Adaptive Delta Management

Implementing adaptive delta management in the River subprogram across scales.

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Preface

Climate change and its noticeable effects in the daily life have interested me for quite some time now. Ever since I was graduating structural engineering on the Hanze University, I have been fascinated by sustainable and innovative methods to keep houses, areas and regions from flooding, be it through exceptional levels of rainfall, high water situations due to peak river discharges or sea level rise. Therefore, in my final project I researched technical solutions to keep houses from flooding. In this period my attention shifted from technical solutions to spatial interventions and I took an increasing interest towards the Dutch spatial planning approach that has kept us safe all this time. Fortunately for me, the enrolment in my pre-master program and subsequently the Environmental and Infrastructure master program was a perfect match for my interests. With climate change getting increased attention worldwide and the Netherlands being renowned for its water management made me want to know more about Dutch spatial planning and living with water. The *Dutch Delta Program* combined with the increasing attention in the change of approaches towards water management formed an ideal case for further research. With a history of flood- and near flood disasters due to high water situations, the development of the famous Delta Works, and the recent implementation of the Room for the River program, the River subprogram forms an ideal case to learn more about the implementation of adaptation strategies through adaptive approaches. Getting to know more about the decision-making in the different riverine areas has fascinated me to no end, sometimes partly shifting my attention away from my research topic to gain more insight into the technicalities of river discharges, the river system and the managing solutions such as dikes, dams and storm surge barriers, which helped me enormously writing this thesis on this challenging subject.

Abstract

With the effects of climate change being increasingly noticeable in the Dutch landscape, the need for more adaptive strategy making becomes more apparent. In the face of climate, uncertainty and social complexity, decision-makers face difficult tasks in ensuring the long-term Dutch water safety. This research examines the development of adaptation strategies with a long-term horizon, through a management approach called A*daptive Management*, which is developed to cope with uncertainties and complexity seems to be a fitting approach in dealing with climate uncertainties. Specifically, this research analyzes the Dutch Delta Program, a comprehensive policy program that prepares the country for the expected effects of climate change. After its introduction in 2010, five years later decisions have been made on how to protect the country from high water, how to manage its fresh water supply and how to spatially adapt to the effects of climate change. In dealing with the uncertainties of climate change, the Dutch have developed the *Adaptive Deltamanagement* approach, which helps decision-making through a flexible manner and combining the short- and long term measures. The implementation of this concept takes place through a series of regional subprograms. The focus of this research lies on the river Rhine subprogram, that must deal with the expected rise in river discharges because of climate change. Specific attention is paid towards the decision-making on a regional and local level and how this program increases adaptability. As it turns out, the Rhine subprogram suffers from a series of difficulties that can negatively affect the implementation of either river widening measures or dike enhancements. This research shows how the adaptive deltamanagement concept is incorporated in regional and local decision-making and questions as to how far this approach is beneficial for the Rhine subprogram.

Key words: ***Adaptivity, Adaptation strategies, Adaptive management, Adaptive Governance Climate Change, Complexity, Flexibility, Preventing Lockins, Spatial Planning, Uncertainty***

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List of Abbreviations

AM	Adaptive Management
ADM	Adaptive Deltamanagement
ATP	Adaptation Tipping Points
CEC	Commission of the European Communities
CPB	CPB Netherlands bureau for Economic Policy Analysis (in Dutch: Centraal Plan Bureau)
EZ	Ministry of Economic Affairs (in Dutch: Ministerie van Economische Zaken)
HWBP	*high water protection program (in Dutch: Hoogwaterbeschermingsprogramma)*
I&M	Ministry of Infrastructure and Environment (in Dutch: Ministry van Infrastructuur en Milieu)
IPCC	International Panel on Climate Change
KNMI	Royal Dutch Meteorological Institute
M&E	Monitoring & Evaluation
MIRT	*Multi-annual program for Infrastructure, Space and Transport (in Dutch: Meerjarenprogramma Infrastructuur, Ruimte en Transport*
MWH	Measuring, Knowing and Acting (in Dutch: Meten, Weten en Handelen)
NAS	National Adaptation Strategies
OECD	Organization for Economic Co-operation and Development
PBL	PBL Netherlands Environmental Assessment Agency (in Dutch: Planburea voor de Leefomgeving)
PSIR	Pressure, State, Impact & Response
SDM	Structured decision-making
SLP	Structured learning-process
UNFCCC	United Nations Framework Convention on Climate Change
VKRS	Preferred strategy (in Dutch: Voorkeursstrategie)
WLO	Welfare and Habitat (in Dutch: Welvaart en Leefomgeving)

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1. Introduction

1.1 A changing approach to a changing climate

Over the course of the past few decades there has been an increasing emphasis on the developments and policies that shape the earths environmental condition. Global recognition of climate change and the speed of which its effects are visible on the global scale have become more apparent and thereby pushing global policy-makers to act. As a result, many countries are accepting the fact that even with mitigation efforts and emission reductions, further climate change seems inevitable and irreversible and are expecting a further increase in the adverse effects of climate change (IPCC, 2014). New challenges arise then, and aside from preventing further climate change from happening on the long term, the need to adjust current environmental policies and safety measures against the effects of climate change are becoming more apparent to many countries around the globe. As a result, the International Panel on Climate Change (IPCC), a collaboration of the United Nations, was founded to assess the risks and impacts of climate change on a global scale.

Climate change will be specifically challenging for the water management sector because many of the experienced and expected effects directly influence the water system (Miller, 2008). The effects on the water system include a higher interval and intensity of precipitation, longer periods of droughts in the summer, global sea level rise, salinization and more (Delta Program 2011). In worst case scenarios, these effects can have a devastating impact on both natural and human systems (Van Wesenbeeck *et al.*, 2014). These impacts will be especially observable in deltas or other estuarine landscapes across the world. Deltas are densely populated, and due to its location have a high level of economic activity. Many deltas, coastal areas and other river basins across the globe are prone to flooding (Van Wesenbeeck *et al.*, 2014).

With the recognition of the potentially inescapable changes that are brought forward through climate change, a need for adjustment of current environmental policies, risk analysis and safety measures seems unavoidable (Biesbroek *et al.*, 2009). This process of *adaptation* is considered the next step in international efforts, to learn and cope with the impacts that cannot be avoided (Burton *et al.*, 2006). Adding to the inevitability of the problem is the notion that climate change problems are inherently uncertain (Dessai and Hulme, 2007). Planning in uncertainty is therefore particularly challenging, because the exact impacts and timescales on which decisions are based are unclear. Decision makers in the context of climate change however do not solely focus on changing environmental effects. Instead the inclusion of other factors such as population growth, economic developments, improving technology, changing societal perspectives and preferences must be considered and require equal treatment and add to the degree of uncertainty (Haasnoot *et al.*, 2013).

Incorporating adaptation initiatives in these areas can be a challenging task, as the climate change impacts and socio-economic conditions are different for each region. Therefore, the effectiveness of adaptation is dependent on the nation's capacity in addressing the problem and for a great deal relies on the projection of long-term developments, both socio-economic developments as well as the effects of climate change.

Within the European Union, nations are setting up National Adaptation Strategies (NAS) that serve to prepare nations for climate change impacts, so that they can cope with the changing conditions and impacts (Biesbroek *et al.*, 2010). The development of these strategies serve to bridge the gap between the traditional planning approaches and the complexity and uncertainty surrounding climate change. This means that finding a balance between short-term measures and long-term tasks is essential. Flexibility is required so that policy adjustments can be made in case of unexpected developments without having to redesign the entire policy program (Biesbroek *et al.,* 2010). This process of adaptation is known as *adaptive management* (AM).

