourishment or wetlands. River arms will be closed by establishing dams or storm surge barriers
- Protect-Open: Similar to Protect-Closed, except for that the river arms will remain open to the sea
- Seaward: Creating new elevated seaward land to protect the Dutch delta against sea-level rise. This strategy implements measures that will influence the morphological system in such a way that the coastline will not erode any further, but will be kept in place or move in a seaward direction (De Ruig, 1998)
- Accommodate: Allows the shoreline to move inland, instead of holding the coastline with structural engineering. This coastal management strategy would be combined with reducing the vulnerability of the Netherlands for the consequences of sea-level rise by enabling water- or salt-tolerant land use (e.g. buildings on piles or cultivation of crops on saline soils), elevating land, adjusting spatial planning or stimulating migration towards higher-lying areas

At this moment, it is not possible to determine the amount of sea-level rise that each LT strategy can cope with, the total costs and the societal consequences; these depend on the LT strategy's exact design. Therefore, too little information is available to already eliminate one of the strategies. Furthermore, per region, another LT strategy might be preferred in the future based on the characteristics of the area. For example, the LT-coastal adaptation strategy Accommodate would make more sense for an area that is sparsely populated than for a densely populated area with a lot of economic activity. In theory, all four LT-coastal adaptation strategies could play a role in the regional strategies to protect the Netherlands against sea-level rise. At this moment, it is not possible to eliminate one of the LT-coastal adaptation strategies or to choose one above the others. Which LT-coastal adaptation strategy will be chosen in the future will be influenced by external developments or the occurrence of an external event with an enormous impact (such as

a major flooding or an economic crisis) (Haasnoot et al., 2019). Hence, Dutch delta management aims for keeping all LT-coastal adaptation strategies open until external developments occur that make one or more strategies less viable. This approach is in line with the ADM approach as described in the Delta Program, since it connects short-term decisions with long-term objectives and it looks for flexibility by keeping multiple strategies open.

2.5. Conclusion

The scientific foundation of the ADM approach in the Netherlands was explored within the development of adaptive approaches. The ADM approach developed in the Netherlands is based on the combination of Adaptive Policy-Making (APM) and the Dynamic Adaptive Policy Pathways (DAPP) approach.

Furthermore, four LT-coastal adaptation strategies for the Dutch coast are identified to protect the Netherlands against sea-level rise in the long term; Protect-Closed, Protect-Open, Seaward and Accommodate. Due to deep uncertainty around sea-level rise, it is not possible to eliminate one of the LT-coastal adaptation strategies or choose one above the others. Hence, Dutch delta management aims to invest in short-term measures that keep all LT-coastal adaptation strategies open in the Netherlands.

3

Theoretical governance framework ADM

This chapter aims to explore how ADM should be shaped according to theory. An integrative literature review will be performed to identify the institutional and instrumental governance elements essential for ADM. Also, the relative importance of the governance elements for ADM will be explored.

3.1. Approach for the literature review

In this chapter, an integrative literature review is performed to gain a deeper understanding of how the governance of delta management should be organized according to scientific research. An integrative review method reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated (Sacred Heart University Library, n.d.). In this research, an integrative literature review method is used to compose an overview of the governance elements discussed in the literature that are important for applying ADM. Because the amount of research into the governance dimension of ADM is fairly limited, articles are also studied that provide a more general assessment of ADM instead of only focusing on ADM's governance perspective. From these more general assessments of ADM, only the governance elements discussed are included in the results of this literature review. In Appendix C, a more detailed description of the selection process, the search terms used, and an overview of the articles included in this literature review can be found. After the framework was composed, additional scientific articles covering the DAPP approach (the scientific foundation of ADM – see Chapter 2) were consulted to supplement how the instruments of ADM should be applied according to its theoretical foundation.

Section 3.2 presents the theoretical governance framework established by the literature review, discussing what ADM's institutional and instrumental governance should look like according to theory. In Section 3.3, the relative importance of the elements is analyzed. Finally, Section 3.4 concludes on the main findings and the meaning for the rest of this research.

3.2. The governance elements of ADM

In the literature review, the articles were studied to deduct which elements are essential for the governance of ADM. The elements identified combined form the theoretical governance framework of ADM (table 2). The elements found were divided into two categories: institutional and instrumental governance elements. Institutional governance elements define what the organizational structure should look like to apply ADM. Institutional governance is about the roles, responsibilities, and interactions of the actors involved in ADM. The instrumental governance defines the methods and tools that are distinctive for ADM. The instrumental governance elements describe what methods and tools should be incorporated and how they should be applied in practice. In this section, all institutional and instrumental governance elements will be discussed one by one.

Institutional governance elements	Instrumental governance elements
Clear agreements on roles and responsibilities	Scenarios – Static scenarios or transient scenarios outline the major uncertainties that play a role in decision making
Transparent information management	Adaptation pathways – Outline the possible strategies, the signposts that should be monitored and the transfer stations on which can be switched to another strategy
Engagement of multiple actors at various levels in monitoring	Adaptation tipping points – Indicate the endpoint of a strategy, which is when a strategy no longer meets the predefined objectives
Engagement of multiple actors at various levels in evaluation	Monitoring system – Keep track of the external developments that may lead to adjusting choices and strategies continuously
Coordination at a higher level than implementation	Evaluation system – Evaluate if pursuing current strategies will lead to reaching the predefined objectives in time considering the external developments and recalibrating strategies whenever new monitoring information comes available

Table 2: Theoretical governance framework of ADM

3.2.1. Institutional governance elements ADM

Clear agreements on roles and responsibilities

First of all, clear agreements should be made about the roles and responsibilities of the actors involved in ADM. The parties that play a role in ADM must understand their responsibilities and tasks (Hermans et al., 2016). Besides, it should be clear to the actors involved in ADM to know what they can expect from each other; this increases mutual trust and stimulates collaboration. For instance, it must be clear who is responsible for monitoring sea-level rise, when the measurements are taken, where the monitoring stations are located and how the data is processed. Therefore, it must be clear who does what, when and how?

Transparent information management

Also, transparency in information management is critical for applying ADM. ADM is a data-driven policy method in which new information on developments determines the course of the strategy. Therefore, all parties involved in delta management must have access to the latest information on external trends and developments of climatic or socio-economic conditions. For example, suppose that Deltares monitors the water levels in the Netherlands and processes the data to predict water levels in the near future. This monitoring information should also be available for other parties, such as regional water authorities, to know when high water levels are forecasted and when they have to take preparatory measures. Besides, it must be clear where information comes from. Information that is being monitored by one party should also be accessible to the other parties (Hermans et al., 2016). Furthermore, the information shall be managed and stored in the long-term to be able to learn about existing trends and developments.

Engagement of multiple actors at various levels in monitoring

Then, multiple actors on various levels should be involved in monitoring (Hermans et al., 2017). Multi-level monitoring of external developments contributes to a deeper understanding of external developments than single-level monitoring. For example, to identify trends in sea-level rise, monitoring shall not be limited to sea-level rise along the Dutch coast, but also melting of the ice caps and sea-level rise globally. The call for incorporating multi-level information stresses the importance of the involvement of actors at all levels (Bloemen et al., 2018). Involving multiple actors in the monitoring process of the external developments relevant to delta management

contributes to the reliability of the knowledge obtained. This is particularly valuable due to our incomplete understanding of dynamic natural systems; multiple actors can keep each other sharp. Therefore, coupling information streams should take place (Loeber & Laws, 2016). Furthermore, involving multiple levels helps to improve information flows and knowledge exchange between these levels (Restemeyer et al., 2017). In doing so, transparent transformation management is enhanced.

Engagement of multiple actors at various levels in evaluation

Involving multiple actors at various levels in evaluating if pursuing current strategies will lead to reaching the objectives in time is important for the governance of ADM (Hermans et al., 2017). Evaluation should not be limited to the national level actors, but local and regional level actors should also be involved. The engagement of local stakeholders is essential for safeguarding the quality of the plans by incorporating their local knowledge. For instance, farmers know best when sea-level rise causes crucial salt intrusion values for growing crops and dike reinforcement is needed. Also, the engagement of local stakeholders is vital for the support of the plans (Bloemen et al., 2018).

Coordination at a higher level than implementation

ADM strategies should be coordinated at a higher level than the level where they are implemented to increase consistency (Bloemen et al., 2018). If different regions develop adaptation pathways maps without aligning them, the regional adaptation pathways may conflict with each other, making it difficult to add up the different maps into a national plan (Dewulf & Termeer, 2015). This was one of the lessons learned in New York, where the higher-level coordination missing led to significant differences in local approaches. When Hurricane Sandy struck, the patchwork of approaches was not successful in protecting New York against the severe consequences of the hurricane (Rosenzweig & Solecki, 2014). This resulted in major flooding, evacuation problems, electricity outages, and even the death of citizens. Policymakers should be aware that security threats stemming from climate change do not know borders, and therefore an overarching strategy for resiliency is needed. Flexible adaptation strategies need to be locally appropriate yet regionally coordinated. Applying this to Delta management in the Netherlands, it should be ensured that local measures fit the regional strategy of the area and that the regional strategies are aligned nationally. Besides, the objectives formulated in the areas of flood risk management, freshwater availability and climate-proof land use planning should be aligned.

3.2.2. Instrumental governance elements ADM

Instruments of ADM that policymakers should use are scenarios, adaptation pathways, and adaptation tipping points (Gersonius et al., 2016).

Scenarios

Scenarios are descriptions of alternative hypothetical futures based on coherent and internally consistent assumptions that reflect different perspectives on past, present and future developments (Lempert, 2013). An ensemble of plausible futures should be incorporated in decision making in the form of scenarios. The scenarios should include the major uncertainties that play a role in decision making such as external developments. The scenarios can be static scenarios (describing an endpoint in the future) or transient scenarios (describing developments over time) (Haasnoot et al., 2019). Since delta management's main uncertainties are climate change and socio-economic conditions (Bloemen et al., 2019), the scenarios used by policymakers should contain these developments.

Adaptation pathways

The adaptation pathways of ADM are based on Dynamic Adaptive Policy Pathways developed by Haasnoot et al. (2013), see figure 4. Adaptation pathways show possible strategies and the moments on which to switch to another strategy. Strategies consist of actions that can be taken to safeguard a future-proof delta. All strategies presented satisfy a pre-defined performance level, such as the safety norm. The performance levels are the criteria that all strategies have to meet to

ensure acceptable results. Switching between strategies can happen simply because the possibility exists of switching or because a strategy is no longer viable. In the first case, it can be decided if, based on external developments, it is preferred to pursue the current strategy or to switch to another strategy. In the adaptation pathway map in figure 4, the moments on which it can be decided to pursue the current strategy or to switch strategy are indicated by 'transfer stations'. The endpoints of a strategy are demarcated as 'adaptation tipping points' (terminals). After reaching an adaptation tipping point, additional measures are needed to achieve the objectives. Some strategies do not meet the predefined minimum performance level in some of the scenarios; dashed lines represent these moments. It cannot be determined yet if this strategy will be viable in the future with the current knowledge. When the decision moment comes closer, the amount of uncertainty will decrease. The preference of decision-makers or other stakeholders for a particular strategy depends on the costs and benefits of the strategies considered. When applying adaptation pathways, 'signposts' and 'triggers' should be determined upfront. Signposts specify the information that should be monitored to determine whether the plan is still meeting the conditions for its success. These signposts can either provide information over external factors (e.g. sea-level rise), policy objectives (e.g. costs or water supply levels) or policy possible side-effects (Hermans, 2016). Triggers are the critical values of signpost variables beyond which additional actions or measures should be taken (Haasnoot et al., 2013).

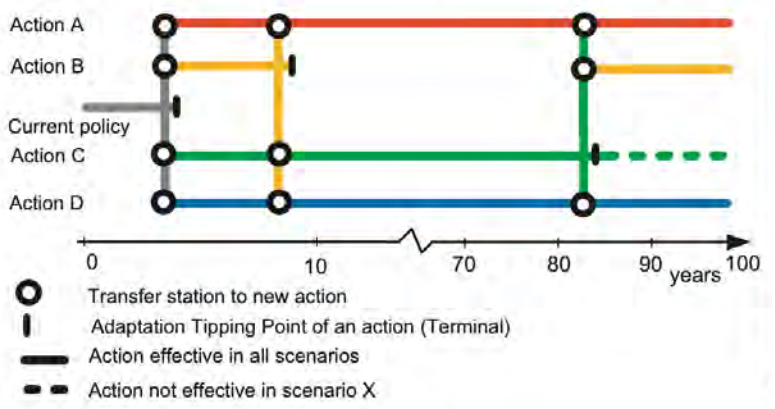

Figure 4: Dynamic Adaptive Policy Pathways map (Haasnoot et al., 2013)

Adaptation tipping points

The endpoint of a strategy is demarcated as an 'adaptation tipping point' (terminal), which is when a strategy no longer meets the predefined objectives (Haasnoot et al., 2013). Adaptation tipping points occur because external conditions (e.g. sea-level rise) make that the strategy will no longer meet the objectives. Therewith, adaptation tipping points give insight into when a water management strategy might fail and other strategies are needed (Kwadijk et al., 2010). The predefined objectives that have to be met can take shape in a pre-defined minimum performance for water safety, freshwater availability or other policy objectives. But adaptation tipping points might also occur because strategies become too expensive, technically impossible or societally unacceptable (Dewulf & Termeer, 2015).

Monitoring system

Having a clear monitoring system in place is essential for the governance of ADM in practice. The monitoring system aims to keep track of the external developments (*signposts*) that may lead to adjusting choices and strategies. It important is that monitoring these external developments happens continuously (Zevenbergen et al., 2018; Dewulf & Termeer, 2015). By ensuring that external developments are constantly monitored, the risk is of overlooking signals is being minimized. Besides, continuous monitoring contributes to being able to identify trends and long-

term developments. The dynamic character of adaptive strategies, and the high stakes involved (e.g., flooding, shortages of freshwater), require the continuous alertness of decision-makers. Choosing an adaptive strategy imposes higher requirements for generating and interpreting data on actual changes and possible future changes in external physical conditions, knowledge and innovation, and societal preferences (Bloemen et al., 2019).

Evaluation system

For adaptive approaches to be successful, policymakers should have a proactive attitude towards new developments and insights (Bloemen et al., 2019). A clear evaluation system must be in place to assess if pursuing current strategies will lead to timely reaching the objectives considering the external developments. New information found on external developments' performance should be incorporated to determine if pursuing the strategy will meet the predefined objectives. Based on the collected information, actions are started, altered, stopped, or expanded in reaction to this information (Bloemen et al., 2019). The situation and the associated uncertainties must be iteratively re-assessed (Dewulf & Termeer, 2015). Continuously evaluating and recalibrating strategies whenever new monitoring information comes available is needed (Hermans et al., 2016).

3.3. The relative importance of the governance elements

All the institutional and instrumental governance elements described above are deducted from the literature review. Apart from understanding which governance elements are essential for enhancing adaptation, it is also important to understand the relative importance of the governance elements. The governance elements and their relative importance will be used in Chapter 6 to determine if the current application of the elements in practice contributes to adaptation to sea-level rise. If it turns out that adaptation to sea-level rise is not enhanced at this moment, the analysis of the relative importance indicates on which governance elements should be focused first.

Because no research was found on the importance of the elements in literature, this section analyzes the relative importance of the elements for enhancing adaptation. Too little information is available on the elements to assign quantitative weights to them; therefore, the relative importance of the elements is assessed. The following rank order is established:

1. Institutional governance elements present
2. Incorporation of scenarios
3. Incorporation of adaptation pathways, monitoring system and evaluation system
4. Definition of adaptation tipping points

The institutional governance elements describe what the organizational structure should look like for applying ADM. The combination of the institutional elements identified form the foundation that is required to apply ADM. Because all the institutional governance elements must be present to apply the instruments of ADM effectively, they are considered requirements for the governance of ADM of equal importance.

The instrumental governance elements describe the tools that can be used for enhancing adaptation. Scenarios, adaptation pathways and tipping points are the basic elements that need to be in place for enhancing adaptation. After these elements are in place, a monitoring system and an evaluation system shall track external developments and assess if adjustments of strategies are needed. The first step in applying ADM includes the specification of the major uncertainties to generate an ensemble of plausible futures in the form of scenarios (Haasnoot et al., 2015). Adaptation pathways, tipping points, the monitoring system and the evaluation system, are based on the scenarios and the primary sources of uncertainty that the scenarios contain. Therefore, scenarios are considered the most important instrumental element for enhancing adaptation. Then, adaptation pathways, the monitoring system and the evaluation system are the second most important. Adaptation tipping points have the lowest relative importance. The rationale behind

this is that adaptation tipping points are only a sub-component of adaptation pathways. It is important to note that although the relative importance of the governance elements differs, all elements have been identified as essential for the governance of ADM according to theory.

3.4. Conclusion

A theoretical framework has been developed based on the integrative literature review, including ADM's institutional and instrumental governance elements (table 2, p. 30). The institutional governance elements define what the organizational structure should look like to apply ADM according to theory. The instrumental governance elements describe what methods and tools should be incorporated and how they should be applied theoretically. The institutional governance elements can be seen as requirements for enhancing adaptation; only if all institutional governance elements are in place, a proper foundation is in place for applying the instruments of ADM. Regarding the instrumental governance elements, scenarios were identified as the most important instrument for enhancing adaptation. Thereafter come adaptation pathways, the monitoring system and the evaluation system. Finally, adaptation tipping points were assessed to have the lowest relative importance. Nonetheless, all the elements included in the theoretical governance framework of ADM have been identified as critical for the governance of ADM.

The findings of this chapter serve as the theoretical foundation for how ADM should be governed theoretically. In Chapter 4, empirical research will be performed to check if the institutional governance in practice meets all the institutional governance requirements that have been identified in this chapter. In Chapter 5, empirical research will explore if the application of ADM's instruments in practice is coherent with the theoretical instrumental governance elements based on the DAPP approach.

II

Empirical Research

4

Institutional governance of ADM

This chapter explores how the institutional governance of ADM is organized in practice, and if the institutional governance is coherent with the elements of the theoretical governance framework.

4.1. Approach for the empirical research into the institutional governance

A combination of primary and secondary sources is used to study the institutional governance of ADM in practice. First, secondary sources, such as policy documents, advisory reports and scientific articles, are reviewed to explore the institutional context of delta management and the roles, responsibilities, and interaction between the actors of ADM. Then, interviews are performed to obtain more insights into the perceived roles and responsibilities, and informal interactions.

This chapter is structured as follows; Section 4.2 explains the institutional context of delta management in the Netherlands. Then, Section 4.3 elaborates on the roles and responsibilities of the actors of ADM and the interactions between them. In Section 4.4 will be studied how the institutional governance elements (Chapter 3) have taken shape in practice for the actors of ADM. Based on these findings, Section 4.5 concludes on if the organizational structure of the actors involved in ADM in practice meets the theoretical institutional requirements (as outlined in Chapter 3).

4.1.1. Identification of the actors of ADM

The objective of this chapter is to explore how the institutional governance of ADM is shaped in practice. To achieve this objective, the first step is to identify what actors are involved in ADM. The initial set of actors that play a role in ADM are identified employing desk research consisting of policy documents. After that, additional actors that play a role in ADM are identified through snowball mapping, which entails asking a few initial actors to identify new stakeholder categories (Resin, 2020).