In the Netherlands, the national climate adaptation program takes form in the *Delta Program.* This is a comprehensive strategic spatial planning program and is designed to cope with the long-term (up to 2100) climate change projections in combination with socio-economic developments and serve to enhance the nation's resilience and adaptivity. In the Delta Program, the adaptive management approach is incorporated into the strategic policy development in the form of *Adaptive Deltamanagement* (ADM). This approach recognizes the uncertainty and complexity surrounding climate change, and is therefore set-up as a flexible approach to long-term decision-making processes. It is therefore interesting to look at how this approach is being put to practice and how it is increasing the countries' resilience and adaptivity.

1.2 Problem statement / Research Objective

This research specifically studies the situation in the Netherlands, a country shaped by the sea and numerous rivers. Because of floodings or near floodings in the past, many residents living in polders or generally beneath sea level, and with the risks of climate change increasing, the Netherlands has developed a climate adaptation strategy.; the Delta Program (in Dutch: Deltaprogramma). The Delta Program is pursuing three main objectives, namely national water safety, sufficient fresh water supply and spatial adaptation. These three objectives should be achieved through an adaptive approach.

The program has been published annually for the last 6 years and many of the designed strategies are now being implemented throughout the country. The research focusses on the applied management approach, A*daptive Delta Management* (hereafter ADM), which offers a framework for approaching uncertainty and complexity, and is derived from the adaptive management approach. For the Dutch, this innovative planning approach is developed as a

national framework for future planning endeavors regarding water safety and spatial development. This management approach is designed to be integrated with the developments of different sectors and to combine long-term developments with short-term tasks, with emphasis on flexibility, solidarity and sustainability.

This research will focus on the process of ADM on a national, regional and local scale within a specific sub-program of the Delta Program; *the Delta Program Rivers*. Within the River sub-program there are numerous developments and strategies to ensure long-term water safety and a stable fresh water supply and is therefore of great importance within the national Delta Program. With the publication of the 2016 Delta Program, a new phase has started. The program is called: *Now it is truly beginning* (Delta Program 2016), which focuses on the practical implementation measures developed in the past 5 years. It is therefore interesting to take a closer look on how the introduction of the ADM concept has been further elaborated over the years and how different governmental organizations are now using the ADM approach in their respective decision-making processes. Therefore, special emphasis will be given to the practical implementation of ADM within the River Rhine sub-program and how this planning approach is beneficial to the municipalities, the region as well as on a national level. Therefore, a closer look will be taken at the difficulties and opportunities that are coupled with the implementation of ADM in national, regional and local decision-making.

This research will focus on the different governmental agencies that cooperate with each other to ensure the water safety in the riverine areas, in which the ADM approach is used as a reference point in decision-making. The safety standard for the Dutch rivers is being revised and peak river discharges are expected to increase in the future. Therefore, a great number of existing dikes and general safety measures no longer meet the safety standards and are therefore being redeveloped. This means that the existing measures and structures need re-enhancement, these measures are prioritized by urgency, and in the context of ADM, still need to be flexible, robust and sustainable. Ever since the introduction of the ADM concept and by applying an integral approach, this should ultimately result in a quality enhancement of the river basins and Dutch water management practice. Therefore, this leads to the formulation of the central research question:

'How has the introduction of the Adaptive Delta Management approach, through the Delta Program, influenced and contributed to the decision-making processes in increasing adaptivity in the Rhine riverine area.'

This research analyzes the national Delta Program and how its approach to climate change is directing developments on the national, regional and local scale. This research does not serve as a prescription on how to develop or successfully implement adaptive management, but rather to map the interaction and difficulties of the separate and combined action of the different governmental agencies in keeping the Netherlands safe in an adaptive manner.

1.3 Theoretical Approach

To better understand the concept of Adaptive Delta Management, it is important to first better understand the concepts and principles of adaptive management theory. Therefore, **Chapter 2** examines the theory on adaptive management and forms the theoretical framework that serves as the foundation for the rest of this research. The framework consists firstly of the general need to increase resilience through adaptation, because of the uncertainties and complexities of climate change. Which is then followed by the introduction of the adaptive management concept. Specific emphasis will be given on how to increase adaptivity in long-term decision-making and three crucial points are distinguished: (1) Agility in the governance process, (2) flexibility in strategy- and plan-making and (3) preventing lock-ins (based on Restemeyer *et al.*, 2016).

The first point will elaborate on the process of managing adaptation and what contributes to an agile governance process. Describing this process is essential in understanding the need for capacity to steer towards a desired direction as well as the capacity to adjust, based on new insights. It stresses the notion of learning and sharing information, which is of major importance in AM. Secondly, to deal with the complexity and uncertainties flexibility in strategy- and plan-making is of major importance, as it strengthens steering capacity. Thirdly, by preventing lock-ins, decision-makers can avoid undesirable outcomes in the future because of past decisions. This theoretical framework will serve as a starting point for the empirical analysis of the Delta Program, the implementation of the ADM concept and how the plans and strategies of current implementation measures encountered in the Delta Program Rivers, exhibit these three crucial points.

1.4 Research Strategy

This research analyses the translation of the ADM approach on both the national level and in more detail on regional level. The Netherlands is considered to be amongst the forerunners of climate adaptation strategies and policy development (Biesbroek *et al.*, 2010) and is therefore an interesting case study. In the latest publication of the Delta Program a new phase has been introduced in which the decisions and strategies are being implemented (Delta Program 2016). The Delta program is divided in multiple sub-programs, each coping with their respective tasks. This research specifically focusses on the River sub-program, which has to deal with major water safety tasks. The River sub-program is incredibly large, so the focus of this research will not include the whole riverine area. Instead it will focus on the river Rhine, more specifically on the Rhine branches, the IJssel and the Waal.

This research focuses on the governmental parties involved in the decision-making process of the Waal and IJssel area, and addresses problems specific to each of the area's. For both these areas, peak river discharges are increasing in the future, and additional measures to ensure water safety are being implemented. The Waal, which is one of the largest rivers of the country,

is characterized by the many dikes built in the past and its low lying hinterlands. A large part of the dikes have been rejected and require additional safety measures. Therefore it is interesting to look at how the ADM approach influences the decision-making in this area and what practical measures are being developed that are considered adaptive. The same for the river IJssel, which is less characterized by the huge dikes, but still copes with recent floodings. Both rivers are Rhine branches, but very different in size and shape.

The empirical data for this research has been collected through a detailed analysis of policy documents, attending a Delta Congress and conducting a total of 10 interviews with the involved governmental agencies; The ministry of Environment and Infrastructure, the Rijkswaterstaat, the Delta program Rhine, the province of Gelderland, the municipalities of Zwolle, Arnhem and Deventer, the Water boards Drents Overijsselse Delta and Rivierenland and the association of river communities. Their knowledge, interpretations and expertise will give insight in how the water safety tasks are handled, how the ADM approach is developed and how this body of thought shapes the decision-making process in water safety issues on different governmental scales. The case studies will further elaborate on how the implementation of the ADM principle influences *regional* and *local* decision-making in the Rhine riverine area.