The actors that play a role in the governance of ADM in the Netherlands are referred to as 'the actors of ADM' (table 4, p. 38). In the Netherlands, each sub-program of the Delta Program has its strategy to meet the objectives in flood risk management, freshwater availability and climate-proof spatial planning (Appendix B). These strategies set the course for which measures should be implemented (Delta Program, n.d.). Based on this, it is concluded that to enhance delta management's adaptivity in the Netherlands, both the strategies and the implementation should be adaptive. The actors identified as essential for ensuring that the strategies are adaptive are the actors involved in the recalibration of the strategies. These actors are the Signal Group, the Knowledge Network, Research Program Sea-Level Rise, (Staff) Delta Commissioner, the Delta Program Sub-Programs, and various knowledge institutions. The implementing actors identified are regional water authorities, municipalities and drinking water utilities. In Appendix D, a detailed description of the actor identification process is presented.

4.1.2. Interviews

In total, fourteen interviews were conducted. The majority of the interviews were held with representatives of the actors of ADM. Unfortunately, scheduling an interview with a representative of a drinking water utility has not been achieved. Furthermore, it was ensured that some of the relevant knowledge institutions were represented (KNMI, PBL and Deltares). While performing interviews, it was found that the engineering consultancy company 'Sweco' researched the application of ADM on the implementation level. In addition, it was found that an alliance of the regional water authorities and the Flood Protection Program (HWBP) checks if the design of new delta measures on the implementation level meet the flood risk management norms. Therefore, HWBP was added to the interview list because it was expected that they have information on the application of the instruments of ADM on the implementation level. The overview of participating actors in the interviews is shown in table 3.

Interview with representative of:	Category:
The Signal Group	Strategy level
The Knowledge Network	Strategy level
Research Program Sea-Level Rise	Strategy level
(Staff) Delta Commissioner	Strategy level
Several knowledge institutions (KNMI, PBL, Deltares)	Strategy level
DP Sub-Programs	Strategy level
Regional water authorities	Implementation level
Municipalities	Implementation level
Sweco	Implementation level
HWBP	Implementation level

Table 3: Participating actors interviews

The interview questions consisted of two parts: the first set of questions aimed to explore the institutional governance and the second set aimed to explore the instrumental governance of ADM. The questions were based on the institutional and instrumental elements of the theoretical governance framework of ADM established in Chapter 3 (table 2, p. 30). To explore the institutional governance of the actors of ADM, implicit open-ended questions were asked that aimed to reveal if the theoretic institutional requirements are present in practice but did not steer the interviewees in a specific direction.

A semi-structured design instead of a structured design for the interview questions was used, allowing a natural flow of the conversation. The interviews were conducted in Dutch because the Dutch language is used for all communication in the delta management sector in the Netherlands. The list of questions was unique for every interview. Based on the information obtained in desk research on the roles, responsibilities and interactions, the questions were tailored to that specific person and organization. Furthermore, the semi-structured interview design also leaves room to alter or add questions based on how the interview evolves. An overview of the interviewees, the interview set-up, the interview questions, and how obtained data are processed can be found in Appendix E.

4.2. The institutional context of delta management

In the Netherlands, delta management is carried out at all government levels (OECD, 2011). The roles and responsibilities of the actors involved in water management are laid down in the 2009 Water Act. According to the Dutch central government (Rijksoverheid, n.d.), the following governmental authorities are involved in water management in the Netherlands:

- The Ministry of Infrastructure and Water Management (part of the Dutch Central government) makes the national delta policy and ensures alignment with other alternate policy areas
- The National Water Authority (Rijkswaterstaat) is the implementing party of the ministry. The National Water Authority is under contract for operation and maintenance of the main water system (include the North Sea and the main rivers)
- Provinces ensure integrated spatial planning of the regions under their responsibility
- Regional water authorities are responsible for managing the regional water systems
- Municipalities are responsible for spatial planning at the local level

In addition to these governmental authorities, a few other actors are involved in water management:

- Drinking water utilities have the responsibility of ensuring drinking water supply
- The Delta Commissioner is in charge of the Delta Program, in which the ministry is advised on how to make the Dutch delta climate-proof
- Various institutes, advisory committees, associations, and NGOs are present in Dutch delta management

4.3. The actors of ADM

Table 4 provides an overview of the actors of ADM. This section explains the roles, responsibilities and interactions of the actors of ADM.

Actor	Role ADM	Level
The Signal Group	Interpretation monitoring information + evaluation	Strategy
The Knowledge Network	Interpretation monitoring information + evaluation	Strategy
Research Program Sea-Level Rise	Interpretation monitoring information + evaluation	Strategy
(Staff) Delta Commissioner	Advice on delta decisions and strategies	Strategy
Knowledge institutions	Knowledge generation, monitoring and advisory role	Strategy
DP Sub-Programs	Recalibration of regional and thematic strategies	Strategy
Regional water authorities	Regional water management	Implementation
Municipalities	Land use planning	Implementation
Drinking water utilities	Drinking water availability	Implementation

Table 4: The actors of ADM

4.3.1. The process of adaptation

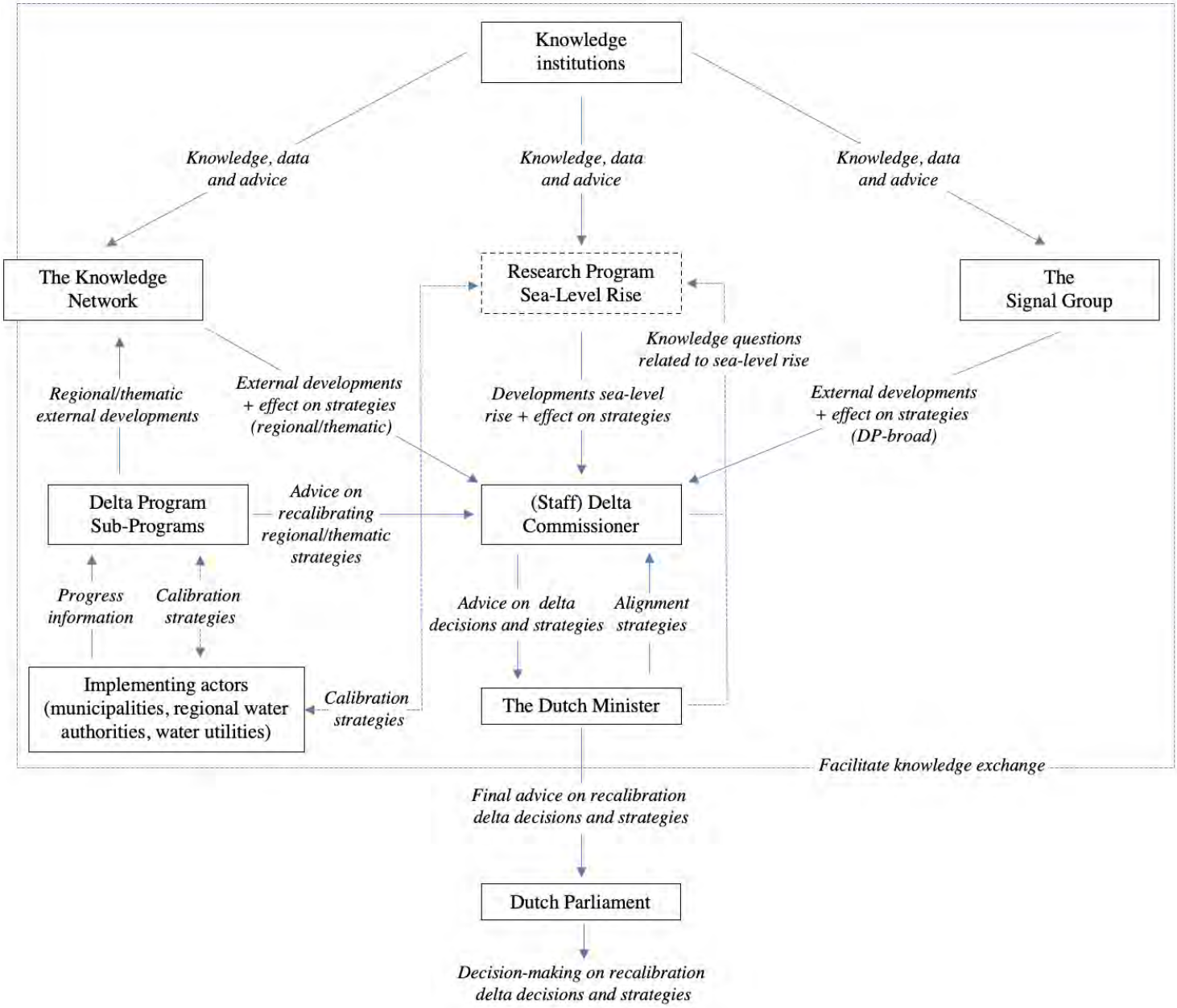

Figure 5: Interactions between the actors of ADM

In figure 5, a schematic representation of the interactions between the actors of ADM is visible. The figure shows who reports to whom and what information is shared between actors. The actors and the interactions between them are based on a combination of desk research and information obtained in the interviews conducted with the actors of ADM.

The two main causes for recalibration of delta decisions and strategies are external developments and if the execution of plans is on schedule. Knowledge institutions are an important source for information on external developments and providing advice. The information on external developments is interpreted by the Knowledge Network, Research Program Sea-Level Rise and the Signal Group. When one of them detects a change in external developments that might compromise the Delta Program's objectives, a signal is issued to the Delta Commissioner. The (Staff) Delta Commissioner will then issue advice to the Dutch Minister (from the Ministry of

Infrastructure and Water Management) on how to move forward from that point; this might be by setting up a plan to conduct additional research into the signal or by advising on the recalibration of strategies. An example is that in 2018, signals for sea-level rise were detected; this resulted in the ad-hoc establishment of Research Program Sea-Level rise. Besides, that information from knowledge institutions can cause recalibration of delta decisions and strategies, recalibration can also occur because the execution of plans is not on schedule. Implementing actors report on the progress of the execution of delta decisions and strategies to the DP Sub-Programs. Based on this progress information, the DP Sub-Programs can evaluate if the execution of the plans is on schedule. When the execution is not on schedule, the DP Sub-Programs can advise the Delta Commissioner on the recalibration of delta decisions or strategies. The Dutch Minister has the formal responsibility of offering the Delta Program (containing advice on the recalibration of delta decisions and strategies) to the Dutch Parliament. Finally, the Dutch Parliament has the final vote in deciding to formalize, adjust or decline the proposed adjustments in delta decisions and strategies. A more elaborate explanation of the roles and responsibilities of the actors of ADM can be found in Section 4.3.

4.3.2 Interactions

Next to the formal interactions visible in figure 5, informal interactions occur, and overlap exists between the actors of ADM. The delta management sector in the Netherlands is a close-knit sector in which many actors know each other personally. Also, many individuals work for or are involved in more than one entity that plays a role in ADM. For example, an individual can be part of the (Staff) Delta Commissioner but also be involved in the Knowledge Network and the Research Program Sea-Level Rise simultaneously. The close network and overlapping individuals result in more interaction and knowledge exchange between the actors of ADM than is visible in the schematic representation of the interactions. The consequences of the informal interactions for the institutional governance of ADM will be discussed in Section 4.4.

4.3.3. Roles and responsibilities actors of ADM

In this section the roles and responsibilities of the actors of ADM are explained. In most of the actors of ADM, various knowledge institutions are involved. More information on the knowledge institutions can be found in Appendix D.

<u>The Signal Group</u>

In 2017, the Signal Group (*De Signaalgroep*) was established under the direction of the (Staff) Delta Commissioner. The Signal Group consists of employees from relevant knowledge institutions and the National Water Authority (RWS - explained in Section 4.2). The representated knowledge institutions are Deltares, KNMI, PBL, WUR, and CBS. The Signal Group's objective is to provide input for the six-yearly recalibration and, if needed, for interim adjustments of delta decisions and strategies (DP2019, 2018). The Signal Group keeps track of external developments (*signposts*) that can be important for the Delta Program by combining the information from all relevant knowledge institutions. A list with all relevant external developments is established consisting of socio-economic indicators, climatic indicators, and knowledge and innovation. Besides, the Signal Group is also paying attention to other developments outside of the list. The combined information is analyzed to examine if there are any signals that adjustments of existing delta decisions and strategies are needed. Adjustments might be needed because the external developments might put the objectives in the areas of flood risk management, freshwater availability and climate-proof land use planning at risk (and adaptation tipping points occur). If the Signal Group observes a signal, this is communicated to the (Staff) Delta Commissioner. Every year the Signal group reports to the (Staff) Delta Commissioner about the yearly developments of all external developments in a letter.

Formally, the Signal Group's involvement ends after reporting the observed signals to the (Staff) Delta Commissioner. In practice, the Signal Group also advises the (Staff) Delta Commissioner on which additional follow-up actions or research is needed.

The Knowledge Network

The Knowledge Network (*Het Kennisnetwerk*) exists of representatives of knowledge institutions and the Delta Program sub-programs (Appendix B). Participating knowledge institutions are, among others, Deltares, PBL, KNMI, STOWA, TU Delft and WUR. The Knowledge Network keeps an overview of all research taking place on Delta Program-broad topics. Delta Program-broad topics consist of flood risk management, freshwater availability and climate-proof land use planning. The Knowledge Network's first objective is connecting actors in the delta management sector that might have valuable information or knowledge for each other. The output of one actor is the input for another, and the Knowledge Network ensures the connection between the actors. Often the actors that have knowledge questions are implementing actors within the sub-programs of the Delta Program. The Knowledge Network's second objective is signaling if any thematic or regional-specific external developments might affect the objectives of the Delta Program (DP2019, 2018). The Knowledge Network is a facilitating organization and does not report to anyone, therefore, the Staff Delta Commissioner pays attention to the activities taking place in the Knowledge Network.

Apart from the formal responsibility of facilitating knowledge exchange and signaling regional-subtheme developments, the Knowledge Network's informal role is nurturing the content of research programs. The knowledge questions asked by implementing actors are currently not being addressed by research programs but are relevant for the themes of the Delta Program. These are put on the agenda of research programs by the Knowledge Network. For example, based on the sub-programs knowledge questions, the Knowledge Network provided input for the set-up of Research Program Sea-Level Rise.

Research Program Sea-Level Rise

Research Program Sea-Level Rise (*Kennisprogramma Zeespiegelstijging*) is a collaboration between representatives of (Staff) Delta Commissioner and the Ministry of Infrastructure and Water Management. The National Water Authority (Rijkswaterstaat), KNMI, and Deltares support the research that is taking place in the research program. The ad-hoc research program kicked off in 2019, and the duration is until 2025. The objective is to provide relevant information regarding sea-level rise for the Delta Program's six-yearly recalibration in 2026 (Ministry of Infrastructure & Water Management, 2019). Until 2023, the focus of the Research Program Sea-Level Rise is knowledge generation. In this period, also the new KNMI-scenarios and new IPCC findings will be released. Research Program Sea-Level Rise advises directly to (Staff) Delta Commissioner. The progress of the research program is yearly reported in the Delta Program. Finally, in 2026, the program's outcomes will be translated into possible adjustments of delta decisions and strategies (Delta Program, 2020).

The research program has organized the most critical knowledge questions along five tracks (Ministry of Infrastructure & Water Management, 2019):

1. Research sea-level rise: what can we expect?
   Follows international research into sea-level rise and performs research into how the Netherlands can contribute to this research. Objective: have access to all information available at every moment and translate what the information means for the Netherlands.
2. System explorations: what is the tenability of the existing strategies?
   Explores what the sea-level rise scenarios mean for the natural (sandy) system of the Dutch coast and rivers, water barriers, flood defence systems, freshwater availability and climate-proof land use planning. This track also explores what additional measures can be implemented for extending the durability of the preferential strategies.
3. Signaling methodology: how do we know when to act?
   Focus on researching how we can timely detect sea-level rise. Instead of waiting for the sealevel to rise along the Dutch coast, research which early-warning signals exist so that we know when to expect a sea-level rise and can timely implement measures.
4. Alternatives and adaptation pathways: action perspective for the far future?

Track 4 develops LT strategies for the Dutch delta for a sea-level rise of over 2 meters. The national LT-coastal adaptation strategies for the coast are developed by Deltares and consist of Protect-Open, Protect-Closed, Seaward, and Accommodate. In this track is researched if the long-term strategies are feasible and the implications of the strategies. Track 4 collaborates with the actors that will have to deal with these LT strategies, such as waterboards, municipalities and provinces. Objective: Develop LT strategies that can cope with sea-level rise over 2 meters and identify which short-term measures are needed to keep all LT strategies open.

5. Implementation strategy: knowledge questions around governance, communication and transition management
   Track 5 explores the social challenges that come with sea-level rise, focusing on governance, communication and transition management questions.

(Staff) Delta Commissioner

Based on the information provided by the Signal Group, the Knowledge Network and Research Program Sea-Level Rise, the (Staff) Delta Commissioner (*Staf Deltacommissaris*) can choose to advise the Minister to alter the speed of implementation of measures and delta decisions or to adjust delta decisions and strategies. But in most cases, a signal results in the advice from the (Staff) Delta Commissioner to intensify research to generate more knowledge on the drivers and effects of the external development. An example was the signal on accelerated sea-level rise issued by the Signal Group in 2018. The signal set in motion research intensification in the form of establishing a new research program: Research Program Sea-Level Rise. As a follow-up to the intensified research, the Delta Commissioner can again decide to issue advice to change the speed of implementation of measures and delta decisions or to adjust delta decisions and strategies. The Delta Commissioner's advice to the Dutch Minister of Infrastructure and Water Management is issued in the form of the yearly Delta Program, which is offered to the Parliament in September every year.

Delta Program Sub-Programs

The Delta Program has nine Delta Program Sub-Programs (*DP Deelprogramma's*), namely three thematic sub-programs and six regional sub-programs (Appendix B). Each sub-program consists of representatives from regional water authorities, provinces, municipalities, the National Water Authority, and the Ministry of Infrastructure and Water Management. The thematic sub-themes comprise water safety, freshwater, and new urban development and restructuring. The six regional sub-programs are Rijnmond-Drechtsteden, Zuidwestelijke Delta, the IJsselmeer area, the rivers, the coast, and the Wadden area. For water safety, the regional sub-programs take the initiative of recalibrating the regional strategies. For freshwater, the thematic sub-program Freshwater coordinates de recalibration of the freshwater regions (DP2019, 2018). The Delta Program sub-programs are part of the Delta Program and therefore directly report to the (Staff) Delta Commissioner.

Knowledge institutions

In the Netherlands, various actors are active in the monitoring of external developments, examples of parties that monitor external developments relevant to the Delta Program are KNMI, PBL, WUR, CBS, STOWA and TU Delft. Also, knowledge institutions provide the Delta Commissioner with advice through their representatives in the Knowledge Network, Research Program Sea-Level Rise or the Signal Group. Furthermore, Deltares is hired as partner of the Ministry of Infrastructure and Water Management for research and advice on DP-related policy decisions. Also, Deltares publishes the Delta Scenarios (explained in Section 5.2) together with PBL, CPB, KNMI, and WUR. An explanation of the knowledge institutions and their roles in delta management can be found in Appendix D.

Regional water authorities

In the Netherlands, regional water authorities (*waterschappen*) are local government bodies responsible for water management in their region. They are public authorities endowed with

specific legal personality and financial resources by the Dutch Constitution and operating in areas defined by their drainage characteristics. The responsibilities of regional water authorities comprise maintaining water levels, water quality and wastewater treatment (OECD, 2014). Another responsibility is ensuring protecting their inhabitant against flooding; this is achieved by maintenance and reinforcement of dikes and rivers (Rijksoverheid, n.d.). Regional water authorities have to ensure that their systems meet the flood protection standards, which are specified on the national level.

Municipalities

In the Netherlands, municipalities are responsible for spatial planning decisions. Therewith, municipalities play a crucial role in the Delta Program's third objective: climate-proof land use planning. They deal with sewerage collection systems, urban drainage and stormwater collection in urban areas (OECD, 2014). Different forms of adaptive strategies can be implemented in urban areas, such as land elevation, modular buildings, and permeable pavements.

Drinking water utilities

In the Netherlands, drinking water utilities are responsible for providing drinking water. Drinking water utilities retrieve water from the underground, rivers, canals or other water bodies and treat the water until it reaches the drinking quality standard. After that, the water is distributed to the consumer.

4.4. Analysis of the institutional governance elements

In Chapter 3, the institutional governance elements essential for ADM were identified by a literature review. In this section, the shape of these institutional governance elements in practice is explored. An overview of the results obtained is visible in table 5. The actors of ADM meet all the theoretic institutional governance elements, resulting in the conclusion that the organizational structure of the actors of ADM is appropriate for applying ADM's instruments. The analysis of the institutional governance elements is discussed one by one in this section.

Institutional governance elements ADM	Presence in practice
Clear agreements on roles and responsibilities	+
Transparent information management	+
Engagement of multiple actors at various levels in monitoring	+
Engagement of multiple actors at various levels in evaluation	+
Coordination at a higher level than implementation	+

Table 5: Results institutional governance ADM in practice

Clear agreements on roles and responsibilities

The first institutional governance element that is essential for ADM is that clear agreements on roles and responsibilities for the actors of ADM are in place. In the interviews was found that all the ADM actors are well-aware of their tasks and responsibilities and the roles and responsibilities of the other actors involved. A possible explanation for this is the introduction of the Administrative Agreement on Water Affairs in 2011, specifying the allocation of roles and responsibilities across public authorities involved in ADM. The only downside identified is that the actor landscape is quite complex. Many actors at various levels with different objectives are involved in ADM, leading to the decision making process not always straightforward because many actors and stakeholders are involved in decision making. However, the engagement of a large number of actors at various level is irreconcilable for applying ADM, since this is one of the theoretical requirements for monitoring and evaluation. Despite the actor landscape being rather complex, clear agreements on roles and responsibilities are in place, increasing mutual trust and stimulating collaboration.

Transparent information management

ADM is a data-driven policy method in which new information on developments determines the course of the strategy. Therefore, transparent information management is critical. In the interviews, it became clear that transparent information management is enhanced in practice because all knowledge, monitoring information and developments are publicly available. In addition, the Knowledge Network contributes to transparent information management by its formal role of facilitating knowledge exchange between the actors involved in delta management. Also, the interviews revealed that the delta management sector is a close-knit network, and several individuals are active in multiple entities; stimulating information exchange outside of the formal routes. Although this informal knowledge exchange does not contribute to 'transparent' information management, it does contribute to the goal of actors being are aware of the latest information on developments. Based on these findings, the conclusion is drawn that transparent information management is enhanced between the actors involved in ADM.

Multiple actors at various levels involved in monitoring

A large number of actors are involved in monitoring in the Netherlands, such as Deltares, KNMI, PBL, WUR, RWS-WVL, CBS, STOWA and TU Delft. Also, The Knowledge Network, Research Program Sea-Level Rise and the Signal Group keep track of the monitoring results of the many international research institutes. Also, monitoring takes place at various levels. For example, for sea-level rise, monitoring is performed for the melting of Antarctic, sea-level globally, average level of the North-Sea, and the sea-level along the Dutch coast. The multi-level monitoring of external developments contributes to a deeper understanding of external developments than single-level monitoring.

Multiple actors at various levels must be involved in evaluation

In practice, several entities are involved in evaluating if pursuing current strategies will lead to timely achieving the pre-defined objectives. For flood risk management, the regional sub-programs take the initiative of recalibrating the area-specific strategies. The reason for this is because they are well-aware of the national plans and strategies but also have knowledge about local needs and access to implementing actors. This can be explained by that the organization of the DP Sub-Programs contains representatives from both regional and local actors (regional water authorities, provinces, municipalities) and national actors (the National Water Authority and the Ministry of Infrastructure and Water Management). Also, regional and local actors regularly update the DP Sub-Programs on their progress of implementing strategies or other developments that might affect reaching the objectives. Hence, multiple actors from both local, regional and national levels are currently involved in the evaluation, stimulating the quality of plans by incorporating local knowledge and contributing to the support of the plans (Bloemen et al., 2018).

Coordination at a higher level than implementation

Implementation of measures takes place at a local/regional level, while the strategies are coordinated and developed regionally. In this way, it is ensured that the local measures fit the regional strategy. A level above the regional strategies, the (Staff) Delta Commissioner ensures coherence between the regional strategies. Also, the (Staff) Delta Commissioner safeguards coherence between the different sub-themes of the Delta Program, namely between water safety, freshwater and new urban development and restructuring. The (Staff) Delta Commissioner works together with provincial and municipal authorities, regional water authorities and other stakeholders; in doing so, there is ensured that the strategy is locally appropriate yet regionally coordinated.

4.5. Conclusion

To enhance the adaptivity of delta management in the Netherlands, both the strategies and the implementation of the strategies should be adaptive. The actors identified as essential for ensuring that the strategies are adaptive are the actors involved in the recalibration of the delta strategies. These actors are the Signal Group, the Knowledge Network, Research Program Sea-Level Rise, (Staff) Delta Commissioner, the Delta Program Sub-Programs, and various knowledge institutions. The actors identified that play a role in the implementation of strategies are regional water authorities, municipalities and drinking water utilities. The combination of the actors involved in ADM at the strategy level and the implementation level is referred to as the 'actors of ADM'.

Based on the empirical research into the institutional governance of ADM, it is concluded that the institutional governance of the actors of ADM is in line with the institutional elements of the theoretical governance framework composed in Chapter 3.

5
Instrumental governance of ADM

This chapter aims to explore how the instrumental governance of ADM is shaped in practice, and if this is coherent with the instrumental governance elements of the theoretical governance framework.

5.1. Approach for the empirical research into the instrumental governance

A combination of primary and secondary sources is used to study the instrumental governance of ADM in practice. First, interviews were performed to explore if and how the instruments are incorporated in decision making by the actors of ADM. Additional secondary sources to which was referred in interviews were also studied such as specific policy documents, advisory reports or issues of the Delta Program. The governance of the instruments of ADM in practice is compared with how the instruments are prescribed according to theory (Chapter 3).

This chapter is structured as follows; Section 5.2 explains the instrumental governance of ADM in practice in the Netherlands. The first part of Section 5.2 focuses on how the instruments of ADM have taken shape on the strategy level and the second part focuses on the implementation level. Based on these findings, Section 5.3 concludes on if the application of the instruments of ADM by the actors on the strategy level and the implementation level is coherent with how they are prescribed in theory (as outlined in Chapter 3).

5.1.1. The actors of ADM

The first step is studying how the instruments of ADM have taken shape in practice. In Chapter 4 was found that to enhance delta management's adaptivity in the Netherlands, both the strategies and the implementation of the strategies should be adaptive. Therefore, within the actors of ADM, two categories can be distinguished: (1) the actors responsible for ensuring that the area-specific strategies are adaptive and (2) the actors responsible for ensuring that the implementation of these strategies is adaptive (table 4, p. 38). For both these categories, the application of the instrumental governance elements will be explored. The comparison will show us the similarities and differences between the instrumental governance elements in theory and in practice. The actor identification process is elaborated on in Section 4.1.1. In Appendix D, a detailed description of the actor identification process can be found.

5.1.2. Interviews

A combination of primary and secondary sources is used to explore the instrumental governance of ADM in practice. The dominant information source is semi-structured interviews. In the same interviews that were conducted to explore the institutional governance of ADM, the instrumental governance was also explored. In total, fourteen interviews were conducted. The interviews were conducted with the actors of ADM and a few other actors that have a clear understanding of how ADM is applied in practice (table 6), as is explained in Section 4.1. Unfortunately, scheduling an interview with a drinking water utility has not been achieved. Therefore, it was not possible to explore the instrumental governance for drinking water utilities. The remaining list of actors for which the incorporation and shape of the instrumental elements are analyzed is shown in table 3 (p. 30). An overview of the interviewees, the interview set-up, the interview questions, and how obtained data is processed can be found in Appendix E.

The interview questions consisted of two parts: one for exploring the institutional governance and one for the instrumental governance. The questions were based on the institutional and instrumental elements of the theoretical governance framework of ADM (table 2, p. 30). The first part of the interviews focused on exploring the institutional governance of ADM in practice, and the second part on exploring the instrumental governance of ADM in practice. In the second part, the interviewee is questioned upon the incorporation of the instruments in decision making and how the instruments are shaped in practice.

Actor	Category
The Signal Group	Strategy level
The Knowledge Network	Strategy level
Research Program Sea-Level Rise	Strategy level
(Staff) Delta Commissioner	Strategy level
Knowledge institutions	Strategy level
DP Sub-Programs	Strategy level
Regional water authorities	Implementation level
Municipalities	Implementation level

Table 6: Actors included in the research into the instrumental governance of ADM

5.2. Instrumental governance of ADM in practice

In this section, the results of the instrumental governance of ADM in practice are presented. Section 5.2.1 presents the findings on the incorporation of the instruments of ADM on the strategy. In Section 5.2.2, the results of the instrumental governance during the implementation of strategies are shown. In Appendix F, an overview of the instrumental governance findings linked to the specific interview in which each finding was obtained can be found.

5.2.1. Strategy level

Table 7 shows the results of the instrumental governance elements of ADM in practice on the strategy level. The results show which instrumental elements of ADM are incorporated in the development of area-specific strategies and if their application is coherent with theory. This section will discuss how the instrumental governance elements have taken shape on strategy level one by one.

Instrumental governance elements of ADM	Incorporation on the strategy level	Application in practice coherent with theory
Scenarios	+	+
Adaptation pathways	+/-	-
Adaptation tipping points	-	-
Monitoring system	+	+
Evaluation system	+	+/-

Table 7: Results instrumental governance - strategy level

Scenarios

In practice, delta scenarios and additional sea-level rise scenarios are considered in the delta management sector. The four delta scenarios are developed to guide the formulation of delta decisions and construct regional strategies under uncertainty (Bloemen et al., 2019). These scenarios outline plausible climate change effects, and socio-economic conditions for 2050 and 2085 and are developed by the knowledge institutions Deltares, KNMI, PBL and CPB. More information on these knowledge institutions can be found in Appendix D. The scenarios contain

values for variables such as temperature rise, sea-level rise, average precipitation, Rhine and Meuse discharges, number of inhabitants, GDP, the surface used for nature, cities and agriculture, and more. The delta scenarios are updated when new socio-economic or climatic projections become available to ensure the most accurate information underlies the projections. The first set of delta scenarios was published in 2011 and updated in 2013. In 2017 and 2018, a revised version of the delta scenarios was issued.

In addition to the delta scenarios, sea-level rise scenarios with a time horizon up to 2200 are considered by the strategy level actors. Although the delta scenarios include the projections for sea-level rise, additional sea-level rise scenarios are considered. This is because sea-level rise projections start significantly diverging from 2050 onwards (figure 3, p. 26). Besides, it is expected that the current area-specific strategies in the Netherlands can be maintained until at least 2050 (DP2021, 2020). Therefore, a time horizon that goes beyond 2050 is considered for sea-level rise. A time horizon until 2085 is not sufficient because the sea-level rise will continue as a result of continuing deep-ocean heat uptake and mass loss of the Greenland and Antarctic ice sheets beyond 2100 (Oppenheimer et al., 2019). The question is not whether sea-level rise will occur but when this will occur (Haasnoot et al., 2020). Therefore, additional sea-level rise scenarios are incorporated in decision making with a time horizon up to 2200 to avoid that strategies might fail due to unforeseen sea-level rise.

According to theory, the scenarios used for ADM should include the major uncertainties that play a role in decision making such as external developments (Haasnoot et al., 2019). Since for delta management, the main uncertainties are climate change and socio-economic conditions (Bloemen et al., 2019), the current use of scenarios in practice does outline the major uncertainties. According to theory, the scenarios can be static scenarios or transient scenarios (describing developments over time) (Haasnoot et al., 2019). In practice, static delta scenarios and transient sea-level rise scenarios are incorporated into the strategies. Thus, scenarios in practice are coherent with how they are prescribed in theory.

Adaptation pathways

In the Delta Program's yearly publications, there are several adaptation pathway maps included for the strategies of the regional sub-themes. An example of such an adaptation pathway map is visible in figure 6. The adaptation pathway maps in the Delta Program consist of short-term, medium-term and long-term measures. However, these adaptation pathways are simpler than the adaptation pathways described in theory. First of all, only one strategy (the preferred strategy) is presented instead of the various strategies considered. Also, within the adaptation pathway map, no signposts are defined, which makes it unclear what variables should be monitored to determine if the strategy is successful or if altering the strategy is needed. Also, since only the preferential strategy is presented, no transfer stations to other strategies are indicated.

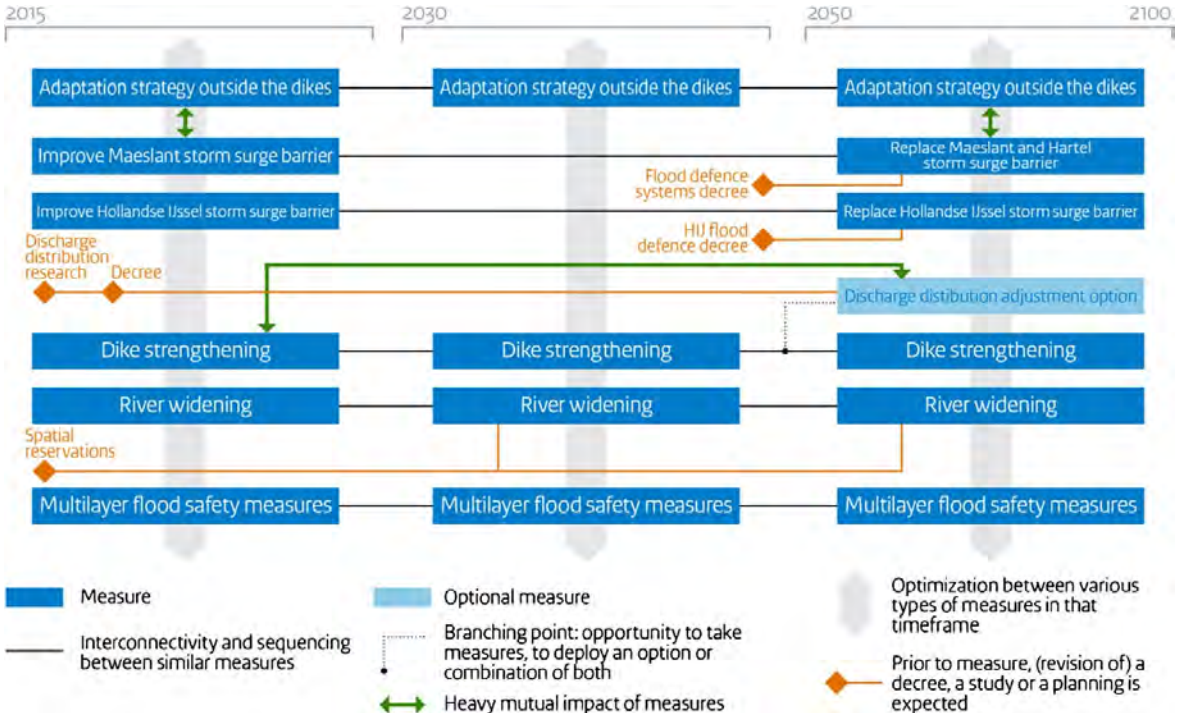

Figure 6: Adaptation pathway map in DP2015 (Bloemen et al., 2018)

Adaptation tipping points

In practice, adaptation tipping points are not clearly defined. Adaptation tipping points of strategies occur when an external development causes the strategy to no longer meet the predefined objectives. The main reason for the absence of adaptation tipping points in practice is that determining tipping points can be challenging if precise policy goals are absent (Bloemen et al., 2018). Policy goals can either be about specific policy objectives or around financial, technical or societal constraints. An example of a specific policy objective is flood risk management; for flood risk management, quantitative flooding probabilities are determined, making it easy for policymakers to determine if the strategy meets the flood risk norm. However, for most other policy objectives, no acceptability thresholds have been legally and quantitatively defined. For example, for freshwater availability, no clear policy objectives have been defined. Freshwater availability for irrigation can be framed as a matter of public interest. But it can also be framed as a sectorial or an individual farmer's problem, all leading to very different acceptability thresholds for freshwater scarcity. Adaptation tipping points can also occur when strategies become too expensive, technically infeasible or societally unacceptable (Dewulf & Termeer, 2015). However, practice shows that there are almost no limits to what is technically feasible. The only question is how much we are willing to spend. Even if there are technical boundaries identified, these may change over time due to innovation. What is financially acceptable is not a fixed amount of money but rather a political assessment of what is acceptable under the current circumstances and the state of the economy. Also, what is societally acceptable can change over time. For example, one might say that heightening a dike in front of their house by two meters is not acceptable. But if due to sea-level rise the area floods a few times, causing damage to people's homes, the residents might change their views on the acceptable amount of dike heightening. Hence, adaptation tipping points in practice are more flexible than in theory.

Monitoring system

In practice, a clear monitoring system is in place that keeps track of external developments that can be relevant for the themes of the Delta Program. To ensure that no critical indicators are overlooked, a list with pertinent external developments is established consisting of socio-economic, climatic, and knowledge and innovation indicators. It is ensured that the list of

indicators is monitored continuously by various institutions. The external developments that are being monitored are sea-level rise, river discharges, land usage and inhabitants, climatic drought, salt intrusion, water nuisance, heat stress, and knowledge and innovation. Within the indicators, three different categories can be distinguished: 'drivers of change', 'effects relevant for delta management', and 'societal consequences'. The drivers of change (such as global warming or melting of polar ice) can be seen as early-warning signals and are valuable for timely identification of change. The effects relevant to delta management (such as the sea-level rise and river discharges) are the external developments that directly impact delta management. Societal consequences (e.g., costs of recent flooding) are valuable in convincing people that there is an urge to act and formulate a new policy. Apart from the indicators on the list, attention is also being paid to other uncertain developments or unexpected occurrences that might be relevant for Dutch delta management. The requirements for the ADM monitoring system prescribed in theory are that the monitoring system aims to keep track of the external developments that may lead to the adjustment of choices and strategies and that monitoring of these external developments happens continuously (Zevenbergen et al., 2018; Dewulf & Termeer, 2015). The monitoring system in place meets these theoretical requirements; therefore, the conclusion is drawn that the monitoring system in practice is in line with theory.