1.5 Academic and societal relevance

There has been an increasing interest in adaptation policies, and many of the researches currently are focused on identifying barriers and dilemmas to adaptation policies and how to overcome them (see for example Moser and Ekstrom, 2010, Biesbroek *et al.*, 2013; 2014). Adaptation policies are herein seen as efforts to solve climate change related problems as effectively and efficiently as possible (Biesbroek *et al.*, 2014). However, with adaptive management and subsequently adaptive delta management being a multi-interpretable term, it can be still unclear as to what adaptive management means (see for example Gregory *et al.,* 2006; Williams, 2011, Rist *et al.*, 2012). Therefore, reviewing scientific literature on AM and what it means for long-term policy-making in water management is essential for this research.

According to the Delta Program itself, the ADM approach and its methodology is under increasing attention of other EU-member states and will prove to be exportable to their specific challenges (Delta Program, 2011). Reviewing a national or regional climate adaptation strategy can therefore be useful to increase insight into adaptation strategies and can serve as possible lessons for other regions or countries that are similarly working on adaptation strategies. For this research the translation from Delta Program theory to practice is interesting and how it compares to adaptive management theories.

The ambiguity surrounding adaptive management means that there is not a standardized method of implementing adaptation measures. Therefore, this research stresses the notion that regional contextual factors, whether political, institutional, financial or physical are decisive in policy-making. This means that to improve adaptivity, be it national or regional,

adaptation processes require tailor-made policy processes. By recognizing the exportability of the ADM approach, setting up a process that is both exportable and tailor-made, is a challenging task. Therefore, this research might be helpful by looking at the practical role of adaptive management in long-term water policies, with a specific emphasis on how this is put to practice at national, regional and local level.

1.6 Thesis Outline and reading guide

Here the main outline of this thesis will be elaborated. First, in **Chapter 2** the theoretical framework of this thesis will be elaborated. Relevant scientific theory will be elaborated and will function as a coherent scientific literature report, which serves as the foundation for the empirical chapters later in the thesis.

In the first section **(2.1)** it will become clear as to why the concept of resilience is considered a promising framework in the context of climate change and academic research. The notion of adaptability and adaptation play in important role in providing a more practical meaning to the resilience concept. Subsequently, the adaptive management concept is elaborated upon and three crucial points to the process are distinguished (Restemeyer *et al.*, 2016): (1) an agile governance process, (2) flexibility in strategy- and plan-making and (3) prioritizing measures that prevent lock-ins. These concepts will later serve as a framing perspective to the empirical analysis. The last section of Chapter 2, will contain a conceptual framework, which will give an overview of the theoretical concepts and how these will be used in the empirical part of this thesis. **Chapter 3** explains the research methods and methodology used in this research in more detail, and how the empirical analysis is formed. **Chapter 4** is the beginning of the empirical research, which describes the Dutch national Delta Program, it's organizational approach, the underpinnings of the ADM approach and how the ADM approach is operationalized. To get into the ADM concept in more detail, **Chapter 5** aims at the River subprogram and how adaptive decision-making is incorporated into the preferred strategy (in Dutch: voorkeursstrategie) in the Rhine region, aiming for a safer, and more livable area. This chapter will be elaborated upon quite extensively, on how the national, regional and local governments work together on adaptive measures, what it means for the different governmental agencies to be adaptive, and how dilemmas form on different scales within the Rhine area. Finally, **Chapter 6**, will answer the main research question addressed in **Chapter 1**. Furthermore, the research outcomes will be discussed, a reflection of research outcomes and recommendations for possible follow-up research topic will be given.

2. Theoretical Framework

This chapter serves as the theoretical foundation for the empirical analysis. First, the concept of resilience is being discussed, as a reaction to changing circumstances, increasing complexity and increasing uncertainty. Secondly, the theoretical concept of the adaptive management approach and its key characteristics is elaborated in detail. Three key points to adaptive management are identified; agility, flexibility and preventing lock-ins, which will be elaborated in more detail. Subsequently, the adaptive management cycle is introduced, in which a distinction is made between the structured decision-making process and the structured learning process. These two processes will be elaborated in more detail in the sections that follow. Finally, a conceptual framework is designed, which shows the conceptual structure for the remainder of this thesis and the way in which this will be applied to the empirical research.

2.1 Resilience for an uncertain future

In the face of climate change, changing social and economic conditions and the scale on which these events take place, *mitigation* initiatives are generally perceived as inadequate in dealing with its developments and its effects (Biesbroek *et al,* 2009; Hooijer *et al.*, 2004). In general, traditional decision-making processes assumed that the future could be predicted, and therefore its desired outcome derived from previous, past decisions. This approach resulted in the development of static and linear plans, with pre-set criteria and guided the decision-making processes in order to take action (Haasnoot *et al.*, 2012; Apitz, 2008). These actions were guided by past experiences, research, scenario studies, models and pilots, and through this 'best'-practices were designed (Apitz, 2008), a kind of 'one-size-fits-all'-approach.

Globally, climate change will result in sea level rise, prolonged periods of precipitation, and an increasing intensity of rainfall. As a result, these effects will likely add to future flood risk (Restemeyer *et al.*, 2016). However, with the understanding that the adverse effects of climate change will be noticeable, but the extent of its effects still largely unclear, policy-makers are faced with a serious dilemma. On the one hand, the climate related impacts need long-term planning; on the other hand, the conditions and impacts itself are hard to define, predict and measure and make successful planning endeavors increasingly difficult (Biesbroek *et al.*, 2010). Especially using traditional decision-making processes which assumed a predictable future, the uncertainty surrounding the impacts of climate change, pose a serious problem.

In the context of water management and increasing flood risks, the concept of *resilience* is considered a promising framework for including risk and uncertainty within planning (Restemeyer *et al.*, 2016). In this context, resilience is an approach to science that embodies the exploration of new and innovative results, through experimenting with a variety of strategies, a multidisciplinary approach and through the examining of the underlying dynamics (Curtin and Parker, 2014). Through this approach, Holling (1973) favored a general

conceptual insight of a major question over a highly detailed assessment of a minor question; it was this insight that evolved into resilience thinking (Curtain and Parker, 2014).

Resilience has a great deal to do with the state of a system, and how a system reacts after being disturbed. A system can be stable, but with a narrow range of limits within the system, can increase the likelihood of its collapse (Folke *et* al., 2010; Curtin and Parker, 2014). A resilient system however, assumes insufficient system knowledge and emphasizes the complexity of system dynamics in natural systems (Holling, 1978). Therefore, resilience can be described as "*the capacity of a system to rebound and reorganize following disturbance or to move between alterative states without changes in system structure or function."* (Curtin and Parker, 2014 p.913). The goal of the concept then is to increase *resilience* in ecosystems. Therefore, within resilience three key factors are recognized (Folke *et al.*, 2010): (1) *Robustness;* the magnitude of shock that the system can absorb and remain within a given state; (2) *Adaptability*; the degree to which the system is capable of self-organization; and (3) *Transformability;* the degree to which the system can build *capacity* for learning and *adaptation*.

2.2 Adaptability and adaptation

In water management robustness is mainly concerned with the first line of protection, which is the protection of water through technical measures, such as dams, dikes and storm surge barriers (Folke *et al.*, 2010). However, there is always the possibility of a situation in which the technical measures alone are not sufficient, thus robustness alone is not enough. Therefore, *adaptability* is considered an important attribute in water management. Together with robustness and transformability, these three make up a resilient system (Restemeyer *et al.*, 2015). Within water- and flood risk management, *adaptability* puts emphasis on land-use and on minimizing the consequences of flooding. This means that a certain level of adaptability is needed within a resilient water system, which stresses the notion that land usage is, to a certain extent, developed to cope with floodings and not leave heavy damages.