Evaluation system

In the Delta Program, an M&E system named Monitoring, Analyzing and Acting (MAA) is implemented. The MAA system distinguishes three groups of developments that may require adjustment of choices and plans: "knowledge and innovation," "climatic and socio-economic developments," and "changes in societal preferences (Bloemen et al., 2019).

First of all, it is determined if the development and execution of delta decisions, strategies and plans are on schedule. Then, it is checked if the implementations of these delta decisions, strategies and plans will help us timely reach our objectives. The objectives are formulated in the areas of flood risk management, freshwater availability and spatial planning. External developments must be tracked to assess if it is needed to implement additional measures or switch to another policy pathway.

The Delta Program operates in a dynamic environment where many developments occur, and frequently new insights are obtained. Simultaneously, the potential consequences of the external developments and the delta decisions and strategies are not always clear. The MAA system has a fixed rhythm of making adaptations in existing delta decisions and strategies. The fixed rhythm has evaluation moments once every year and once every six years. In the yearly evaluation, it is determined if the execution of the current strategies is on schedule. Also, if external developments show significant short-term consequences, and the cause and direction of these external developments are well-understood, the strategy can also be adjusted in this yearly evaluation moment. The evaluation that takes place once every six years is the systematic recalibration of the delta decisions and preferred strategies. The recalibration objective is checking carefully if the underlying assumptions under which the preferred strategies are formed are still relevant, outdated, or if other developments create the need to adjust delta decisions and strategies. This rhythm aims to keep the balance between being flexible on the one hand and between reacting to new developments and offering stability and coherence in choices made on the other hand (DP2019, 2018).

Looking at the requirements for the evaluation system, in theory, new information found on the performance of external developments must be incorporated to determine if pursuing the strategy will meet the predefined objectives. Also, theory prescribes that continuous evaluation and recalibration of strategies are needed whenever new information from monitoring comes available is required (Hermans et al., 2016). In practice, a clear evaluation system is in place that determines if pursuing the strategy will meet the predefined objectives. In practice, the pace of strategy recalibration is not determined by the rate at which new information on external developments comes available. Instead, fixed moments are determined on which the strategies are evaluated and

adjusted (the yearly and six-yearly rhythm). A shift from 'adaptive planning' to 'planned adaptation' is visible: from adjusting strategies whenever new information occurs to planning fixed moments when to adjust strategies.

The idea behind ADM in theory is that evaluation of the collecting information would tell policymakers when altering the pace of a strategy, adding additional measures or switching to alternate strategy is needed. However, the absence of concrete adaptation tipping points in combination with that no clear adaptation pathway maps have been defined, make that ADM in practice provides less guidance on when and which adjustments are needed. Nonetheless, ADM in practice is still valuable in providing policymakers an overview of the possible actions and strategies, how and which strategies can be combined or which ones are mutually exclusive, and what external variables should be monitored to safeguard the success of a strategy.

5.2.2. Implementation level

Table 8 shows the research results into instrumental governance elements of ADM in practice on the implementation level. The actors considered at the implementation level are regional water authorities and municipalities, who are responsible for regional water management and climate-proof land use planning. Because the results show that none of the instrumental elements of ADM is applied on the implementation level, no comparison with theory was made. How the instrumental governance elements have taken shape at the implementation level will be discussed one by one.

Instrumental governance elements of ADM	Incorporation on the implementation level
Scenarios	-
Adaptation pathways	-
Adaptation tipping points	-
Monitoring system	*Findings cannot be generalized*
Evaluation system	*Findings cannot be generalized*

Table 8: Results instrumental governance - implementation level

Scenarios, adaptation pathways and adaptation tipping points

Regional water authorities and municipalities rarely incorporate scenarios in decision making around new measures. Instead of taking into account uncertainty about the future in decision making by incorporating a set of plausible scenarios, mean projections are used for the external developments that they consider important. For example, suppose a dike needs reinforcement. In that case, the regional water authority will first determine the desired technical lifetime of the dike and then use the mean projection of the external developments considered important (e.g., increase in polder discharge). Furthermore, in the rare case that regional water authorities and municipalities use scenarios, generally, one scenario is chosen instead of taking into account the full range of plausible scenarios. Also, the actors on the implementation level do not make use of adaptation pathways. Finally, the implementation level actors declared that determining adaptation tipping points of strategies in practice is difficult. The same explanation holds for the difficulty of defining adaptation tipping points for the actors on the implementation level as holds for the actors on the strategy level (see 5.2.1).

Monitoring system

There are no rules or arrangements on how the monitoring system used by the actors at the implementation level should be shaped in practice. How monitoring is performed, which external developments are monitored and if monitoring happens continuously depend upon the specific actor and its resources. For example, the municipality of the Hague has a different monitoring

system than the municipality of Rotterdam. Therefore, the interview findings could not be generalized to the entire implementation level.

In the interviews, the following findings were obtained: Regional water authorities monitor water levels, water quality, and other important indicators for the operation and management of the regional water systems. Also, municipalities monitor external developments relevant to climate-proofing the city, such as groundwater levels and subsidence. Both regional water authorities and municipalities use sensors in combination with automated systems for processing the real-time data for monitoring whenever possible. Hence, the monitoring systems of the actors at the implementation level interviewed meet the theoretical requirement of aiming to track the external developments that may lead to the adjustment of choices and strategies. Also, the use of automated systems implies that monitoring happens continuously.

Evaluation system

Similar to the monitoring system, there are also no rules or arrangements on how the evaluation should be performed on the implementation level. Therefore, how evaluation is performed varies per actor. The interview findings on the evaluation system could not be generalized to the implementation level.

In the interviews, the following findings were obtained: Regional water authorities and municipalities have no clear evaluation system that assesses if pursuing current strategies will lead to timely reaching the objectives considering the external developments. The evaluation measures in place aim to determine if the current strategies achieve the pre-defined objectives in the short term. For example, visual inspection of dikes is performed every spring and fall to check if the dikes still look solid and if the dikes will be able to function properly for another season. Another example is, whenever short-term predictions of external developments indicate a sharp change, preventive measures are taken where possible to deal with this in the short term. If heavy rainfall is predicted, the water levels are lowered before the rain starts. Therewith, there is proactively dealt with new developments and insights in the short-term. However, no clear evaluation system to determine how external developments will influence strategies' success in the long-term and how strategies are recalibrated is in place.

5.3. Conclusion

On the strategy level, all the theoretical instruments of ADM are applied. However, most of the instruments shape in practice is not coherent with theory. Differences found that adaptation pathways are only for some strategies defined, and for the strategies adaptation pathways are defined, they are more simple in practice than in theory. Also, adaptation tipping points are more flexible in practice than in theory, and evaluation takes place on fixed moments instead of continuously whenever new information comes available. The most important implication of these differences is that ADM in practice provides less guidance on when and which adjustments are needed than in theory. On the implementation level, the majority of instrumental governance elements is not applied.

Concludingly, more instruments of ADM are applied on the strategy level than on the implementation level. Furthermore, the application of the greater part of the instruments is not coherent with how they should be applied according to theory. Hence, the results confirm the finding of Timmermans et al. (2015) that the link between ADM in practice and its scientific foundation has vanished. In Chapter 6, there will be analyzed if the instrumental governance of ADM in practice enhances adaptation to sea-level rise in the Netherlands.

III

Analysis

6

Enhancing adaptation to sea-level rise

This chapter aims to explore if the institutional and instrumental governance of ADM enhance adaptation to sea-level rise in the Netherlands. Also, for the improvement areas identified, recommendations and actions on implementing the recommendations will be provided.

6.1. Approach for analysis

In this chapter, the findings of the previous chapters are combined and analyzed to determine if the institutional and instrumental governance of ADM in practice enhance adaptation to sea-level rise. First, the institutional governance of sea-level rise will be explored and there will be determined if the institutional governance of sea-level rise is appropriate for applying the instruments of ADM. Then, there will be studied if the instrumental governance in practice enhances adaptively coping with sea-level rise. Finally, for the areas of improvement identified, recommendations will be provided on how to improve the adaptation to sea-level-rise in the Netherlands.

6.2. Institutional governance of adaptation to sea-level rise

This section analyzes if the institutional governance of the actors involved in adaptation to sea-level rise is appropriate for applying ADM. Chapter 4 and 5 focused on the institutional and instrumental governance of ADM in the Netherlands but did not explore the governance of sea-level rise in particular. Therefore, this section wil start with exploring the actor landscape of the actors involved in adaptation to sea-level rise. Also, the interaction between the actors involved in adaptation to sea-level rise on the strategy level and the implementation level is explored. Then, the the institutional governance of the actors involved in adaptation to sea-level rise will be analyzed to determine if the current governance enhances adaptation to sea-level rise.

6.2.1. The actor landscape

The actors of ADM (table 4, p. 38) are also responsible for ensuring adaptation to sea-level rise. A distinction is made between the actors of ADM that are involved in ensuring the strategies are adaptive, and the actors that are involved in the implementation of these strategies. The reason for this is that both the strategies to cope with sea-level rise and the implementation of those strategies should be adaptive to enhance an adaptive approach to sea-level rise.

First, the actors that are responsible for ensuring the adaptivity of the strategies to cope with sea-level rise are the actors involved in the recalibration of strategies. These actors are the Signal Group, the Knowledge Network, Research Program Sea-Level Rise, the (Staff) Delta Commissioner, the DP Sub-Programs, and various knowledge institutions. The current delta management strategy for the Dutch coast is determined by the Delta Program Sub-Program Coast. The area-specific DP Sub-Program ‘Coast’ is also responsible for taking the initiative of recalibrating the strategy of the Dutch coast (to ensure the strategy is robust to sea-level rise and other external developments). The strategy for the Dutch coast also impacts the strategy for the Dutch rivers because the rivers flow into the sea. The other roles and responsibilities of the actors involved in ensuring the adaptivity of the strategy to cope with sea-level rise are coherent with the description in Section 4.3.

The implementing actors are regional water authorities, municipalities and water companies. These implementing actors have to deal with the consequences of sea-level rise on a local or regional level: regional water authorities enhance water safety in their area, the municipalities safeguard local climate-proof land-use planning, and drinking water utilities enhance drinking water availability.

6.2.2. Interaction between the strategy level and the implementation level

The current strategy for the Dutch coast is called 'soft where possible, solid where needed'. The soft measures are beach nourishment which can flexibly grow apace with the rise of the sea level. The expectation is that the Dutch coast's current strategy can be maintained until at least 2050 (DP2021, 2020). For the long-term, four national LT-coastal adaptation strategies on the Dutch coast have been identified to protect the Netherlands against sea-level rise; Protect-Closed, Protect-Open, Seaward and Managed Accommodate (Haasnoot et al., 2019). A more detailed description of the LT-coastal adaptation strategies can be found in Section 2.4.2. Due to deep uncertainty around sea-level rise, it is impossible to eliminate one of the LT strategies or choose one above the others. Hence, in the Netherlands is aimed to invest in short-term measures to keep all LT-coastal adaptation strategies open.

The consequences of sea-level rise that the implementing actors have to deal with depend on the rise of the sea level along the Dutch coast combined with the measures implemented on the national level. The illustrative example below explains the interaction between the national strategy to cope with sea-level rise (determined by the actors on strategy level) and the local/regional actors on the implementation level.

Illustrative example: Interaction strategy and implementation level

The city of The Hague borders the Dutch coastline. Ensuring that the spatial planning of The Hague can withstand the effects of climate change belongs to the municipality's tasks. One of the matters that the municipality of the Hague is currently concerned with is the national urban housing challenge, for which the municipality has to build new houses in The Hague to contribute to the shortage of urban houses. The municipality of The Hague determines where new housing developments will take place and what the requirements for the housing developments are. The technical lifetime of a house is on average 120 years (Westeneng, 2018); meaning that a house build today, will last until around 2140.

Hence, houses build today will probably stay longer than the current strategy to cope with sea-level rise can be maintained. For the municipality of The Hague, it is important to know what LT-coastal adaptation strategies are considered for the Dutch coast to protect the Netherlands against sea-level rise. Each LT-coastal adaptation strategy comes with different consequences for the municipality of The Hague. For example, if the national LT-coast strategy implemented in the future is 'Protect-Closed', seawater would be kept out of The Hague along the coast. Therefore, the consequences of sea-level rise for the municipality would probably be limited. The municipality could just continue their housing development without taking sea-level rise into consideration. If the LT-coastal adaptation strategy implemented is 'Accommodate', large amounts of seawater are expected to flow inland in the future. Therefore, some areas will no longer be suitable to build residential areas or would only be suitable if additional measures would be implemented (such as raising the foundation of houses or building houses on piles). If no consideration is given to the LT-coastal adapation strategies to cope with sea-level rise, the risk exists that houses will become unhabitable before the end of their lifetime leading to sunk costs. Or worse, the result could be that the safety of Dutch citizens is at stake because the flood risk management norms cannot be met.

As the example shows, the strategy pursued on the national level to cope with sea-level rise impacts decisions taken to climate-proof the area (such as new housing developments) in the city of The Hague. The same holds for regional water authorities; the national strategy determines the severity of measures that need to be taken for water management and the water safety of the residents in the area. Also, the LT-coastal adaptation strategy determines the measures that need to be taken by drinking water companies to safeguard drinking water availability, because the saltwater flowing inland cause salt intrusion in natural freshwater reserves. If the LT strategies are not taken into account on the implementation level, the risk of overinvestment or underinvestment in measures exists. Underinvestment may result in that policy objectives (such as water safety norms) cannot be met. Overinvestment may lead to unnecessary expenses for society. Thus, to enhance adaptation to sea-level rise, it is required that the implementing actors take into account the measures on the strategy level.

6.2.3. Interpretation of institutional governance

In Chapter 3, the institutional governance elements that are essential for ADM according to the theory were identified (table 2, p. 30). It was found that these theoretical institutional governance elements function as requirements for applying the instruments of ADM. Only if all theoretic institutional governance elements are present in practice, a proper foundation exists for applying the instruments of ADM. Section 6.2.1 explains that the actors involved in ensuring an adaptive approach to sea-level rise are the same as the actors of ADM identified in Chapter 4. Therefore, the results of the empirical research into the institutional governance of ADM in practice in Chapter 4 are still valid; meaning that the theoretical requirements for institutional governance are all met in practice. These institutional governance elements are:

- Clear agreements on roles and responsibilities
- Transparent information management
- Engagement of multiple actors at various levels in monitoring
- Engagement of multiple actors at various level in evaluation
- Coordination at a higher level than implementation

Hence, the organizational structure of the actors of ADM is appropriate for enhancing adaptation to sea-level rise.

6.3. Instrumental governance of adaptation to sea-level rise

Regarding the instrumental governance of ADM in practice, it was found that not all instruments of ADM are applied in the same way in practice as prescribed in theory (table 2, p. 30). Furthermore, differences are observed in ADM's instrumental governance between the strategy level and the implementation level. In this section, the current institutional governance is analyzed to determine if adaptively coping with sea-level rise is enhanced.

6.3.1 The strategy level

Scenarios

In practice, delta scenarios are incorporated when developing strategies to guide decision making under uncertainty. The two main uncertainties for delta management are climatic and socio-economic developments, these are both incorporated in the delta scenarios. For sea-level rise, additional scenarios are incorporated with a time horizon up to 2200, in this way the uncertainty of sea-level rise is properly taken into account. When developing strategies, all future scenarios are considered instead of taking mean projections. The current use of scenarios in practice is in line with theory because they outline the most important uncertainties and are incorporated when developing strategies. Concludingly, the current design and the incorporation of scenarios in practice enhance adaptation to sea-level rise.

Adaptation pathways

In the Delta Program, some adaptation pathways have been defined, but no adaptation pathways have been developed for the strategies to cope with sea-level rise. The lack of adaptation pathways towards the LT-coastal adaptation strategies makes it more difficult for policymakers to cope with sea-level rise in an adaptive manner. The explanation for this is that without adaptation pathways, policymakers have lower insight into which short-term measures are needed and when they must be implemented to keep the LT-coastal adaptation strategies open. Also, without adaptation pathways, it is more challenging for policymakers to recognize path dependencies and lock-ins. An example is the replacement strategy for the Maeslantkering. It is currently expected that the decision process upon the future design for the Maeslantkering will start in 2030. Both open storm surge barrier designs similar to the current design, as closed designs, such as a sea lock, belong to the possibilities for the future design that are being explored (Dutch Second Chamber, 2016). Given the design lifetime of 100 years for locks and weirs (Pot, 2020), the decision for the design will impact the future coastal adaptation strategy. Imagine there is decided that a sea-lock replaces the Maeslantkering; this would make switching to the LT-coastal adaptation strategy 'Accommodate' difficult in the future. Hence, the lack of adaptation pathways on the strategy level reduces the adaptiveness of coping with sea-level rise.

Adaptation tipping points

In practice, the actors of ADM on the strategy level have not clearly defined adaptation tipping points. The main explanation why defining adaptation tipping points is difficult is because clear policy objectives lack - except for water safety. The theoretical rationale behind the definition of concrete adaptation tipping points is that monitoring information tells the policymaker if a strategy meets the conditions for its success or if strategies must be adjusted. When clear objectives are absent, it is more challenging for policymakers to assess if adjustments of strategies are needed; this could lead to postponement of action. Therewith, the lack of concrete adaptation tipping points reduces the adaptiveness of coping with sea-level rise.

Monitoring system

The current monitoring system meets the requirements described in theory and is monitoring continuously. Attention is being paid to all external developments that may be relevant for the Delta Program, including sea-level rise. Many actors at various levels are involved in the monitoring of sea-level rise. For sea-level rise, monitoring is performed for the melting of Antarctic, sea-level globally, level of the North-Sea, and the sea-level along the Dutch coast. Also, the Research Program Sea-Level Rise has been established for the interpretation of what the monitoring results of sea-level rise mean for the Netherlands. This research program ensures that the Netherlands has access to the latest information and best knowledge on sea-level rise and its consequences for the Netherlands. Concluding, the current monitoring system is expected to provide all relevant monitoring information regarding sea-level rise needed for enhancing adaptation to sea-level rise.

Evaluation system

Finally, a clear evaluation system is in place, but the evaluation of strategies does not happen continuously whenever new information becomes available as is prescribed in theory. In practice, a fixed rhythm for recalibrating the strategies every year and every six years is employed. The rationale behind this is that a fixed rhythm helps to keep the balance between being flexible on the one hand and between reacting to new developments and offering stability and coherence in choices made on the other hand (DP2019, 2018). The fixed rhythm of the systematic recalibration of the delta decisions and strategies once every six years makes that all actors work towards this moment in time. For example, Research Program Sea-Level Rise is not focused on continuously generating new insights to adjust strategies but works towards the next systematic recalibration in 2026. Imagine that policymakers decide during one of the fixed six-yearly recalibration moments to pursue the current strategy without any adjustments. During that official recalibration moment, policymakers are well aware that the next formal opportunity for recalibrating strategies is not for another six years. Suppose it turns out in the time between the formal recalibration

moments that the strategy can no longer be maintained. In that case, policymakers will have to revisit the decision, which could result in loss-of-face. Hence, policymakers will deliberately consider if pursuing the current strategy will be effective for another six years. On the other hand, continuous evaluation whenever new information comes available could result in postponing the adjustment of strategies, especially when no concrete adaptation tipping points are defined. This argument is supported by Dewulf and Termeer (2015), who state that the possibility of pushing adaptation tipping points further into the future could be misused for postponing difficult decisions. Based on this interpretation, the conclusion is drawn that the evaluation system in practice is appropriate for enhancing adaptation to sea-level rise.