In the context of climate change, the Intergovernmental Panel on Climate Change (IPCC) (2014) refers to *adaptation* as a system adjustment to the impacts of actual or expected climate change. Adaptation initiatives in this context take form in adaptation strategies and have been part of the political agenda for years. Many member states of the European Union have developed, or are currently developing *National Adaptation Strategies*. These adaptation strategies serve to enhance the country's resilience and with it the entire EU's resilience to the adverse effects of climate change (CEC, 2009). Niang-Diop and Bosch (2005: 186) define adaptation strategies as *'...a general plan of action for addressing the impacts of climate change, including climate variability and extremes.'* This plan of action will '*…include a mix of policies and measures with the overarching objective of reducing the country's vulnerability.'* And determine the nature of the strategic plan as *'…context specific and will depending on the circumstances, be comprehensive at a national level, addressing adaptation across sectors,*

regions and vulnerable populations, or it can be more limited, focusing on just one or two sectors or regions'. The objective of adaptation strategies consists therefore of mostly anticipatory and planned action, as to prevent projected climate impacts (Swart *et al.*, 2009). Adaptation measures serve to increase a country's resilience, i.e. reducing the *vulnerability* of a country. Adaptation measures are therefore designed to cope with uncertainty through the ability to change management practices (*ad hoc*) based on new experiences and insights (Dessai and Hulme, 2007).

Here, *adaptation* is also considered a fundamental aspect of resilience, by making a nation less vulnerable to the impacts of climate change by making adjustments within the system (Restemeyer *et al.*, 2015). However, it is important to note that adaptation measures are not straight forward tasks that can be implemented one by one in a linear order. In practice, dealing with adaptation options consists of cross-cutting themes, involve multiple governmental and non-governmental sectors across different scales and is therefore a complex undertaking (Restemeyer *et al.,* 2016). In water management, adaptation measures require long-term plan making, which adds to the complexity of decision-making within the cross-cutting themes, multiple sectors across multiple scales. Still, recent efforts in tackling the effects of climate change and setting up adaptation strategies seem to be increasingly geared towards *adaptive management* concepts (Wilson and Termeer, 2011).

Adaptive management is a collaborative, flexible and learning-based approach, that recognizes that the future is not linear, and that society is dynamic and therefore in a constant state of flux (Folke *et* al., 2002; Biesbroek *et al.*, 2011). Therefore, by constantly evaluating goals and objectives, as new information and insights become available, adaptive management can be more responsive to changing conditions (Pahl-Wostl *et al.*, 2007).

2.3 Adaptive Management

There are many different interpretations of the adaptive management concept. Generally, adaptive management is, in environmental management and spatial planning, referred to as an approach for dealing with problems that are characterized by high levels of uncertainty (Gunderson and Holling, 2002 in Gotts, 2007). However, a lot of practices that are working under the Adaptive Management banner, exhibit in reality hardly any characteristics of adaptive management that are generally considered to be essential (Gregory *et al.,* 2006). As a result, there are *"…a paucity of success stories on which to build, paradigms in different domains that favor reactive rather than proactive approaches, failure to recognize the potential for shifting objectives and the failure to acknowledge the social source of uncertainty, and hence an increased risk of surprise"* (Allen *et al.,* 2011: 1341). This lack of clarity in definition and approach result in confusion and undermine the potential of adaptive management and as a result, mixed reactions to the adaptive management approach are put forward. In fact, the central premise of adaptive management, *'learning by doing',* seems so universally applicably,

that nearly every environmental policy in some way or another can at least make some form of commitment to the use of adaptive management (Gregory *et al.*, 2006).

Adaptation initiatives itself have a wide variety of options, and its effectiveness is dependent on many factors. Within different domains, political as well as scientific, adaptive management has turned out to be a renewing approach to complex tasks, which is based on a strong, long-term commitment to *learning*, the use of innovative methods and the recognition of uncertainty (Murray & Marmorek, 2003). So, whatever widespread definitions there exist of adaptive management, the aim of this section is not to state or develop its best definition. Rather, this section will serve to elaborate and emphasize on the theoretical foundations of adaptive management, its basic principles and main objectives.

Adaptive management was first introduced by the ecologists Holling (1978) and Walters (1986) and is based on the concerns that traditional management practices inadequately considered system dynamics, complexity and uncertainties (Apitz, 2008). This line of thought emerged as it became increasingly apparent that the conventional approaches to ecology were inadequately addressing problems within resource management, through the realizations that the responses of natural ecosystems to human intervention were in fact not - as opposed to previous insights - linear, predictable and therefore controllable (Curtin and Parker, 2014; Folke *et al.*, 2002). Instead research suggested that natural and social systems are closely interlinked, nonlinear and dynamic (Folke *et al.*, 2002). These new insights asked for a shift from conventional approaches towards an approach that is more open and accessible, with a strong linking in social and ecological perspectives, through a holistic approach to complex problems that treated large-scale studies as theoretical experiments (Restemeyer *et* al., 2016; Curtin and Parker, 2014).

Adaptive management can therefore be described as a formal, systematic, on-going process, continuously monitoring behavior in its systems, learning from it and adjusting to new knowledge, for continually improving management policies and practices (Nyberg, 1999; Pahl-Wostl, 2007). Adaptive management consist of a framework that continuously reassesses outcomes of its operational programs and with it can adjust when- and wherever it proves most needed. This process of learning is especially appropriate to circumstances clouded in uncertainty, where possible outcomes of alternative actions are hard to predict and where delaying action is either unnecessary or would have unacceptable impacts and is therefore less likely to meet management objectives (Nyberg, 1999). By putting in place both learning processes and the conditions needed for learning processes to take place adaptive management processes, if done correctly, improve over time (Pahl-Wostl *et al.* 2007; Smit & Wandel, 2005). The ability to learn and adjust management practices is a strong requirement for adaptive management to be effective, as well the necessity for adequate resources and expertise (Nyberg, 1999). In this way, adaptive management distinguishes itself from the traditional approaches, because the approach is structured and theoretically driven, flexible

and uses extensive learning to systematically adjust and improve management practices (Arvai *et al.*, 2006).

Therefore for adaptive management to be successful, three different points are distinguished that are considered crucial elements to improve adaptability in long-term water policies (Restemeyer *et al.,* 2016); (1) an agile governance process, (2) flexibility in strategy- and plan-making and (3) prioritizing measures that prevent lock-ins. Flexibility, learning and policy adjustment are key characteristics of this approach, of which the theoretical underpinnings will be introduced in the following section.

2.4 The process of adaptive management

An agile governance process

Dealing with the adverse impacts of climate change, such as the increasing flood risks, requires special emphasis on the interaction and cooperation of multiple sectors and governmental bodies, as such issues are not restricted by administrative borders. Therefore collaboration is crucial for dealing with uncertainties, as multi-level, multi-actor and multi-sector arrangements improve the learning process (Restemeyer *et al.*, 2015). By combining multiple forms of knowledge the context can be better understood and finding innovative solutions can be stimulated (Pahl-Wostl, 2009).

This participatory approach, or the emergence and broadening of involved actors in societal affairs beyond the governmental institutions has led to the emphasis of the notion of *adaptive governance*. Governance refers to the institutional structures and processes that shape actor's actions, decisions and behavior (Hatfield-Dodds *et al.*, 2007). Adaptive governance then is a form of governance that emphasizes on the evolvement of formal and informal institutional structures and processes, to better satisfy the changing needs of society (Hatfield-Dodds *et al.*, 2007). Adaptive governance suggests a more localized and therefore more practical approach in the implementation of adaptive management; to see what works and what not in practice (Brunner, 2010). Therefore, adaptive governance adds a social dimension to adaptive management, in which power in decision-making is shared among stakeholders as to better address the needs and desires of society (Hatfield-Dodds *et al.*, 2007).

A multi-level, multi-actor and multi-sector form of governance requires capacity to steer towards a desired direction as well as the capacity to adapt based on new insights (Restemeyer et al., 2016). This is also known as *Adaptive Capacity*, which refers to the ability of how well a system can implement these adaptation measures. Adaptive capacity is referred to as "*…a vector of resources and assets that represents the asset base from which adaptation actions and investments can be made."* (Vincent, 2006). Basically, this means the ability to adapt to changes, whether this depends on financial means, social willingness or awareness (Adger *et al.*, 2005; Brooks *et al.*, 2005; IPCC, 2014). Smit and Pilifosova (2003) determine adaptive capacity by the economic, social, technical and institutional conditions that either constrain

or facilitate the development and deployment of adaptive measures (Grothmann and Patt, 2005). Adaptive capacity presumes social learning, as it requires collaboration to generate new insights as well as the continuous monitoring and evaluation of practices and contextual circumstances (Allen *et al.*, 2011). Feeding these insights back into the decision-making process through specific reassessment moments is essential for adaptive management.

The Adaptive Management Cycle

An important model visualizing the trajectory of adaptive management, in which both the building of adaptive capacity and translating that adaptive capacity into implementation measures is recognized is the *Adaptive Management Cycle* **(Fig. 1 -** Allen *et al.*, 2011). It is not always clear as to what exactly adaptive management is, as there exist different definitions and interpretations of adaptive management and consequently adaptive management cycles (Murphy & Weiland, 2014). However, within the scientific literature, all these different interpretations follow a comparable approach to adaptive management, and within there are several commonalities represented in each of the various approaches (see for example Nyberg, 1999; Stankey *et al.*, 2005; Williams *et al.*, 2009; Moser and Ekstrom, 2010; Allen *et al.* 2011). The Adaptive management cycle emphasizes particularly the two distinct phases within the process of adaptive management. And although the steps in this cycle are recognized as essential for adaptive management and disregarding either of the steps results in ineffective learning from management actions, these steps should not be considered a series of successive steps to successful adaptive management, as in practice these steps may overlap, some will need to be done in better detail and some must be revisited (Nyberg, 1999).

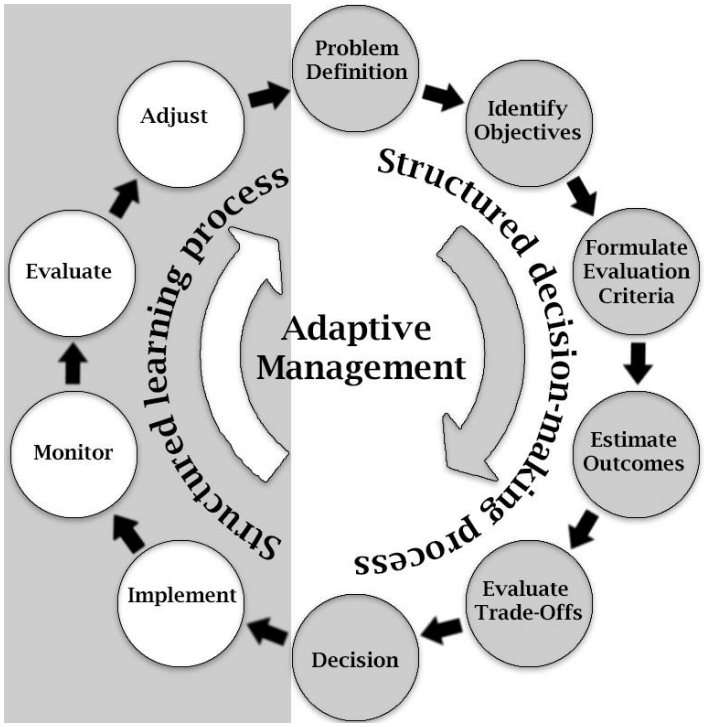

Figure 1: The Adaptive Management Cycle (Allen *et al.*, 2011).

- The first phase of the cycle is the formal process of adaptation, which is referred to as the *structured decision-making process* (SDM), which consists of a thorough and comprehensive research on problem assessment, which defines the problem, considers multiple options and then leads to the implementation decisions (Nyberg, 1999; Allen *et al.*, 2011).

These are the commonalities that can be referred to as the *plan-making phase*. This phase is set up as an organized and transparent approach to decision-making and is used for the identification and evaluation of alternatives and to justify complex decisions (Allen *et al.*, 2011; Nyberg, 1999).

- The second phase of the cycle, in which the formal decisions formulated in the SDM process are put in practice, consists of learning through detailed monitoring and evaluation, and if current management decisions prove unsuccessful, they can be adjusted, basically completing the cycle and starting back at step 1.

Learning in adaptive management takes place through monitoring and evaluation programs (M&E). These programs M&E programs are complex issues within the adaptive management approach, as they are highly affected by temporal and spatial scales, and should therefore be designed to be cost effective, extensive and comprehensive (Douvere & Ehler, 2011; Chapman, 2012; Chapman, 2014). The adaptive management approach is only as good as its weakest link in the cycle, and therefore an inadequately conducted monitoring and evaluation program renders the whole adaptive management approach ineffective. The M&E framework is a critical component in adaptive management, as it provides new knowledge about system behavior and enables adjustment of goals and strategies. Monitoring involves activities that measure the effectiveness of management actions, whereas evaluation involves the interpretation of that information (Jacobsen *et al.*, 2014). Plummer & Armitage (2007) describe evaluation as "*the process of systematically assessing the merits or worth of an act.*" Monitoring then is "*the continuous measurement of activity between design at the beginning, and evaluation at the end of a development intervention"*, with the aim of "*reporting progress, identifying lessons and make improvements during the lifetime of an intervention*" (Jacobs *et al.*, 2010). Therefore, the second phase of the cycle can be defined and described as a 'structured learning process' (SLP).

Together these two phases take the shape of an iterative learning cycle, a sort of feedback loop of the management process. Within this process several different steps are identified, depending on the scale and scope of the adaptive process (Moser and Ekstrom, 2010). The adaptive management cycle is therefore a dynamic process, with emphasis on the ability to change strategies as new understanding, new information and new developments might change the applicability of previously chosen strategies.

2.5 Structured decision-making

The main purpose of SDM is a problem-solving approach that is primarily used to identify and evaluate alternative options (Allen *et al.*, 2011; Murphy & Weiland, 2014). The premise of structured decision-making is a transparent and proactive approach, addressing and acknowledging complexity and uncertainty explicitly in natural resource management through very clear and detailed objectives (Nyberg, 1999; Allen *et al.*, 2011). The SDM process therefore serves as a tool to avoid undesirable outcomes, through a structured, detailed and step-wise manner, incorporating scientific information into decision-making (Murphy & Weiland, 2014).

The SDM process is characterized through a set of steps to evaluate problems, and provides a roadmap - which guides the process into the optimal direction - with a specific focus on achieving the fundamental objectives of the program and reaching a future desired state (Allen *et al.*, 2011). The set of steps focus on specific components of a decision to better cope with the diverse factors influencing a decision, and then by integrating these components a solution is analyzed. Generally, the objectives, potential management actions and the expected consequences of the potential actions are distinguished components (Lyons *et al.*, 2008; Moser and Ekstrom, 2010; Allen *et al.*, 2011; Murphy & Weiland, 2014). Consequences can be derived from models that map and predict system behavior and a monitoring program that keeps track of system behavior (Martin *et al.*, 2009). Together these components help to reach the desired outcome of management actions and are therefore critical to the process.