6.3.2. The implementation level

On the implementation level, scenarios, adaptation pathways and adaptation tipping points are currently not incorporated in decision making. No findings could be generalized about the monitoring and evaluation system at the implementation level because no rules or arrangements are in place on how monitoring and evaluation should be shaped. Therefore, the monitoring and evaluation system is unique for every implementing actor.

The absence of scenarios results in that implementing actors use mean projections for external developments when designing new measures. The plausible range of future scenarios for sea-level rise should be incorporated when designing new measures to enhance adaptation to sea-level rise. In addition, municipalities currently regard all locations that lay within the dikes as appropriate locations for new housing construction or other spatial developments. Municipalities presume that the national coastal adaptation strategy combined with the regional water authorities' measures will ensure that all areas inside the dikes will stay habitable now and in the future. In doing so, it is not taken into consideration that some of the national LT-coastal adaptation strategies considered may result in that areas become unhabitable (as is explained in the text box in Section 6.2). Concluding, uncertainty around sea-level rise and the national LT-coastal adaptation strategies are not taken into account in the decision making on the implementation level.

The absence of adaptation pathways and the lack of a clear definition of adaptation tipping points has similar effects at the implementation level as it has on the strategy level. Namely, the absence of adaptation pathways results in that the implementation level actors have reduced insight into the adaptation options, path dependencies, and possible lock-ins. The lack of a clear definition of adaptation tipping points makes it more challenging for the actors at the implementation level to determine when additional measures are needed.

Based on the absence of scenarios, adaptation pathways and adaptation tipping points, it can be concluded that currently, uncertainty is not incorporated in decision making on the implementation level. Hence, the instrumental governance of ADM at the implementation level does not enhance adaptation to sea-level rise.

6.4. Recommendations to enhance adaptation to sea-level rise

This section presents the recommendations on how the adaptivity of coping with sea-level rise can be further improved in the Dutch delta management sector. The Staff Delta Commissioner should be responsible for taking the lead in implementing the proposed recommendations. Naturally, the Staff Delta Commissioner can ask other actors for help or advice in implementing the recommendations, this is further discussed per recommendation. The recommendations are based on the analysis of the institutional and instrumental governance of sea-level rise. The analysis of the institutional governance of sea-level rise shows that institutional governance is appropriate for coping with sea-level rise adaptively (Section 6.2). Therefore, no recommendations will be provided on how to improve the institutional governance of ADM. The instrumental governance analysis identifies that the governance of some of the instruments currently does not enhance adaptively coping with sea-level rise (Section 6.3). For these improvement areas, recommendations are provided in this section.

6.4.1. The strategy level

Develop adaptation pathways for LT-coastal adaptation strategies

Adaptation pathways for the LT-coastal adaptation strategies need to be developed to enhance adaptively coping with sea-level rise on the strategy level. These adaptation pathways need to include transfer stations and the signposts that should be monitored to determine whether the plan is still meeting the conditions for its success (Haasnoot et al., 2013). These adaptation pathways shall be scenario-neutral and will be based on the amount of sea-level rise. So, when looking at the example of an theoretic adaptation pathways map in figure 4 (p. 32), the amount of sea-level rise shall be put on the X-axis instead of the passing of time. The reason for this change is that by replacing the time component with the level of sea-level rise, the discussion about which scenario to choose to decide upon the adaptation measures is avoided. The development of adaptation pathways will provide policymakers insight into the possible adaptation options, lock-ins and path dependencies. But more importantly, adaptation pathways will help policymakers understand which short-term measures need to be taken to keep the different LT-coastal adaptation strategies to cope with sea-level rise open. Until these adaptation pathways (including transfer stations, signposts and adaptation tipping points) are developed and incorporated in decision making, adaptation to sea-level rise is not enhanced at the strategy level.

Research Program Sea-Level Rise is already planning to develop adaptation pathways for the LT-coastal adaptation strategies. Therefore, it is a logical choice that the Staff Delta Commissioner collaborates with or assigns the task of developing these adaptation pathways to Research Program Sea-Level Rise.

6.4.2. The implementation level

Develop area-specific consequence scenarios

As follows from the relative importance analysis of the instrumental governance elements (Section 3.4), incorporating scenarios is the foundation for applying the other ADM instruments. Therefore, the first step towards enhancing adaptation to sea-level rise on the implementation level is incorporating scenarios. These scenarios must include the major uncertainties that play a role in the decision making (Haasnoot et al., 2019). The primary sources of uncertainty for the actors at the implementation level when coping with sea-level rise are socio-economic developments, climatic developments, and the LT-coastal adaptation strategies. Therefore, implementing actors should have area-specific consequence scenarios at their disposal. These scenarios should outline the plausible consequences of sea-level rise and the national LT-coastal adaptation strategies for a specific area (such as groundwater levels and the effects on salt intrusion in groundwater and surface waters). Insights into the possible consequences of sea-level rise for implementing actors is crucial to make an informed decision on the appropriate measures and actions.

The proposed area-specific consequence scenarios can serve as the basis for applying the other instruments of ADM on the implementation level. After the development of the scenarios, adaptation pathways could be developed, and adaptation tipping points of strategies should be identified. Subsequently, alignment if the monitoring system keeps track of the signposts that determine whether the plan is still meeting the conditions for its success is needed. Also, a systematic evaluation system that fits with the other instruments should be developed.

The Staff Delta Commissioner should be responsible for taking the lead in developing these area-specific consequence scenarios. The Staff Delta Commissioner could ask the regional Sub-Programs of the Delta Program for help in working out these scenarios. The regional Sub-Programs are a suitable partner to do this because they are well-aware of the national plans and strategies and have knowledge about local needs and access to implementing actors.

6.4.3 Overarching recommendations

Formulate policy objectives more precisely

Another recommendation is to formulate policy objectives more precisely because this contributes to more concrete adaptation tipping points. A good example can be found in the area of flood risk management. For flood risk management, quantitative flooding probabilities have been defined for dike sections and other water barriers (based on the potential consequences of flooding). The definition of more precise policy objectives for freshwater availability, salt intrusion levels and other policy goals is recommended. Clearly defined objectives make it easier to determine if a strategy is successful or when it is not (and an adaptation tipping points occurs). Resulting in that policymakers have insight into when adjustment of a strategy is needed. This recommendation is supported by Doremus et al. (2011), who stress that adaptive management requires formulating policy objectives as clear and explicit as possible, preferably with measurable indicators.

The Staff Delta Commissioner should take the initiative in setting up a policy plan group that explores the possibilities for assigning quantitative norms to delta management-related policy objectives. A similar process has been followed for defining the new flood protection standards. The results of the policy plan group were presented in the Delta Program of 2015. Two years later, the new norms were adopted in the Water Act (STOWA, n.d.).

Provide workshops on the application of the instruments of ADM

Finally, ADM and its instruments are difficult to apply; ADM is a highly academic and conceptual method. The complex method makes it challenging for actors to correctly incorporate scenarios, develop and use adaptation pathways, define tipping points, and employ the monitoring and evaluation systems in decision making. Therefore, workshops and training should be provided to teach the actors of ADM how to apply the instruments. Understanding how to apply the instruments will enhance adaptation to sea-level rise at both the strategy and the implementation level. In the future, the development of a learning platform on which policymakers and implementing actors can share best practices regarding the application of the instruments of ADM might be valuable.

The Staff Delta Commissioner could hire Deltares to advise on the workshops' content or provide the workshops. Deltares is an eligible party for providing guidance on the application of ADM since they were responsible for working out the method of ADM as introduced in the Delta Program of 2012.

6.5. Action plan

Based on the recommendations, the following steps can be taken by the Staff Delta Commissionner to enhance an adaptive approach to sea-level rise:

1. Develop adaptation pathways for the LT-coastal adaptation strategies
2. Develop national coastal adaptation scenarios
3. Translate coastal adaptation scenarios into area-specific consequence scenarios
4. Provide workshops on the application of the instruments of ADM

The LT-coastal adaptation strategies (Protect-Closed, Protect-Open, Seaward and Accommodate) should be used to develop adaptation pathways to cope with sea-level rise. These adaptation pathways should contain transfer stations, signposts and concrete adaptation tipping points. These adaptation pathways should be scenario-neutral and will be based on the amount of sea-level rise. Also, policy objectives should be defined more precisely to make it easier to determine concrete adaptation tipping points. The LT-coastal adaptation strategies combined with the delta scenarios and the additional sea-level rise scenarios should be translated into national coastal adaptation scenarios. These scenarios should outline the plausible futures in terms of climatic and socio-economic conditions and which LT-coastal adaptation strategy performs best per scenario. Thereafter, the national coastal adaptation scenarios can be translated into area-specific consequence scenarios, which outline the possible consequences for a specific area of sea-level

rise combined with the considered LT-coastal adaptation strategies. The implementing actors can use these area-specific consequence scenarios as the basis to develop adaptation pathways, define tipping points, and design a matching monitoring system and an evaluation system. Finally, workshops should be provided to the actors on the strategy level and the implementation level to teach them how to apply the instruments of ADM.

6.6. Conclusion

Before deriving to the conclusion on if the governance of ADM enhances adaptation to sea-level rise in the Netherlands, an important finding is that the implementing actors must take into account the measures considered on the strategy level. The reason for this is that the consequences of sea-level rise for the implementation level depend on the amount of sea-level rise combined with the measures taken on the strategy level to protect the Netherlands against sea-level rise.

The research found that the organizational structure in the Netherlands is appropriate for enhancing adaptation to sea-level rise. However, the results show room for improvement for how the methods and tools of ADM are applied in practice. At the strategy level, no adaptation pathways towards the national LT-coastal adaptation strategies to cope with sea-level rise have been defined. The result is that it is more challenging for policymakers to identify the short-term actions needed to keep the LT-coastal adaptation strategies open. Also, the absence of adaptation pathways could result in path-dependency and lock-ins. On the implementation level, the greater part of the instruments of ADM are not applied in practice. The absence of scenarios at the implementation level means that uncertainty is not incorporated in decision making, while uncertainty around the consequences of sea-level rise for implementing actors is high. Hence, for both the strategy and the implementation level, adaptation to sea-level rise is not fully enhanced.

The following recommendations have been proposed to enhance adaptation to sea-level rise in the Netherlands, the Staff Delta Commissioner should be responsible for taking the lead in the implementation:

- Develop adaptation pathways for LT-coastal adaptation strategies
- Develop area-specific consequence scenarios
- Formulate policy objectives more precisely
- Provide workshops on the application of the instruments of ADM

IV

Discussion and Conclusion

7
Discussion

This chapter aims to provide a discussion of this research. The first section reflects on the research results. Then, the second section discusses the implications of the results for policymakers and researchers. Finally, the third section elaborates on the research limitations. All sections include suggested areas for further research.

7.1. Reflection on the results

In this section, a reflection on the results of this research is provided. Before conducting this research, the following objectives were set out (Section 1.3); (I) analyzing whether the governance of Adaptive Delta Management (ADM) in practice is coherent with its scientific foundation and (II) analyzing whether the current governance of ADM enhances adaptation to sea-level rise. The first objective has been achieved by exploring ADM's scientific foundation and, after that, systematically researching how all the scientific elements have taken shape in practice. Based on this comparison, the application of the greater part of the instruments in practice is not coherent with how they should be applied according to theory. Differences found were that adaptation pathways are simpler in practice than in theory, adaptation tipping points are more flexible, and evaluation takes place on fixed moments instead of continuously whenever new information comes available. The main implication of these differences is that ADM in practice provides less guidance on when and which adjustments are needed than in theory. The results confirm the finding of Timmermans et al. (2015) that the link between ADM in practice and its scientific foundation has vanished. The second objective has been achieved by analyzing the similarities and differences between the theoretical foundation of ADM and its governance in practice in the Netherlands. Based on this analysis, areas of improvement were identified, and recommendations for enhancing adaptation to sea-level rise were provided.

When reflecting on the recommendations for enhancing adaptation to sea-level rise that has been provided in this research (Section 6.4), one could argue that the recommendations are rather theoretically oriented. This is because most of the recommendations have been inspired by the theoretical foundation of ADM (the Dynamic Adaptive Policy Pathways approach). However, when implementing these recommendations, one must not forget that the theory behind ADM is still under development. Moreover, even if a theory might function optimally on paper, it may not fit the unruly reality. Next to that, policymakers have many complex theoretical approaches they have to deal with, and they cannot implement them all. Besides, differences will always exist between theory and practice. Therefore, whenever differences are detected, it is essential to be critical about whether aligning the application of that theory in practice with its theoretical foundation will yield the desired effects. In some cases, an application in practice that deviates from theory might even be functional, for example, because the proposed method is too complex or time-consuming to implement. Therefore, it is important to stay critical regarding the implementation of the theory behind ADM in practice. Hence, the right balance between theory and practice must be found, in which the theoretical method of ADM developed by researchers gets chances but also leaves room for policymakers to apply more pragmatic approaches whenever this makes sense.

In line with the previous paragraph, one could argue that the recommendations and the action plan proposed in this research are difficult to implement and might struggle to obtain support.

First of all, developing the adaptation pathways for the long-term (LT) coastal adaptation strategies (including signposts, transfer stations and adaptation tipping points) will be challenging for policymakers due to the complexity of the ADM method. Determining the plausible range of consequences of sea-level rise combined with the LT-coastal adaptation strategies for a specific area will be even more difficult. The proposed solution is time-consuming, and it will only work if the actors on both levels understand how to apply the instruments of ADM. Furthermore, the recommendations are expected to pay off in the long-term by protecting the Netherlands against sea-level rise, but the policymakers and implementing actors will not experience any benefits from implementing the recommendations in the short-term. Currently, no real problems are encountered from not properly taking into account the uncertainty around sea-level rise. Therefore, policymakers and implementing actors might regard the proposed recommendations as cumbersome with no clear benefits. Although the proposed solutions are challenging to implement and might experience trouble to obtain support from policymakers and implementing actors, the benefits are expected to outweigh the costs in the long-term. If the ADM method does not function properly, the risk of overinvestment or underinvestment exists. Overinvestment in flood protection measures comes with extremely high sunk costs at the expense of society. On the other hand, underinvestment risks the Dutch living environment, economy, and citizens' safety. Therefore, further research into the feasibility of the proposed recommendations and action plan is needed.

Apart from improving the application of ADM in practice by learning from its scientific foundation, practical experience is valuable to further develop the ADM method. The empirical research in this study identified two key findings that affect the theory behind ADM. Firstly, it was found that adaptation tipping points are more flexible in practice than in theory. Secondly, it was found that evaluation knows a fixed rhythm instead of continuous evaluation whenever new information comes available. As this research predominantly focuses on how ADM in practice can learn from theory, optimization of the theory behind the ADM approach is not elaborated upon. However, these two findings could be used as a starting point for future research to further develop the theory behind ADM.

Furthermore, one of the recommendations of this research is to develop area-specific consequence scenarios. This recommendation aims to enhance transparency in information and knowledge between the strategy level and the implementation level. However, reflecting on this matter, one could say that there will always be unequal access to, and use of information between different levels (also in other fields and policy areas), meaning that this disparity is somewhat inevitable. Furthermore, one could argue that informing actors at the implementation level on the possible long-term consequences of sea-level rise for their area could distract from today's objectives. For example, municipalities in the Netherlands are currently working on the national housing challenge, trying to overcome the shortage of urban houses in the upcoming ten years. Insight into the possible consequences of sea-level rise could lead to postponing or even annulling new housing developments because the safety of large parts of the Netherlands cannot be guaranteed in some of the future scenarios. Therefore, policymakers should be careful that insight into the possible consequences of sea-level rise should not lead to postponement of action. Instead, it should contribute to informed decisions on the safest areas for new developments and if additional measures are needed (such as raising the foundation of houses or building houses on piles). In this way, the living environment, economy, and citizens' safety are enhanced in the Netherlands, while safer investment decisions can be made. Hence, although a disparity in information is partly inevitable, striving for diminishing this disparity is essential to protect the Netherlands against sea-level rise.

Next, the action plan proposed in this research to enhance adaptation to sea-level rise is a top-down approach. The action plan starts with national actors determining the national coastal adaptation strategies to cope with sea-level rise. Subsequently, the regional and local implementing actors have to react to these national plans by adjusting their decisions and strategies to cope with sea-level rise on a local or regional level to the decisions made on the

strategy level. An advantage of this top-down approach is that consistency of strategies is ensured because the strategies are coordinated at a higher level than implemented. However, it could be questioned if a top-down approach is an optimal solution; a bottom-up approach could also be designed to achieve adaptation to sea-level rise. An advantage of a bottom-up approach is that implementing actors would have more room to incorporate local knowledge in decision making on how to cope with sea-level rise to ensure that the strategies are locally appropriate. Further research into the possibilities for a bottom-up approach or a combination of bottom-up and top-down is suggested.

Finally, reflecting on the overall results of this research, one could wonder if the ADM approach will be successful to cope with sea-level rise in the future or if it is a lost cause. The current application of the instruments does not enhance adaptation to sea-level rise. However, it is vital for the Netherlands that action is taken. If no action is taken, the risk of overinvestment or underinvestment exists. Overinvestment in flood protection measures comes with extremely high sunk costs at the expense of society. On the other hand, underinvestment may result in major flooding with enormous consequences for the Dutch living environment, economy, and risking the safety of citizens. Based on the results, two conditions are essential to prevent loss of all the possibilities that ADM has to offer to cope with sea-level rise. Firstly, policymakers should have insight into the solution space to cope with sea-level rise. They should understand what short-term measures are needed to keep all the LT-coastal adaptation strategies open. Also, policymakers must understand how, and which strategies can be combined or are mutually exclusive. Secondly, the actors on the implementation level should have insight into the possible consequences of sea-level rise for a specific area and know how to cope with this adaptively. A prerequisite to achieve this is that actors understand how to apply the instruments of ADM.

7.2. Implications of the results

This section explains the implications of the research's results for policymakers and researchers. The implications for two different stakeholder categories will be discussed; the policymakers that have to implement ADM in practice and the researchers that develop the ADM concepts and methods.

Implications for policymakers

Based on the results of the institutional and instrumental governance of ADM and the analysis of what this means for enhancing adaptation to sea-level rise in the Netherlands, the following recommendations have been proposed in this research (1) Develop adaptation pathways for LT-coastal adaptation strategies, (2) Develop area-specific consequence scenarios, (3) Formulate policy objectives more precisely, and (4) Provide workshops on the application of the instruments of ADM (Section 6.4). The implications of the recommendations for policymakers will be discussed in this section.