Within SDM, the development of alternative options serves as an important foundation, as it provides and promotes more flexibility and robustness in the decision-making process in reaching the desired state of the system. When using the AM cycle, **step 1** consists of a detailed problem definition. And as in any management approach, defining objectives is critical for the success of management actions. After problem definition, **step 2** in the SDM process is the clear formulation of objectives, which help guide the process and make room for alternative options, and both the success or failure of meeting the objectives is an important tool to evaluate the decisions. Formulating management objectives within natural resource management can be difficult, as there are many different stakeholders, the system is complex and uncertain, and there are limited resources available in managing the problem (Allen *et al.*, 2011). Therefore, central to this approach is the engagement and inclusion of multiple stakeholders, experts and decision-makers. This means that stakeholders, policy-makers and experts have a different and distinct role within the processes, as stakeholders define the general importance of objectives, and experts research the consequences of various actions to the objectives (Lyons *et al.*, 2008). Together these parties identify various actions that both meet objectives and are viable options. The SDM process therefore suggests an open process, with organizations that can deal with complexities, through cross-scale communication and an explicit recognition of the underlying structure and interactions of the linked systems (Allen *et al.*, 2011). The **third** most recognized step in adaptive management cycle is the

estimation of outcomes of the research objectives, which is aimed at achieving the fundamental objectives of the program (Allen *et al.*, 2011) . **Step 4** then is about the evaluation of trade-offs and the development of alternate strategies. These steps are usually part of the research design of the problem, which after it has concluded results in the actual design-making (**step 5).**

The outcomes of **step 3** and how the system is supposedly shifted can be tracked through a variety of *back-casting* techniques, which allow the identification of necessary steps to shift the system towards the desired future state (Jiggings & Röling, 2000). These steps are sometimes labelled as *adaptation pathways* (Haasnoot *et al.*, 2013). The next section will elaborate on the adaptation pathways and will be an important guideline to the structured learning process.

Flexibility in strategy- and plan-making

Adaptive management can be explained as an approach that is characterized by the need for flexibility in decision-making, especially with focus on long-term decision-making (Restemeyer *et al.*, 2016). There are multiple tools for making long-term plans more adaptable, namely scenarios, tipping points and adaptation pathways. Scenarios help in anticipating the future and improve understanding of what might come and what to prepare for (Pahl-Wostl *et al.*, 2007; Wilkinson 2011; Restemeyer *et al.*, 2016).

Tipping points and adaptation pathways can help policy-makers to timely change or adjust the current approach or objectives. It helps identify moments in time, when the current adaptation measures no longer fully accommodate changes in the system. Within the context of adaptive management, a number of approaches exist to support flexibility and include uncertainty within long-term plan making; decision-trees, real option analysis, roadmaps etc. (Haasnoot *et al.*, 2013). These scenario-based approaches apply a limited set of scenarios to define robust strategies for the various possible futures (Haasnoot and Middelkoop, 2012). Such an approach requires a clear formulation of the future desired state and through it the steps needed to accomplish this desired state, starting from the present. This approach is also known as a back-casting approach (Höjer and Mattsson, 2000). Through incorporating uncertainty - by having various scenarios of the future - adaptation measures are designed to be effective through experiences and developments as the future unfolds and by the policy responses that stem from these future events (Haasnoot *et al.*, 2013). Generally, this translates in the notion that with different possible futures, different measures and approaches need to be considered. This means that for adaptive management to be effective, the development of alternative actions and hypotheses, and therefore the distinguishability between results of those actions and hypotheses is of great importance.

It is important to note that scenario planning and adaptive management are both different approaches. While they are complementary approaches, there is a distinct difference in usage of each approach. A distinction of the two approaches can be made in the controllability of a

given situation. Where scenario planning is used in situations where uncertainty is high and controllability is low, adaptive management assumes high uncertainty and high controllability (Allen *et al.*, 2011). This indicates that scenario planning is used to learn and cope with future developments while uncontrollable, rather than mitigate effects of the expected situations as is done with adaptive management (Allen *et al.*, 2011). Combining these two approaches can be a helpful tool in analyzing future developments and allocating resources to minimize future impacts.

Therefore, adaptation pathways is an approach that is based on scenario planning, to reach a desired future state by applying a pathway from present to the future (Haasnoot *et al.*, 2013). Along this pathway, adaptation measures are taken to reach the specified objectives and guide the process towards the desired state. As the future unfolds, extensive monitoring of adaptation measures, socio-economic developments take place. Depending on the outcomes of the scenarios, specific moments in time will decide on how to continue along the path. These are so called *Adaptation Tipping Points* (ATP). ATPs, in the face of climate change, can be defined as points of magnitude of change, such that the current management strategy will no longer be able to meet the objectives (Kwadijk *et al.*, 2010). These two similar approaches are evident in adaptive policy pathways as they provide insight into the sequence of actions over time, potential lock-ins and path dependencies (Haasnoot *et al.* 2013).

Within adaptive pathways, Haasnoot *et al.* (2012) draw on three different concepts that serve as pillars of their approach: (1) Pressure State Impact Response (PSIR); (2) the Perspectives methods and (3) transient scenarios. PSIR is basically a cause and effect methodology, which describes the impacts and responses of pressures on the state of a system (OECD, 1993). The perspectives method describes how a person interprets the world and act according to its interpretation (Van Asselt & Rotmans, 1997, in Haasnoot *et al.*, 2012). The transient scenarios describe possible futures from today to a determined point in time, including different developments resulting in different scenarios (Haasnoot *et al.*, 2011). Combining these three different factors into a single ‘story line’ over a pre-set course in time using simulation programs, will result in different pathways into the future (Haasnoot *et al.*, 2011).

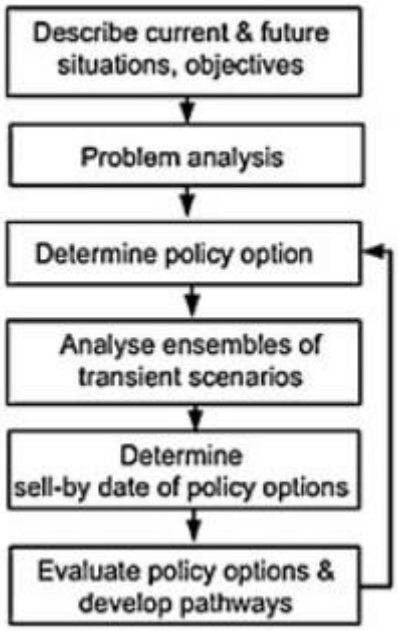

Figure 2 Stepwise policy analysis to construct adaptation pathways (Haasnoot *et al.*, 2013)

Figure 2 is a representation of a stepwise analysis to construct adaptation pathways (Haasnoot *et al.*, 2013). The *ATPs* are central to this approach, as they indicate when the specified objectives are no longer met through current actions (Haasnoot *et al.*, 2013). The pathways are formed through scenario-based planning, each with their own conditions. When a scenario in a point in the future reaches its 'sell-by date' (step 5, fig. 2), the current scenario, or path in this case, is no longer viable and additional measures are needed. After reaching one ATP, a sequence of further actions is available to determine future actions. These actions are different from each other, as they represent other scenario's, which means that any given ATP represents, from the current time through the future points, different routes, thus different adaptation paths, to get to the same desired point in the future (Haasnoot *et al.*, 2013). Each different route presented satisfies a pre-specified minimum performance level, that way for each route it can be determined whether the results are acceptable or not (Haasnoot *et al.*, 2013).

These adaptive policy pathways serve as an important foundation for future actions, by monitoring the implemented actions and developments. The specified time periods also require careful monitoring and elaborate evaluation, as only through that, can future actions be decided. There is extra emphasis on the monitoring and evaluation process, as real time analysis is more reliable than the simplified generated computer models. Haasnoot *et al.* (2012) state that it is one of the weaknesses of the method, because when complexity is increasing, simplifications are needed.

2.6 Preventing lock-ins

The focus of the development and usage of the adaptation paths is the ability for decision-makers to identify opportunities, no-regret actions, lock-ins, timing within the specified time-period in which change is occurring (Haasnoot *et al.*, 2013). Specifically, the primary objective of adaptation pathways is to offer support in choosing short-term actions, while keeping open the possibility to modify, extend or otherwise alter the plans in response to how the future unfolds (Haasnoot *et al.*, 2013). However, the strong focus on technical flood protection that dominated the last century is considered to already have caused 'lock-ins' (Wesselink *et al.*, 2007; Huitema and Meijerink, 2010; Restemeyer *et al.,* 2016). A lock-in can be defined as a situation in which non-desired solutions persist because they have materialized in the physical, as well as the social, environment (Restemeyer *et al.*, 2016). This can be illustrated in the case in the technical flood protection measures such as dikes and dams.

Because for decades a government has chosen to protect the land by building dikes, whether it was the cheapest option or fastest option or the 'best practice' method in the past, the dikes have become an important part of the landscape. While later it is recognized that traditional technical flood protection measures are expensive, offer little ecological opportunities, can be harmful for natural systems, are economically infeasible, cannot easily be adapted, and most importantly increases vulnerability because development in the hinterlands took place without any restrictions (Van Wesenbeeck *et al.*, 2014). Realizing the negative effects of the measures too late, the dikes and dams have become inseparable from the landscape and land-use that it no longer directly offers other 'feasible' flood protection measures (Huitema and Meijerink, 2010) and you become dependent on building dikes for years longer. This can be considered an area lock-in.

Breaking free from a lock-in is difficult, as it requires major investments to adjust the physical environment, i.e. shift dikes, removing sluices and 'flood proof' the built environment in the hinterlands (Huitema and Meijerink, 2010). However, this shift is already noticeable in flood-risk management. In many countries there is an increasing recognition in nature-based flood risk management – a more adaptive approach, as opposed to the technical flood protection management (Van Wesenbeeck *et al.*, 2014). These adaptive measures generally have multiple uses, as opposed to the single usage of a dam for example. Combining flood safety, recreational activities, nature development and spatial quality, robustness of an area can be increased (Hartman *et al.*, 2015).

Systematically identifying future developments, through the use of adaptive management, seems a promising framework for increasing adaptivity in long-term water policies. It is clear that adaptive management can assist in complex decision-making processes (Moser & Ekstrom, 2010), by keeping the governance process agile, include flexibility in strategy- and plan-making, and prioritizing adaptation measures that prevent lock-ins. By using adaptive management, based on improved understanding and extensive knowledge, new and innovative strategies can be developed to overcome difficulties in plan-making and increase adaptivity in long-term policy-making. This chapter is coming to its conclusion by elaborating the role of this theoretical framework in the remainder of this research in the next section.

2.7 Conceptual framework

Following **Chapter 1**, which elaborated on the subject, problem description and research objective, this chapter has elaborated on the theoretical concepts relevant to this research. Based on these chapters, a conceptual framework has been developed which positions the main concepts of interest to this research, as well as their mutual relationships.

This framework elaborates on the relation between research objectives and main concepts that are of interest for this research, leading to the conclusion of this thesis. The following chapters will consist of a case study of the Dutch Delta Program, and will elaborate on the three steps identified in chapter 2: an agile governance process, flexibility in strategy- and plan-making and preventing lock-ins. The transition from chapter 2, the theoretical framework, to the empirical analysis, chapter 4 & 5, takes place through different research steps and is based on the theoretical concepts discussed in chapter 2.

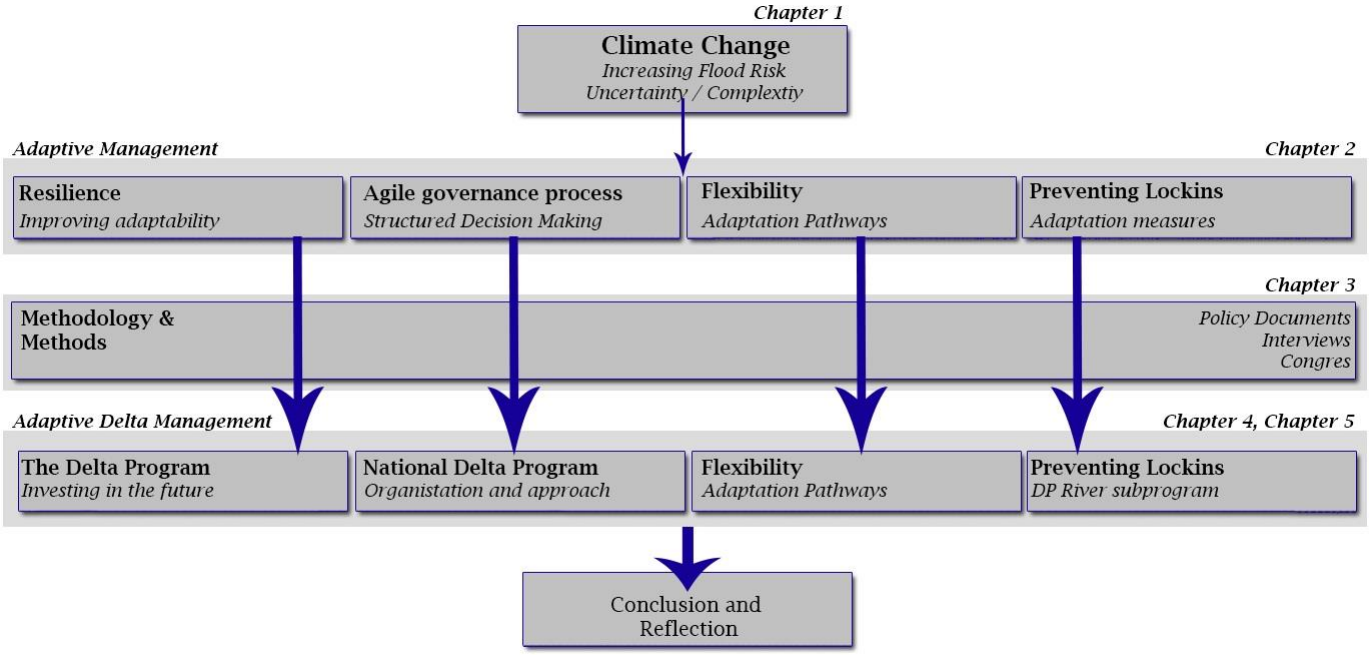

Figure 3 Conceptual Framework

Resilience and adaptability

The need for adaptation strategies will form a useful starting point to explore the development of the Dutch Delta program and the need for an adaptive approach in climate proofing the Netherlands. **Chapter 4** will therefore start off with a short introduction of the establishment of the Dutch Delta program. This section will elaborate on the historical need for water management provisions and why the Netherlands need to improve resilience and increase adaptability. With the notions of resilience, uncertainty and complexity becoming increasingly prominent in Dutch climate debate, the Dutch have developed an approach called *Adaptive Delta Management*

Adaptive Management

Adaptive Delta Management draws strongly on the theoretical underpinnings of AM and recognized the need for an agile governance process, learning, flexibility and the need to prevent lock-ins or path dependency. Therefore the theoretical concept of Adaptive Management, as elaborated in **chapter 2** will be used as a frame of reference in analyzing the ADM concept and its intended benefits.