Firstly, policymakers should shift their focus from solving today's problems to further into the future. The four LT-coastal adaptation strategies identified (Protect-Open, Protect-Closed, Seaward, and Accommodate) aim to protect the Netherlands against extreme sea-level rise over the next 100 to 200 years. A more future-oriented mindset is required for policymakers to explore the long-term strategies to cope with sea-level rise and connect short-term decisions with long-term objectives.

The second implication is that more alignment between the actors at different levels is needed. Particularly, alignment is necessary to ensure that actors on the implementation level are aware of the strategies considered on the national level. Only then, actors on the implementation level can obtain insight into the possible consequences of sea-level rise for their region and explore the accurate measures to protect the area and its residents from the consequences.

Thirdly, policymaking at the implementation level will become more complex and time-consuming than it is today. The actors on the implementation level will need to learn how to incorporate uncertainty around the consequences of sea-level rise in decision making. Even after the actors on the implementation level have learned how to apply the instruments of ADM, the proposed method will still be more complex and time-consuming than the current decision making system.

Implications for researchers

As is explained before, differences between a theory and its implementation in practice will always exist. Therefore, whenever differences are detected, it is essential to be critical about whether aligning theory and its implementation in practice will yield the desired effects. Two implications of this research were detected that are valuable for further developing the ADM method.

First of all, it was found that adaptation tipping points are more flexible in practice than in theory. Even when policymakers follow up on the proposed recommendation to formulate policy objectives more precisely, it will not be possible to define concrete adaptation tipping points in practice. As technical feasibility and financial or societal acceptability of solutions change over time, policymakers cannot define in advance when a strategy will be no longer viable, and an adaptation tipping points occurs. Therefore, further research is suggested on how adaptation tipping points can be defined when precise policy objectives are absent.

The second finding that has implications for the ADM method is that the pace at which the evaluation of strategies is performed in theory and practice differs. In practice, evaluation has a fixed rhythm of making adaptations in existing delta decisions and strategies once every year and once every six years. According to the theory (Hermans et al., 2016), continuous evaluation and recalibration strategies should be performed whenever new information comes available. However, the fixed rhythm is expected to be positive for the ADM method. The rationale for this is that, on the one hand, a fixed rhythm helps to keep the balance between being flexible and, on the other hand, it helps to react to new developments and offers stability and coherence in choices made on the other hand. But more importantly, it is expected that the fixed rhythm of evaluation can create political momentum for adjusting strategies. Continuous evaluation whenever new information comes available could result in postponing the adjustment of strategies, especially if concrete adaptation tipping points are absent (this is explained in Section 6.3.1). Further research is suggested into the effectiveness and the implications of a fixed rhythmic for evaluation instead of continuous evaluation whenever new information comes available to develop the ADM method further.

7.3. Limitations of the research

In total, fourteen interviews were conducted to explore the governance of ADM in practice. From these fourteen interviews (table 11, p. 91), the number of interviews conducted with actors on the implementation level was relatively small (n=4). Therefore, caution must be applied when generalizing the findings on the application of the instrumental governance elements, as the findings on incorporating the instruments might not be representative to all actors on the implementation level. Therefore, additional research is suggested in how the instrumental governance elements of ADM have taken shape in practice at the implementation level. Nonetheless, the conclusion that adaptation to sea-level rise is currently not enhanced on the implementation level can be generalized. The rationale for this is that implementation actors currently cannot properly take into account uncertainty in decision making because they do not have access to the information on the consequences of sea-level rise for a specific region. Therefore, although additional research is needed to generalize the findings on the application of the instruments of ADM, the recommendation to develop area-specific consequence scenarios is still valid to enhance adaptation to sea-level rise on the implementation level.

Another limitation of this research is that drinking water utilities were not represented in the interviews, so the implementation level results are based on implementing actors active in flood risk management (regional water authorities) and climate-proof spatial planning (municipalities). Therefore, how the governance of ADM has taken shape at the implementation level for safeguarding freshwater availability has not been researched. Further research into exploring how ADM's institutional and instrumental governance is shaped for drinking water utilities is recommended.

Finally, it would also be interesting to explore the governance of ADM in the Netherlands at a more general level, instead of focusing only on the adaptation to sea-level rise. The interviews conducted for this research have aimed to explore this more general view. However, it was evident that the research would be too broad for the time and scope that was available for this study and therefore the focus was shifted to adaptation to sea-level rise. This results in a disadvantage and an advantage regarding the interview results. Firstly, as the interview questions on the roles, responsibilities and instruments of ADM were not focused on sea-level rise specifically, the results on the institutional and instrumental governance of ADM are less tangible for sea-level rise. The fact that many interviewees got confused by the questions about the application of scenarios illustrates this. The confusion could have been prevented if the interviewees would have been questioned upon the application of scenarios for sea-level rise specifically instead of the use of scenarios in general. However, the more general questioning also knows an important advantage for this research; namely, the interviews explored the governance of ADM in general instead of only to the governance of sea-level rise. Hence, the results of this research apply to the governance of ADM in general in the Netherlands instead of only to the adaptation to sea-level rise.

8
Conclusion

The main research question of the presented study is: *"Is the governance of ADM in the Netherlands coherent with its scientific foundation, and does the governance of ADM enhance adaptation to sea-level rise?"*. This chapter answers the main research question by highlighting the key findings of the study.

The research shows that the application of the greater part of the instruments of Adaptive Delta Management (ADM) is not coherent with how they should be applied according to theory. Based on the analysis of the similarities and differences between theory and practice, the research found that currently, the governance of ADM in practice in the Netherlands does not enhance adaptation to sea-level rise. The study stresses the importance of taking action to keep the Netherlands safe from sea-level rise now and in the future. Therefore, several recommendations inspired by the theoretical foundation of ADM are proposed to ensure adaptation to sea-level rise is enhanced. The first recommendation aims to ensure that policymakers get insight into the solution space to cope with sea-level rise. They should understand what short-term measures are needed to keep all the long-term strategies to cope with sea-level rise open. Also, they must understand how, and which strategies can be combined or which ones are mutually exclusive. Furthermore, actors involved in the implementation of strategies should obtain insight into the possible consequences of sea-level rise for their area and know how to incorporate this in decision making.

Is the governance of ADM in the Netherlands coherent with its scientific foundation?
Based on the empirical research, the conclusion was drawn that the application of the greater part of the instruments in practice is not coherent with ADM's scientific foundation. Hence, the results confirm that the link between ADM in practice and its scientific foundation has vanished. The first difference observed is that adaptation pathway maps in practice are far simpler than prescribed in theory; they only contain the preferential strategy instead of multiple strategies, and no signposts and transfer stations are defined. Secondly, adaptation tipping points are more flexible in practice than is prescribed in theory. The final difference observed is that evaluating strategies in practice has a fixed rhythm, while according to theory, continuous evaluation and recalibration should occur whenever new information comes available. The main implication of these differences is that ADM in practice provides less guidance to policymakers on when and which adjustments of strategies are needed than in theory.

Does the governance of ADM enhance adaptation to sea-level rise?
Before proceeding to the conclusion of this sub-question, it is important to understand which actors are involved in the governance of ADM. The actors identified to play a role in developing adaptive strategies are the Signal Group, the Knowledge Network, Research Program Sea-Level Rise, (Staff) Delta Commissioner, the Delta Program Sub-Programs, and various knowledge institutions. The actors responsible for implementing the strategies are regional water authorities, municipalities and drinking water utilities. Furthermore, an important finding is that the implementing actors must take into account the measures considered on the strategy level. This is because the consequences of sea-level rise for the implementation level depend on the amount of sea-level rise combined with the measures taken on the strategy level to protect the Netherlands against sea-level rise. For example, which flood protection measures are taken along the Dutch

coast by the actors on the strategy level determine which areas will remain safe in the future for new housing developments for municipalities.

The study shows that the organizational structure in the Netherlands is appropriate for enhancing adaptation to sea-level rise. However, the results show room for improvement in how the ADM methods and tools are applied in practice. The empirical research shows that no adaptation pathways towards the national long-term strategies to cope with sea-level rise have been defined at the strategy level. The result is that it is more challenging for policymakers to identify the short-term actions needed to keep the long-term strategies to cope with sea-level rise open. Moreover, the absence of adaptation pathways could result in path-dependency and lock-ins. The empirical research into the application of the instruments of ADM at the implementation level shows that the implementing actors do not apply the greater part of the instruments of ADM. The absence of scenarios at the implementation level means that uncertainty is not incorporated in decision making, while uncertainty around the consequences of sea-level rise for implementing actors is high. Hence, for both the strategy level and the implementation level, adaptation to sea-level rise is currently not enhanced through the governance of ADM.

Recommendations

Concludingly, the current application of the instruments of ADM does not enhance adaptation to sea-level rise. If no action is taken, the risk of overinvestment or underinvestment in flood protection measures exists. Overinvestment comes with extremely high sunk costs at the expense of society. On the other hand, underinvestment may result in major flooding with enormous consequences for the Dutch living environment, economy, and risking the safety of citizens. Hence, it is vital for the Netherlands that action is taken to enhance adaptation to sea-level rise. Four recommendations have been proposed to enhance adaptation to sea-level rise, the Staff Delta Commissioner should be responsible for taking the lead in implementing recommendations.

- Develop adaptation pathways to the LT-coastal adaptation strategies. Adaptation pathways shall be developed for the LT-coastal adaptation strategies considered in the Netherlands (Protect-Open, Protect-Closed, Seaward, and Accommodate). The development of adaptation pathways will provide policymakers insight into the possible adaptation options, lock-ins and path dependencies. Furthermore, it will help policymakers identify short-term measures that have to be taken to keep the long-term strategies open.
- Develop area-specific consequence scenarios. These area-specific scenarios should outline the plausible consequences of sea-level rise and the LT-coastal adaptation strategies for a specific area. Insights into the possible range of consequences of sea-level rise are crucial for implementing actors to make an informed decision on appropriate measures and actions. Furthermore, these scenarios are the basis for applying the other instruments of ADM on the implementation level.
- Formulate policy objectives more precisely. Policy objectives should be defined as clear and explicit as possible, preferably with measurable indicators. Clearly defined goals make it easier to determine if a strategy is successful or not (and an adaptation tipping point occurs). Resulting in that policymakers have insight into when adjustment of a strategy is needed.
- Provide workshops on the application of the instruments of ADM. Workshops and training should be provided to teach the actors of ADM how to apply the instruments. This is important because applying the instruments of ADM in the prescribed manner is challenging.

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A

Scientific paper

Enhancing the adaptiveness of Adaptive Delta Management

Empirical research into the institutional and instrumental governance of ADM for enhancing adaptation to sea-level rise in the Netherlands

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Abstract: In 2011, Adaptive Delta Management (ADM) was introduced in the Dutch Delta Program as a policy development method to incorporate uncertainty in decision making transparently. At this moment, little is known over the functioning of ADM in practice, while this is determining its success. This paper presents the results of research into the application of ADM in Dutch practice. Starting from the scientific foundation of ADM, researched how ADM is shaped in practice using interviews with actors on the strategy level and the implementation level. The results are analyzed to explore what they mean for the adaptiveness of Dutch delta management. This research shows important differences between ADM in theory and practice – for example, in the design of adaptation pathways for the long-term strategies Protect-Open, Protect-Closed, Seaward, and Accommodate. The implementing actors, such as regional water authorities, municipalities and water utility companies, lack instruments and insight into the area-specific consequences of sea-level rise and the national strategies. With area-specific consequence scenarios based on the national long-term strategies, adaptation to sea-level rise can also be enhanced at the implementing level.

Keywords: Adaptive delta management, adaptive policies, governance, instruments, institutions, adaptation pathways, strategy level, implementation level

1. Introduction

Recently, the speed and severity of sea-level rise have been the main topic of discussion. The most recent IPCC projections (Oppenheimer et al., 2019) estimate a sea-level rise in 2300 between 2.3 and 5.4 meters in the highest scenario and a sea-level rise of 1 meter in the lowest scenario. The high level of uncertainty makes it hard to evaluate the risk, leading to a possible outcome that insufficient measures are taken or implemented too late to protect the Netherlands against sea-level rise. Simultaneously, the possibility exists that the measures taken are over-dimensioned, which leads to unnecessary expenses for society. The rising sea-levels represent a growing threat to urbanized deltas all over the world.

In 2011, the Dutch Delta Program introduced the policy development method Adaptive Delta Management (ADM) to incorporate uncertainty about future external developments in decision making transparently and minimize the risk of overinvesting or underinvesting in measures (DP2012, 2011). Adaptive is defined as having the ability to speed up or temporize efforts or to change strategy if the actual or expected rate of climatic and socio-economic developments indicate this might be necessary (Bloemen et al., 2019).

In March 2021, a search on 'adaptive delta management' on Scopus and Web of Science yielded 22 scientific articles on ADM. On the same day, the same search term on Google generated 14.400.000 hits. The significant difference gives the impression that ADM is mainly grounded on policy documents and advisory reports but that ADM's embedding in scientific literature is limited. The same conclusion was drawn by Timmermans et al. (2015), who also derived from this that the link between ADM in practice and its scientific foundation has vanished. Furthermore, limited attention is being paid to ADM's governance dimension, while the governance challenges are considerable (Van der Brugge & Roosjen, 2015). Concludingly, little is known over ADM's functioning in practice, while this is key to its success.

The goal of this paper is to contribute to the scientific knowledge on the functioning of ADM in practice by exploring how ADM is governed and whether this is coherent with ADM's scientific foundation. Insight into the similarities and differences between practice and theory is critical for further developing ADM as a policy development method. Furthermore, this research aims to explore if ADM's governance in practice enhances adaptation to sea-level rise by analyzing the previous findings.

The remainder of the paper is structured as follows: Section 2 contains a description of the methodology used in this research; Section 3 discusses the findings of the literature review on ADM in theory. Section 4 presents the findings of the institutional governance of ADM in practice. Section 5 presents the findings on the instrumental governance of ADM in practice. Section 6 analyzes the research results to determine if adaptation to sea-level rise is enhanced in practice and provides recommendations on improving the adaptation to sea-level rise. The seventh and final section wrap the paper up with a discussion and the conclusion arguing for the development of adaptation pathways for the LT-coastal adaptation strategies (Protect-Open, Protect-Closed, Seaward and Accommodate) and area-specific consequence scenarios.

2. Methodology

The research is a qualitative study split into four phases. Phase I explores how the governance of ADM should be shaped theoretically. Phase II examines how ADM's institutional and instrumental governance is shaped in practice and if this is coherent with theory. Phase III analyzes the previous phases' results to determine if the governance of ADM in practice enhances adaptation to sea-level rise. In addition, recommendations will be provided for the improvement areas identified. Finally, Phase IV discusses the implications and validity of this research and answers the main research question. The methodology used for Phase I and II will be explained in the next section.

In Phase I, an integrative literature review method is used to compose an overview of the governance elements discussed in the literature that are important for the governance of ADM. An overview of the search methods and search terms are visible in table 1. A review of Dutch literature is included because ADM as a policy method is developed in the Netherlands. From the list of articles obtained, articles were removed based on title and abstract relevance. The criteria for the title and abstracts were that the articles covered governance elements of ADM. The remaining literature studies were used as the starting set of papers on which the backward snowballing procedure was applied - backwards snowballing means that the reference list of articles is used to select new articles to include in the literature study (Wohlin, 2012). Because the amount of research into the governance dimension of ADM is limited, articles are also studied that provide a more general assessment of ADM instead of only focusing on ADM's governance perspective. From these more general assessments of ADM, only the governance elements are included in the results of this literature review. After the governance elements were identified, additional scientific articles covering the DAPP approach (the scientific foundation of ADM) were consulted to supplement how ADM should be applied according to theory.

Search method	Search terms	Language
Scopus	govern* OR evaluat* OR assess* AND "adaptive delta management"	English
Google Scholar	"governance adaptive delta management" "assessing adaptive delta management" "evaluating adaptive delta management"	Both
Backwards snowballing	-	Both

Table 1: Search methods and terms literature review

In Phase II, empirical research was performed to explore how ADM's governance is currently shaped in practice. Information was gathered through conducting interviews and studying policy documents and advisory reports. The institutional governance of ADM was explored by analyzing the actors involved in ADM. Then, it was analyzed if the institutional governance of ADM in practice is in line with the theoretical framework's institutional elements. The second part of Phase II entails exploring how the instrumental governance of ADM is shaped in practice. Again, the findings will be compared with the instrumental elements of the theoretical framework to explore the coherency between practice and theory (SQ4).

A combination of primary and secondary sources was used to identify the actors that play a role in ADM. The initial set of actors was identified by studying secondary resources, such as policy documents and reports. To ensure that no important actors are missing, actors were asked to identify other actors that play a role in ADM. An overview of the actors identified is visible in table 3. In this paper, these actors are referred to as 'the actors of ADM'.

Semi-structured interviews were performed to explore how the governance of ADM is shaped in practice. In total, fourteen interviews were conducted. The interviewees were held with representatives of the actors of ADM (table 3), Sweco, and HWBP. Unfortunately, scheduling an interview with a representative of a drinking water utility has not been achieved. Furthermore, it was ensured that all the important knowledge institutions were represented (KNMI, PBL and Deltares). The interviews were conducted in Dutch because the Dutch language is used for all communication in the delta management sector in the Netherlands. The first part of the interviews focused on exploring the institutional governance of ADM in practice, and the second part on exploring the instrumental governance of ADM in practice. The institutional and instrumental elements of the theoretical governance framework of ADM (Table 2) serve as the basis for the interview questions. To reveal the institutional governance of the actors of ADM, implicit questions were asked that aimed to reveal if the theoretic institutional governance elements were present in practice. In the second part, explicitly was asked if each instrument is incorporated by the actor and how they have taken shape in practice.

3. Theoretical governance framework

The findings of the integrative literature review (Phase I) show that several institutional and instrumental governance elements are essential for ADM. Institutional governance describes how the organizational structure of the actors involved in ADM should be shaped. The instrumental governance describes the methods and tools (instruments) that can be used for applying ADM. The institutional and instrumental governance combined form the theoretical governance framework of ADM (table 2).

Institutional governance elements	Instrumental governance elements
Clear agreements on roles and responsibilities	Scenarios – Static scenarios or transient scenarios outline the major uncertainties that play a role in decision making
Transparent information management	Adaptation pathways – Outline the possible strategies, the signposts that should be monitored and the transfer stations on which can be switched to another strategy
Engagement of multiple actors at various levels in monitoring	Adaptation tipping points – Indicate the endpoint of a strategy, which is when a strategy no longer meets the predefined objectives
Engagement of multiple actors at various levels in evaluation	Monitoring system – Keep track of the external developments that may lead to adjusting choices and strategies continuously
Coordination at a higher level than implementation	Evaluation system – Evaluate if pursuing current strategies will lead to reaching the predefined objectives in time considering the external developments and recalibrating strategies whenever new monitoring information comes available

Table 2: Theoretical governance framework

The actors that play a role in ADM must understand their own and each other's responsibilities and tasks; this increases mutual trust and stimulates collaboration (Hermans et al., 2016). In addition, transparency in information management is critical for applying ADM (Hermans et al., 2016). ADM is a data-driven policy method in which new information on developments determines the course of the strategy. Furthermore, involving multiple levels helps to improve information flows and knowledge exchange between these levels (Restemeyer et al., 2017). Then, involving multiple actors in the monitoring process of the external developments relevant to delta management contributes to the reliability of the knowledge obtained (Bloemen et al., 2018). Next, involving multiple actors at various levels in evaluating if pursuing current strategies will lead to timely reaching the objectives is important for the governance of ADM (Hermans et al., 2017). In addition, the engagement of local stakeholders is vital for the support of the plans (Bloemen et al., 2018). Finally, ADM strategies should be coordinated at a higher level than the level where they are implemented to increase consistency (Bloemen et al., 2018; Dewulf & Termeer, 2015; Rosenzweig & Solecki, 2014)

According to scientific literature, scenarios can be static scenarios or transient scenarios (Haasnoot et al., 2015) and should outline the major uncertainties that play a role in decision making (Haasnoot et al., 2015; Bloemen et al., 2019). Adaptation pathways outline the possible strategies, the signposts that should be monitored and the transfer stations on which can be switched to another strategy (Haasnoot et al., 2013). Adaptation tipping points indicate the endpoint of a strategy, which is when a strategy no longer meets the predefined objectives (Haasnoot et al., 2013; Dewulf & Termeer, 2015; Kwadijk et al., 2010). The monitoring system keeps tracks of the external developments that may lead to adjusting choices and strategies continuously (Zevenbergen et al., 2018; Dewulf & Termeer, 2015). The evaluation system evaluates if pursuing current strategies will lead to timely reaching the predefined objectives considering the external developments and recalibrating strategies (Bloemen et al., 2019) whenever new monitoring information comes available (Hermans et al., 2016).

An analysis is performed in this research to determine the relative importance of the elements for enhancing adaptive delta management. It is concluded that the institutional governance elements can be seen as requirements for applying ADM. Only if all institutional governance elements are present in practice, a proper foundation for applying the instruments of ADM is in place. Regarding the instrumental elements, scenarios were identified as the most critical instrument for applying ADM. Thereafter come adaptation pathways, the monitoring system and the evaluation system. Finally, adaptation tipping points were assessed to have the lowest relative importance for applying ADM. It is important to note that if an element has low relative importance, this does not mean the element is not important for applying ADM. All the elements included in the theoretical governance framework of ADM have been identified as essential for the governance of ADM.

4. Institutional governance ADM

The results of the empirical research reveal the institutional governance of ADM in practice (Phase II). The actors responsible for adaptive delta strategies are the actors that play a role in the six-yearly recalibration of the Delta Program (Delta Commissioner, 2018). These actors are referred to as the actors on the strategy level and are the Signal Group, the Knowledge Network, Research Program Sea-Level Rise, (Staff) Delta Commissioner, the Delta Program Sub-Programs, and various knowledge institutions. The actors responsible for the adaptive implementation of the strategies are regional water authorities, municipalities and drinking water utilities. These actors are referred to as the actors on the implementation level. Based on the empirical research, it is concluded that theoretic institutional governance elements are all present in practice.

Actor	Level
The Signal Group	Strategy
The Knowledge Network	Strategy
Research Program Sea-Level Rise	Strategy
(Staff) Delta Commissioner	Strategy
Knowledge institutions	Strategy
DP Sub-Programs	Strategy
Regional water authorities	Implementation
Municipalities	Implementation
Drinking water utilities	Implementation

Table 3: The actors of ADM

5. Instrumental governance ADM

The results of the empirical research into the instrumental governance of ADM in practice (Phase II) show that differences between practice and theory, and between the strategy level and the implementation level. On the strategy level, the application of scenarios and the monitoring system aligns with how they should be shaped according to theory. For adaptation pathways, differences between theory and practice were observed; the adaptation pathway maps used in practice only contain the preferential strategy instead of multiple strategies, and no signposts and transfer stations are defined. Also, the research found that adaptation tipping points in practice are more flexible than in theory. Furthermore, evaluation and adjustment of strategies do not happen as soon as new information comes available, as is prescribed in theory, but has a fixed rhythm in practice. The main implication of these differences is that ADM in practice provides less guidance to policymakers on when and which adjustments of strategies are needed than in theory.

Instrumental governance elements of ADM	Incorporation on the strategy level	Application in practice coherent with theory
Scenarios	+	+
Adaptation pathways	+/-	-
Adaptation tipping points	-	-
Monitoring system	+	+
Evaluation system	+	+/-

Table 4: Results instrumental governance on the strategy level

On the implementation level, the majority of instrumental governance elements is not applied. Scenarios and adaptation pathways are hardly ever used by the actors at the implementation level. Also, no concrete adaptation tipping points have been identified at the implementation level. Finally, it was not possible to generalize the findings on the monitoring and the evaluation system because no rules or arrangements in place on how monitoring and evaluation should be shaped in practice. Therefore, the monitoring and evaluation system is different for every implementing actor.

Instrumental governance elements of ADM	Incorporation on the implementation level
Scenarios	-
Adaptation pathways	-
Adaptation tipping points	-
Monitoring system	*Findings cannot be generalized*
Evaluation system	*Findings cannot be generalized*

Table 5: Results instrumental governance on the implementation level

6. Enhancing adaptation to sea-level rise

The results of the analysis of the previous findings to determine if the governance of ADM in practice enhances adaptation to sea-level rise (Phase III) show that the institutional governance is appropriate and that in the instrumental governance is still room for improvement. An important finding from the institutional analysis is that to enhance adaptation to sea-level rise on the implementation level; it is required that the implementing actors take into account the measures considered on the strategy level. The explanation for this is that the consequences of sea-level rise that the implementation level has to deal with depend on the amount of sea-level rise combined with the Dutch coastal adaptation strategy. For example, which flood protection measures are taken along the Dutch coast by the actors on the strategy level determine which areas will remain safe in the future for new housing developments for municipalities.

The actors of ADM are responsible for ensuring adaptation to sea-level rise. Therefore, the results of the stakeholder analysis are still valid, meaning that the theoretical requirements for institutional governance are all met in practice. Hence, the organizational structure of the actors of ADM is appropriate for enhancing adaptation to sea-level rise.

Regarding the instrumental governance at the strategy level, the current application of scenarios, the monitoring system and the evaluation system enhance adaptation to sea-level rise. However, no adaptation pathways towards the national LT-coastal adaptation strategies to cope with sea-level rise have been defined. The result is that it is more challenging for policymakers to identify the short-term actions needed to keep the LT-coastal adaptation strategies open. Also, the absence of adaptation pathways could result in path-dependency and lock-ins. Also, defining concrete adaptation tipping points is challenging; this makes it more challenging to determine when a strategy should be adjusted.

On the implementation level, most instruments of ADM are not applied in practice. The absence of scenarios at the implementation level means that uncertainty is not incorporated in decision making. Furthermore, the lack of adaptation pathways and adaptation tipping points results in policymakers not having insight into the possible adaptation options, path dependencies and lock-ins. Therefore, adaptation to sea-level rise is not enhanced on the implementation level.

The following recommendations have been proposed to improve the adaptation to sea-level rise:

- Develop adaptation pathways to the LT-coastal adaptation strategies. Adaptation pathways shall be developed for the LT-coastal adaptation strategies considered in the Netherlands (Protect-Open, Protect-Closed, Seaward and Accommodate). The development of adaptation pathways will provide policymakers insight into the possible adaptation options, lock-ins and path dependencies. Furthermore, it will help policymakers identify short-term measures that have to be taken to keep the LT-strategies open.
- Develop area-specific consequence scenarios. These area-specific scenarios should outline the plausible consequences of sea-level rise and the LT-coastal adaptation strategies for a specific area. Insights into the possible range consequences of sea-level rise are crucial for implementing actors to make an informed decision on appropriate measures and actions. Furthermore, these scenarios are the basis for applying the other instruments of ADM on the implementation level.
- Formulate policy objectives more precisely. Policy objectives should be defined as clear and explicit as possible, preferably with measurable indicators. Clearly defined goals make it easier to determine if a strategy is successful or not (and an adaptation tipping point occurs). Resulting in that policymakers have insight into when adjustment of a strategy is needed.
- Provide workshops on the application of the instruments of ADM. Workshops and training should be provided to teach the actors of ADM how to apply the instruments because using the instruments of ADM in the prescribed manner is challenging.

Based on the recommendations, the following action plan has been proposed to enhance an adaptive approach to sea-level rise in the Netherlands:

1. Develop adaptation pathways for the LT-coastal adaptation strategies
2. Develop national coastal adaptation scenarios
3. Translate coastal adaptation scenarios into area-specific consequence scenarios
4. Provide workshops on the application of the instruments of ADM

7. Discussion

In this section, the results of this study are discussed. The first section reflects on the research results. Then, the second section discusses the implications of the results for policymakers and researchers. Finally, the third section elaborates on the research limitations. All sections include suggested areas for further research.

When reflecting on the recommendations for enhancing adaptation to sea-level rise that has been provided in this research, one could argue that the recommendations are rather theoretically oriented. Therefore, further research into the feasibility of the proposed recommendations and action plan is needed. Furthermore, the recommendation to develop area-specific consequence scenarios aims to enhance transparency in information and knowledge between the strategy level and the implementation level. However, reflecting on this matter, one could say that there will always be unequal access to, and use of, information between different levels (also in other fields and policy areas), meaning that this disparity is somewhat inevitable. Although a disparity in information is partly inevitable, striving for diminishing this disparity is essential to protect the Netherlands against sea-level rise. Next, the action plan proposed in this research to enhance adaptation to sea-level rise is a top-down approach. However, it could be questioned if a top-down approach is an optimal solution; a bottom-up approach could also achieve adaptation to sea-level rise. Further research into the possibilities for a bottom-up approach or a combination of bottom-up and top-down is suggested.

Finally, reflecting on the overall results of this research, one could wonder if the ADM approach will be successful to cope with sea-level rise in the future or if it is a lost cause. Although he current application of the instruments does not enhance adaptation to sea-level rise, it is vital for the Netherlands that action is taken to enhance the Dutch living environment, economy, and the safety of citizens. Based on the results, two conditions are essential to prevent loss of all the possibilities that ADM has to offer to cope with sea-level rise. Firstly, policymakers should have insight into the solution space to cope with sea-level rise. They should understand what short-term measures are needed to keep all the LT-coastal adaptation strategies open. Also, policymakers must understand how, and which, strategies can be combined or which ones are mutually exclusive. Secondly, the actors on the implementation level should have insight into the possible consequences of sea-level rise for a specific area and know how to cope with this adaptively. A prerequisite to achieve this is that actors understand how to apply the instruments of ADM.

Based on the recommendations for enhancing adaptation to sea-level rise in the Netherlands, three implications for policymakers have been identified. Firstly, A more future-oriented mindset is required for

policymakers to explore the long-term strategies to cope with sea-level rise and connect short-term decisions with long-term objectives. Secondly, more alignment between the actors at different levels is needed. Thirdly, policymaking at the implementation level will become more complex and time-consuming than it is today.

Although the primary focus of the research was if the governance of ADM enhances adaptation to sea-level rise, also two implications of this research were detected that are valuable for further developing the ADM method. Firstly, adaptation tipping points are more flexible in practice than in theory. Further research is suggested on how adaptation tipping points can be defined when precise policy objectives are absent. Secondly, the pace at which the evaluation of strategies in practice has a fixed rhythm, while inn theory, continuous evaluation should happen continuously whenever new information comes available. The fixed rhythm is expected to be positive for the application of the ADM method in practice. Therefore, further research is suggested into the effectiveness and the implications of a fixed rhythmic for evaluation in the ADM method.

In total, three limitations of the research have been identified. Firstly, the number of interviews conducted with actors on the implementation level was relatively small (n=4). Therefore, caution must be applied when generalizing the findings on the application of the instrumental governance elements, as the findings on incorporating the instruments might not be representative to all actors on the implementation level. Secondly, drinking water utilities were not represented in the interviews, so the implementation level results are based on implementing actors active in flood risk management (regional water authorities) and climate-proof spatial planning (municipalities). Therefore, how the governance of ADM has taken shape at the implementation level for safeguarding freshwater availability has not been researched. Finally, it would also be interesting to explore the governance of ADM in the Netherlands at a more general level, instead of purely sea-level rise. The interviews conducted for this research have aimed to explore this more general view. However, it was evident that the research would be too broad for the time and scope that was available for this study and therefore the focus was shifted to adaptation to sea-level rise.

8. Conclusion

The research shows that the application of the greater part of the instruments is not coherent with how they should be applied according to theory. Based on the analysis of the similarities and differences between theory and practice, the research found that currently, the governance of ADM in practice in the Netherlands does not enhance adaptation to sea-level rise. The research stresses the importance of taking action to keep the Netherlands safe from sea-level rise now and in the future. Therefore, several recommendations inspired by the theoretical foundation of ADM are proposed to ensure adaptation to sea-level rise is enhanced. The first recommendation aims to ensure that policymakers get insight into the solution space to cope with sea-level rise. They should understand what short-term measures are needed to keep all the long-term strategies to cope with sea-level rise open. Also, they must understand how, and which strategies can be combined or which ones are mutually exclusive. Furthermore, actors involved in the implementation of strategies should obtain insight into the possible consequences of sea-level rise for their area and know how to incorporate this in decision making.

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B

The Dutch Delta Program

B.1 Establishment of the Dutch Delta Program

After the disastrous floods in the Netherlands in 1953, the first Delta Committee was established to prevent the Netherlands from similar disasters in the future. The Delta Committee had two options back then to protect the Netherlands against storm floods; either raise and strengthen more than 1000 kilometers of dikes or closing the sea outlets that were threatened by tidal waves. The Delta Committee chose for the latter of the two possibilities and therewith, the beginning of the Delta Works was announced. In 1997, the Delta Works were officially finished by the completion of the Maeslantkering (Rijkswaterstaat, n.d.).

In 1993 and 1995, rising river levels of the Rhine and the Meuse nearly led to dike failure in various parts of the Netherlands. At the same time, scientific evidence showed that the assumed hydraulic baseline conditions such as storm wave characteristics and maximum river discharges were probably more severe than expected initially and that climate change and sea-level rise would worsen this (Kabat et al., 2009). Therewith, the discussions re-opened again with a fundamental reassessment of the acceptability of flood risk in the Netherlands, with a stronger focus on economic impact than before (Zevenbergen et al., 2013). After Hurricane Katrina in 2005, it became apparent that many of the implications of the hurricane were due to reliance on a single approach of 'complete protection' from flooding and inept engineering (Jonkman et al., 2009). The Netherlands reflected on this situation leading to the reorganization of the Delta Committee in 2009.

The main result of the Dutch Delta committee's reorganization is that the Delta Program obtained a legislative foundation in de Delta Act in 2010. The Delta act describes the responsibilities and power of the Delta Program Commissioner, sets out agreements for financing the Delta Program, and obliges the government to renew the Delta Program every year. The yearly budget that stems from the Delta act is defined in the Delta fund and equals 1.25 billion euros per year. The Delta Program unites the central government, provinces, municipalities, waterboards. Apart from governmental institutions, also involved are civil-society organizations, the business community and organizations with specialized water expertise (Rijksoverheid, n.d.). At the core of the Delta Program is resilience: striving towards an appropriate balance between protection, prevention and preparedness, both now and into the future (Gersonius et al., 2010). The Delta Program consists of three national generic sub-programs: improvement of flood risk management, freshwater availability, and climate-proof spatial planning. Also, six area-specific Sub-Programs are in place: Rijnmond-Drechtsteden, Zuid-Westelijke delta, the Ijsselmeer area, the Wadden area, rivers and the coast.

B.2 The Delta Program's Sub-Programs

Figure 7 represents the Netherlands, with colored lines, the six area-specific sub-programs of the Delta Program are visible. In addition, three sub-themes are distinguished: water safety, freshwater, and new urban development and restructuring. Source: The Delta Program 2012 (DP2012, 2011).

Figure 7: Delta Program Sub-Programs

C

Literature review

C.1 Search terms and process

The search engines used to find the initial set of scientific papers are Scopus and Google Scholar. Both English and Dutch articles are included in the literature review. A review of Dutch literature is included because ADM as a policy method is developed in the Netherlands. By also searching literature in the Dutch language, it is ensured that no relevant Dutch studies are missing. From the list of articles obtained, articles were removed based on title and abstract relevance. The criteria for the title and abstracts were that the articles covered governance elements of ADM. The remaining literature studies were used as the starting set of papers on which the backward snowballing procedure was applied - backwards snowballing means that the reference list of articles is used to select new articles to include in the literature study (Wohlin, 2012). The overview of the article selection process is visible in figure 8.

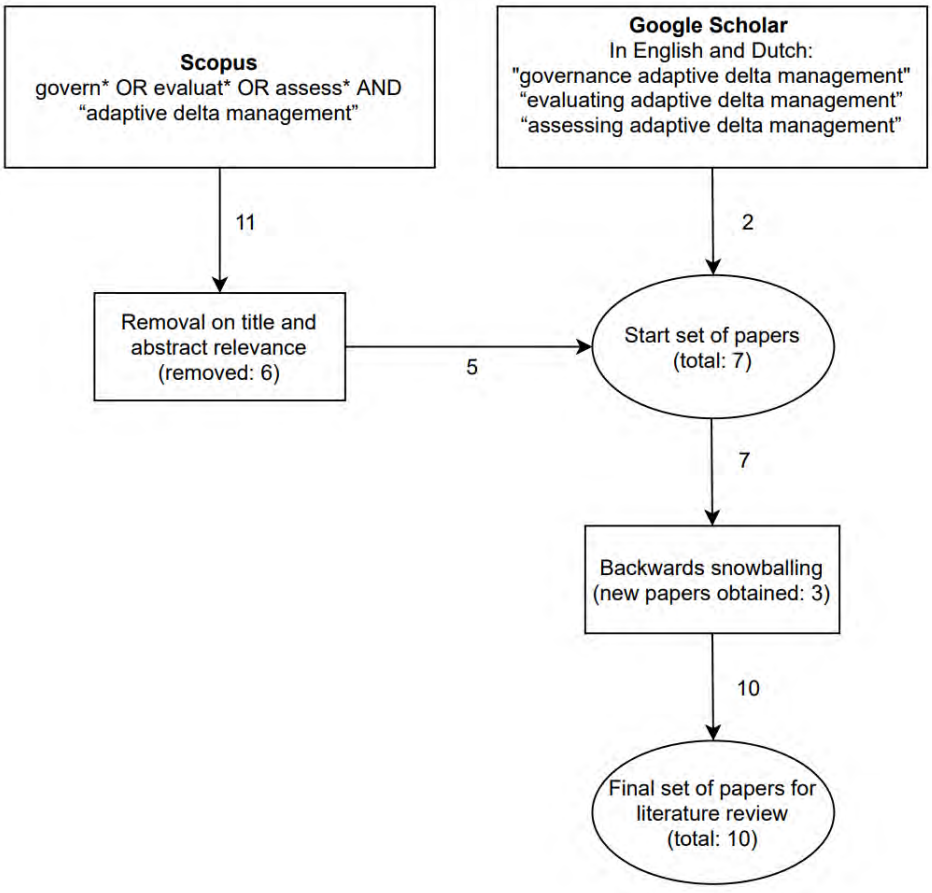

Figure 8: Article selection process

C.2 Articles literature review – identifying the governance elements of ADM

Table 9 presents the final set of scientific articles used for the integrative literature review. The institutional and instrumental governance elements included in the theoretical governance framework of ADM have all been deducted from these articles.

Author(s) and year	Title	Content
Loeber, A. & Laws, D. (2016)	Reflecterend in de Delta: naar een systematiek voor monitoring en evaluatie in het Deltaprogramma gericht op lerend samenwerken.	Develops a design for M&E-system
Gersonius et al. (2016)	Adaptive Delta Management for flood risk and resilience in Dordrecht, The Netherlands	Explains current understanding ADM + examines the added value and limitations of Adaptive Delta Management concerning its application
Bloemen et al. (2018)	Lessons learned from applying adaptation pathways in flood risk management and challenges for the further development of this approach	evaluate the current use of adaptation pathways and its utility to practitioners and decision makers
Zevenbergen et al. (2018)	Adaptive delta management: a comparison between the Netherlands and Bangladesh Delta Program	This paper explores the challenges and opportunities for successful formulation and implementation of a delta plan (similar to Dutch one, including ADM) in Bangladesh.
Hermans et al. (2017)	Designing monitoring arrangements for collaborative learning about adaptation pathways	Designs monitoring arrangements that should be implemented for adaptation pathways
Dewulf & Termeer (2015)	Governing the future? The potential of adaptive delta management to contribute to governance capabilities for dealing with the wicked problem of climate change adaptation	Assess the potential of ADM to contribute to each of the governance capabilities required to deal with wicked problems: reflexivity, responsiveness, resilience, revitalization and rescaling
Hermans et al. (2016)	Monitoring en Evaluatie ten behoeve van Leren voor Adaptief Deltamanagement	Develops analytical framework for monitoring and evaluation of ADM.
Restemeyer et al. (2017)	Between adaptability and the urge to control: making long-term water policies in the Netherlands	Reveals that Dutch policymakers are torn between adaptability and the urge to control. Reflecting on this dilemma, the paper suggests a stronger focus on monitoring and learning to strengthen the adaptability of long-term water policies. Moreover, increasing the adaptive capacity of society also requires a stronger engagement with local stakeholders including citizens and businesses.

Bloemen et al. (2019)	Chapter 14: DMDU into Practice: Adaptive Delta Management in The Netherlands	(I) keep political involvement "at arm's length". (II) Strategy development requires a narrative that explains how uncertainty is dealt with; that narrative should match the specific societal and political context of the moment. (III) Implementing adaptive strategies requires organizational arrangements for systematically accommodating adjustments, a monitoring system for timely detecting of signals, and a decision making process that links directly to its output.
Rosenzweig & Solecki (2014)	Hurricane Sandy and adaptation pathways in New York: Lessons from a first-responder city	Lessons learned from New York about applying adaptation pathways in practice.

Table 9 - Articles literature review

D

The actors of ADM

D.1 Actor identification process

In this research, a combination of primary and secondary sources is used to identify the initial list of actors. First, secondary resources, such as policy documents and reports, were studied to determine the first set of actors. To ensure that no important actors are missing, the actors were asked to identify other actors that play a role in ADM.

The actors responsible for adaptive delta strategies are the actors that play a role in the six-yearly recalibration of the Delta Program. According to (Delta Commissioner, 2018), these actors are The Signal Group, The Knowledge Network, and the (Staff) Delta Commissioner. The Delta Program's Sub-Programs were also identified because they take the initiative of recalibrating strategies (DP2019, 2018). In addition, Research Program Sea Level Rise is expected to have a valuable contribution to knowledge development for the next recalibration of the Delta Program (Kernteam DPRD, 2020). Finally, the actors identified were asked to identify other important actors. They indicated that the various knowledge institutions (Such as KNMI, PBL and Deltares) are critical for the monitoring information incorporated when recalibrating strategies. Finally, the initial set of actors highlighted the importance of implementing actors for ensuring an adaptive implementation of the strategies. Based on their answers, the following implementing actors were added to the actor list: regional water authorities, municipalities and drinking water utilities. An overview of the actors iof ADM is visible in table 4 (p. 38).

D.2 Delta Program knowledge institutions

Table 10 shows an overview of the relevant knowledge institutions for the Delta Program. Per knowledge institution a short description of its role in delta management is provided. In addition, a hyperlink to a website containing more information is included.

Actor	Role in delta management
Deltares	Deltares is hired as partner of the Ministry of Infrastructure and Water Management for (quantitative) research and advice on DP-related policy decisions. Deltares publishes the Delta Scenarios together with PBL, CPB, KNMI, and WUR. Also, Deltares, processes the monitoring information from the sea-level measuring stations along the Dutch coast
KNMI	Royal Netherlands Meteorological Institute; National data- and knowledge center for weather forecasting and monitoring of weather, climate, air quality and seismic activity
WUR	Wageningen Univerisity & Research performs research into assessment methodologies to support the Delta Program
CBS	The Netherlands' Central Statistical Agency is a Dutch governmental that gathers statistical information. One of their tasks is gatering information on land use and population trends to support PBL
PBL	The Netherlands' environmental assessment agency performs research into demographic and population developments
CPB	The Netherlands' Central Planning Agency is primarily responsible for performing economic research and developing economic forecasts

STOWA	STOWA is the knowledge center for Dutch regional water authorities and provinces. STOWA performs applied research with the objective to develop and share knowledge that regional water managers need
TU Delft	The Technical University of Delft also performs research in spatial design, engineering and governance of deltas

Table 10: Knowledge institutions

E

Interview approach

E.1 Interviewee selection process

First of all, it was ensured that from all the institutions identified as 'the actors of ADM' (table 4, p. 38), a potential respondent was approached. Whenever possible, the chairperson of the institutions was approached because chairpersons usually oversee all processes that are going on within the institution well. Therefore, it is expected that they have knowledge of the institutional and instrumental governance. Unfortunately, scheduling an interview with a representative of a drinking water utility has not been achieved. Furthermore, it was ensured that all the important knowledge institutions were represented (KNMI, PBL and Deltares). Because the role of Research Program Sea-Level rise is expected to be significant in the next systematic recalibration, the program managers of all the tracks of Research Program Sea-Level Rise were approached. While performing interviews, it was found that the engineering consultancy company 'Sweco' researched the application of ADM on the implementation level. Therefore, it was expected that Sweco has valuable information regarding ADM on the implementation level, so they were added to the interviewee list. In addition, it was found that an alliance of the regional water authorities and the Flood Protection Program (HWBP) checks of the design of new delta measures on the implementation level meet the flood risk management norms. Therefore, HWBP was added to the interview list because it was expected that they have information on the application of the instruments of ADM on the implementation level.

Interview ID	Entities the interviewee is involved in	Level	Date
NA1	Research Program Sea-Level Rise + the Ministry of Infrastructure and Water Management	Strategy	12-01-2021
NA2	Research Program Sea-Level Rise + The National Water Authority (Rijkswaterstaat)	Strategy	14-01-2021
NA3	The Knowledge Network + KNMI	Strategy	18-01-2021
NA4	The Knowledge Network + PBL + the Signal Group	Strategy	19-01-2021
NA5	The (Staff) Delta Commissioner + the MAA system	Strategy	22-01-2021
NA6	The (Staff) Delta Commissioner + The Knowledge Network + The Signal Group + Research Program Sea-Level Rise	Strategy	22-01-2021
NA7	The Signal Group + Deltares	Strategy	22-01-2021
NA8	The Signal Group + Deltares	Strategy	22-01-2021
NA9	Research Program Sea-Level Rise + the Ministry of Infrastructure and Water Management	Strategy	27-01-2021
NA10	DP Sub-Program Rijnmond-Drechtsteden + the National Water Authority (Rijkswaterstaat)	Strategy	01-02-2021
LO1	Engineering consultancy company 'Sweco'	Implementation	09-02-2021
LO2	The High Water Protection Program (Hoogwaterbeschermingsprogramma - HWBP)	Implementation	10-02-2021

LO3	Regional water authority - Hoogheemraadschaap Hollands Noorderkwartier	Implementation	22-02-2021
LO4	Municipality of The Hague	Implementation	23-02-2021

Table 11: Overview interviews

E.2 Interview set-up

The potential respondents received an introductory e-mail to invite them for the interviews. Within this e-mail, I briefly introduced myself and explained that I would like to talk with them about ADM in practice and their experiences with it. Only a limited amount of information was provided on the conctent of the research to avoid influencing the potential respondent's perceptions.

Because of the Covid-19 situation, all the interviews had to be performed digitally instead of meeting in real life. Microsoft Teams was used as a tool to set up video calls. Before an interview was started, the interview procedure and how the data would be retrieved and stored were discussed. Besides, permission was asked for audio recordings. In case the interviewee would not grant permission, detailed notes would be taken manually. The last preparatory step was checking if the interviewees had any questions left or wanted any more clarification before their informed consent was asked.

A semi-structured design instead of a structured design for the interview questions is used. This enables the researcher to ask additional questions when new information becomes available that seems relevant (Longhurst, 2003). Moreover, a semi-structured interview design allows a natural flow of the conversation. The interviews were conducted in Dutch because the Dutch language is used for all communication in the delta management sector in the Netherlands.

E.3 Interview questions

Before explaining the questions, it is important to note that the list of questions was unique for every interview. Based on the information obtained in desk research on the roles, responsibilities and interactions, the questions were tailored to that specific person and organization. Furthermore, the semi-structured interview design also leaves room to alter or add questions based on how the interview evolves.

The interview questions consisted of two parts. The first part focuses on exploring the institutional governance of ADM in practice, and the second part on exploring the instrumental governance of ADM in practice. The institutional and instrumental elements of the theoretical governance framework of ADM (table 2, p. 30) serve as the basis for the questions. Finally, the interviewees are questioned upon their views about the challenges of ADM and who else is involved in the application of ADM. This will ensure that insights that do not fit the pre-defined questions are revealed and that no key actors are missing in the actor analysis.

Part I – Institutional governance

<u>Organisatie Signaalgroep + interactie met andere partijen</u>

1. Kunt u uzelf kort introduceren en uw betrokkenheid bij de signaalgroep?
2. Kunt u de rol van de Signaalgroep omschrijven?
3. Hoe ziet de organisatie van de Signaalgroep eruit? (Wie zitten erin, wanneer komen jullie samen, wie doet wat?)
4. Hoe komt de Signaalgroep aan de informatie die wordt gebruikt om signalen te detecteren?
5. Aan wie rapporteert de Signaalgroep? Antwoord X
6. Hoe evalueert X de constateringen van de Signaalgroep, als advies, zwaarwegend advies of bindend?
7. Hoe ziet u de verantwoordelijkheid van de Signaalgroep ten aanzien van de opvolging van de constateringen door X?

8. Op het moment dat de Signaalgroep een signaal detecteert, wat zijn dan de vervolgstappen? Na het verschijnen van het signaal in 2017 van de mogelijke mogelijk versnelling van de zeespiegelstijging wat was de reactie?

Part II – Instrumental governance

ADM in de praktijk binnen de Signaalgroep

1. Hoe gebruikt de Signaalgroep scenario's? En welke?
2. Maakt de Signaalgroep gebruik van adaptatiepaden? En zo ja, hoe?
3. Hoe vindt monitoring binnen de Signaalgroep plaats? Welke parameters worden gemonitord om te bepalen of er bijvoorbeeld versnelde zeespiegelstijging langs de Nederlandse kust is?
4. Hoe worden kantelpunten van strategieën bepaald?
5. Hoe vindt evaluatie plaats om te bepalen of strategieën nog op koers liggen?

ADM in de praktijk - algemeen

1. Wat zijn de grootste veranderingen in de praktijk sinds de introductie van ADM?
2. Wat ziet u als de grootste uitdagingen voor het toepassen van ADM in de praktijk?
3. Welke actoren zijn er nog meer belangrijk voor adaptief management. Wie vinden jullie dat nog meer geïnterviewd moet worden?

D.4 Data processing

All the interviews conducted were audio-recorded. The interviews were all transcribed to prevent biases in interpretation by third parties. The transcripts have been summarized and are available upon request (contact details of the researcher are provided on page 3 of this thesis). A computer program named ATLAS.ti was used to analyze the findings qualitatively. The transcripts of the interviews conducted are available upon request, please contact the author by sending an e-mail to anne-mariedejong@hotmail.com.

F

Results interviews instrumental governance

In this appendix, an overview of the findings on the instrumental governance obtained in the interviews is provided. Behind each statement, an interview ID code is shown. Appendix E shows to which interview the interview ID code refers.

Scenarios strategy level

- The delta scenarios are used in developing strategies (NA5, NA7, NA8, NA9)
- Since the introduction of ADM, we do not pick the most likely scenario anymore to determine strategies. But the entire bandwidth of plausible scenarios is used, and strategies are developed that can deal with all changes possible in the defined scenario bandwidths (NA5)
- The delta scenarios help to align different parties; contributes to a shared understanding/view of the problem (NA7)
- Together with the introduction of ADM, KNMI changed from 3 scenarios to 4. This made that no intermediate scenario could be chosen anymore and that policymakers had to incorporate uncertainty in policy (NA8)
- Analyses of strategies become more scenario-neutral. The sea level will keep rising, that is a fact. Only when specific levels will be reached is the question. Therefore, the strategies should be independent of when sea level rise occurs, only taking into account that it occurs (NA8)
- With current measures, our system would be able to deal with sea-level rise up to 2 meters. But the sea level rise will definitely reach this point. The only question is when. Is this in 2080 or 2200? (NA6)
- Additional sea-level rise scenarios are used in practice because the timeline of the delta scenarios (2050 + 2085) is relatively close, until then, the bandwidths for sea-level rise are not that big. It is crucial for ADM in practice to consider sea level rise up to 2200 (NA3)
- Focus on sea-level rise scenarios up to two centuries from today. We pick the mean expected values for the other variables from the delta scenarios because predictions would be very unreliable up to then (NA2).
- The values for socio-economic conditions of the delta scenarios do not differ much (NA10)
- Only incorporating delta scenarios is not sufficient for ADM in practice. Also, sea level rise scenarios with a longer time horizon must be considered (up to 2200). Up to 2085, as in the delta scenarios, all our strategies will still be ok, but later, when more sea-level rise occurs, the current strategies will not be ok. Therefore, to prevent lock-ins and keep all options open for the future, we must consider sea-level rise for a longer period (NA2, NA3, NA6)

Scenarios implementation level

- No scenarios are used for designing quay walls inside and outside of the municipality of The Hague. One mean projected value is used for the considered uncertainties (e.g. sea-level rise), and a margin is added to ensure robustness (LO4)
- Within projects, mostly the worst-case scenario is chosen, because policymakers want to make sure that they do not have to come back to a specific area (LO2)

- Only climate scenarios are used in the design of dikes and barriers; socio-economic developments up to 2050 are already included in the safety norm (LO2)
- Only one scenario is chosen (LO3)
- If scenarios are used on project level in practice, only climate scenarios are used; these are brought back to 2 instead of 4 – only the two most extremes are used (LO1)

Adaptation pathways strategy level

- In DP2015, 14 adaptation pathways with a time horizon until 2100 are included. They are not detailed at all. Therefore, the time horizon of these adaptation pathways does not match where we stand now. They do not help in policymaking since this happens in February, and this is not anywhere close to the time horizon of the adaptation pathways until 2100 (NA5)
- No adaptation tipping points are defined in the adaptation pathways in DP2015 and no conditions are defined when the strategy should be altered. These adaptation pathways consist of short-term, medium-term and long-term measures and can be seen as an implicit form of adaptation pathways (NA8)
- Adaptation pathways are planned for sea-level rise (NA6)

Adaptation pathways implementation level

- In projects: space is left for developing adaptation pathways, but it is not required. It is up to the trajectory operator is he uses them (LO2)
- On the national level, the adaptation pathways are sometimes used; at the project level they are not used at all (LO1)
- In the municipality, no adaptation pathways are used (LO4)

Adaptation tipping points – strategy level and implementation level

- No concrete tipping points exist in practice – no such a moment that when you pass this moment that everything collapses exists. Tipping points can be moved forward and backwards in time. You are always quite in control; a tipping point is being reached you can anticipate, and after it occurred, you can still repair the damage. Therefore, tipping points do not really exist in the policy-dominated water sector (NA5, NA8)
- In the theory of ADM, an important aspect is that when specific threshold values are exceeded, you need to change strategy (tipping points). In practice, these tipping points are not as concrete as in theory. What is technically possible changes over time because of innovation. What is financially acceptable is political assessment. Also, what is societally acceptable can change (NA6). No limits exist of what is feasible technically; the only question is how much we want to spend (NA1)
- Regularly is being checked if the quality is still ok, but no explicit adaptation tipping points have been defined (LO4)

Monitoring system strategy level

- A list of indicators is being monitored, an overview of the indicator developments is issued yearly. The list consists of both climate and socio-economic indicators. The list of indicators consists of drivers, effects and social consequences. But we also keep our eyes open for other relevant developments that are not included in the list (NA7, NA8)
- First, the goal of monitoring was to reduce uncertainty, but we came to the conclusion this is not possible. The more research we do, the larger the bandwidths of sea-level rise scenarios become (NA7)
- Monitoring sea-level rise takes place at four levels: 1) Antarctica, 2) global, 3) North-sea, 4) the Dutch coast. Monitoring takes place at various levels. Also, various knowledge institutions are involved in the monitoring process (NA1).

Monitoring system implementation level

- Regional water authorities monitor water levels, water quality and other indicators. Sensors are used for monitoring water levels, and the real-time data about water levels are processed automatically. For water quality, the presence and concentration of various compounds in the water are monitored at various locations. Depending on the type of compound, the frequency of taking samples is determined. The water samples taken are sent to the laboratory for analysis (LO3)
- We perform a lot of monitoring: groundwater levels, subsidence, heat stress, air quality, and more. Within the municipality, sensors in combination with automated systems for processing the real-time data are used for monitoring whenever possible (LO4)

Evaluation system strategy level

- Yearly is checked if we achieved to realize what we planned to realize. This is checked for all three Delta Program sub-themes separately. In the yearly issue of the Delta Program, the results of tracking progress are presented (NA5)
- Currently, the focus of sea-level rise is mainly on knowledge generation (monitoring); the objective is that in a few years, when enough knowledge is generated, the current strategies are recalibrated/evaluated (NA6, NA1)
- The idea behind ADM was that monitoring information would tell you if you needed to adjust the pace of your strategy and when you had to switch strategies (through adaptation pathways). In practice, it doesn't work like this since you can quite control processes and tipping points are flexible (NA5)
- A shift from 'adaptive planning' to 'planned adaptation' → instead of continuously evaluating and recalibrating when new monitoring information comes available, now the focus lies on fixed moments when strategies are evaluated (every six years) (NA5)

Evaluation system implementation level

- Visual inspection of dikes is performed every spring and fall to check if the dikes still look solid and if the dikes will be able to function properly for another season (LO3)
- If heavy rainfall is predicted, the water levels are lowered before the raining starts (LO3)
- Regularly is being checked if the quality is still ok, but no explicit adaptation tipping points have been defined (LO4)