First of all, the organization of the Delta Program, has worked on the Delta Program since before 2010 and during this time, decisions have been set up in climate proofing the Netherlands. In **chapter 4** the governance process involved in making the so called *Delta Decisions* will be elaborated and the theoretical underpinnings of **chapter 2** will be used as a frame of reference for analyzing the value of the organization and consequently the ADM approach in the Delta Program. Secondly, core concepts such as learning and flexibility as part of the ADM approach will be analyzed in relation to the theory of AM, and specifically how these concepts have influenced decision-making on a national, regional and local scale. These concepts should ultimately lead to flexible adaptation measures that should prevent lock-ins or path-dependencies. This concept will be mostly researched in **chapter 5**, which will show how the ADM concept is put in practice in the DP Rhine subprogram, and how this is experienced on different governmental scales.

Finally, these research steps will be used to formulate a well-founded answer to the research question formulated in **Chapter 1**. The conclusion will consist of an overview of the line of argumentation used in this research and general reflection of the Dutch Delta Program and of the river DP Rhine subprogram, and how ADM has taken form in practical adaptation measures. Furthermore, the research outcomes will be discussed and a broad research reflection and recommendations for further research will be given.

Overview of important literature used in this research:

Resilience

Resilience Thinking: Integrating Resilience, Adaptability and Transformability	Folke *et al.* 2010
Between adaptability and the urge to control: making long-term water policies in the Netherlands	Restemeyer *et al. 2016*
Foundations of Resilience Thinking	Curtin and Parker, 2014

Adaptive Management

Governance of climate change adaptation: introduction to the special issue	Wilson and Termeer, 2011
Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations	Folke *et* al., 2002
Barriers to climate change adaptation in the Netherlands	Biesbroek *et al.*, 2011
Managing Change toward Adaptive Water Management through Social Learning	Pahl-Wostl *et al.*, 2007
Adaptive management for a turbulent future	Allen et al. 2011
Adaptive Management: A science-based approach to managing ecosystems in the face of uncertainty.	Murray and Marmormek, 2003
Adaptation, adaptive capacity and vulnerability	Smit and Wandel, 2006
An introductory guide to adaptive management for project leaders and participants	Nyberg, 1999
A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes	Pahl-Wostl, 2009

Flexibility

Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world	Haasnoot *et al.*, 2013
A history of futures: A review of scenario use in water policy studies in the Netherlands	Haasnoot and Middelkoop, 2012
Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands	Kwadijk *et al.* 2010
A Method to Develop Sustainable Water Management Strategies for an Uncertain Future	Haasnoot *et al.* 2011
Realizing water transitions: the role of policy entrepreneurs in water policy change	Huitema and Meijerink, 2010
Dutch Dealings with the Delta	Wesselink *et al.*, 2007
Damming deltas: A practice of the past? Towards nature-based flood defenses	Van Wesenbeeck *et al.*, 2014

3. Methodology

This chapter will elaborate on the methodology and the research methods used in finding the answers to the central research question as described in chapter 1. To do so, a comprehensive empirical analysis of the case will take place, with a large variety of information sources consulted. The research consists of a case study approach of the Dutch Delta Program , in which a multilevel analysis has been performed through a number of interviews with government officials from 4 different governmental layers, each with their unique tasks and responsibilities. Together, these sources will help find the answer to the central research question.

Research Methods

Over de last decades, research has shown that much of the Netherlands' land is prone to subsidence, the (sea)water level is rising and the extremes of precipitation (either heavy rainfall or prolonged periods of draught) are increasing (Delta program, 2011). The Dutch Delta Program is a large, comprehensive national program, developing and executing large projects to ensure the country's water safety and usage for now and in the future. Naturally, there are a great deal of people involved in this process.

Therefore, to ensure the legitimacy of this research, this research employs *triangulation* as an important quality criteria. Triangulation, is a research method that is focused on the use of multiple perspectives from multiple information sources to improve the reliability of the research. The use of policy documents, interviews, and attending a national congress are the main sources of information for this research. With the use of these information sources, an analysis is done on how the Netherlands is working towards increasing adaptability within their long-term plan-making. The official policy documents have played in important role in understanding what the Delta Program aims to accomplish and how this process is progressing over the years. The policy documents have also contributed in understanding the importance of the ADM concept, and how decisions are based on this concept.

The policy documents are all official publications of the state and research institutes. The Delta Program documents are free and available at the Delta commissioner's website (Delta commissioner, 2015), an official information platform of the national government. Other documents from research institutions are received on request (Van Rhee, 2015) or picked up at the Delta Congress (2015). However, policy-documents are official and legally binding documents that serve to inform the public; they do not represent much of the actual work and processes going on in developing adaptation strategies. Therefore, personal engagement with experts, researchers and government officials is a major contribution to this research to map out differences in mainstreaming the ADM in the Delta Program.

Therefore, a total of 10 face-to-face interviews have been conducted with parties involved with the Delta Program on different governmental scales. For the scope of this research, the selected government officials represent 4 different layers; The national government, the

regional government (provinces), local governments (municipalities) and water boards. These respondents have been selected based on their function and responsibilities within the Delta Program and within their respective governments. These four layers can be separated in two groups, a group with focus on the national level of the Delta Program and a group with a specific focus on the subprogram. From the national Delta program are two respondents; Jan Kruijshoop, who represents Rijkswaterstaat and Wim de Vries, who represents the Ministry of Infrastructure and Environment.

The second group, the regional and respondents were selected based on their level of government in combination with their connection to the Rhine river subprogram. Going from national to regional, there have been 5 interviews with government officials. Jos Athmer, program coordinator of the Rhine subprogram; Rob Lambermont, from province of Gelderland, involved in the project team of the Delta program; Edmee van der Hoeven, project leader of the Dutch river towns, Evert Haasnoot of the Waterboard Rivierenland, specialized in the Hoogwaterberschermingsprogramma (High water protection program) (hereafter HWBP) and Pieter Kroes & Bert Bijkerk of the Waterboard Drents Overijsselse Delta. For the local interviews, 3 respondents from the municipalities connected to the Rhine and its branches were chosen to see how the ADM is incorporated into local decision-making; Andreas Van Rooijen, municipality of Zwolle; Kitty Schoorlemmer, municipality of Deventer and Ronald Bos, municipality of Arnhem.

The interviews conducted were semi-structured and all start with the same generic themes. The interview respondents were not interviewed in a pre-set order. The first topic was ADM, and what it meant and how it is interpreted in the specific area of expertise. The second topic was about the involved organizations and how different agendas are being joined. The third theme asked specifically how to incorporate and develop adaptive strategies on their respective levels and how it influences their decision-making. The fourth theme was about future chances and current difficulties. Finally, most respondents were asked to name a specific project in which Adaptive Deltamanagement is being brought out in practice. Because of some questions specifically related to their personal experience with the Delta Program and adaptive deltamanagement, the interviews will be biased to a certain point. This has been deliberate choice, as it better reflects the government officials' own experience and opinions with the difficulties encountered within the Delta Program or River subprogram accordingly.

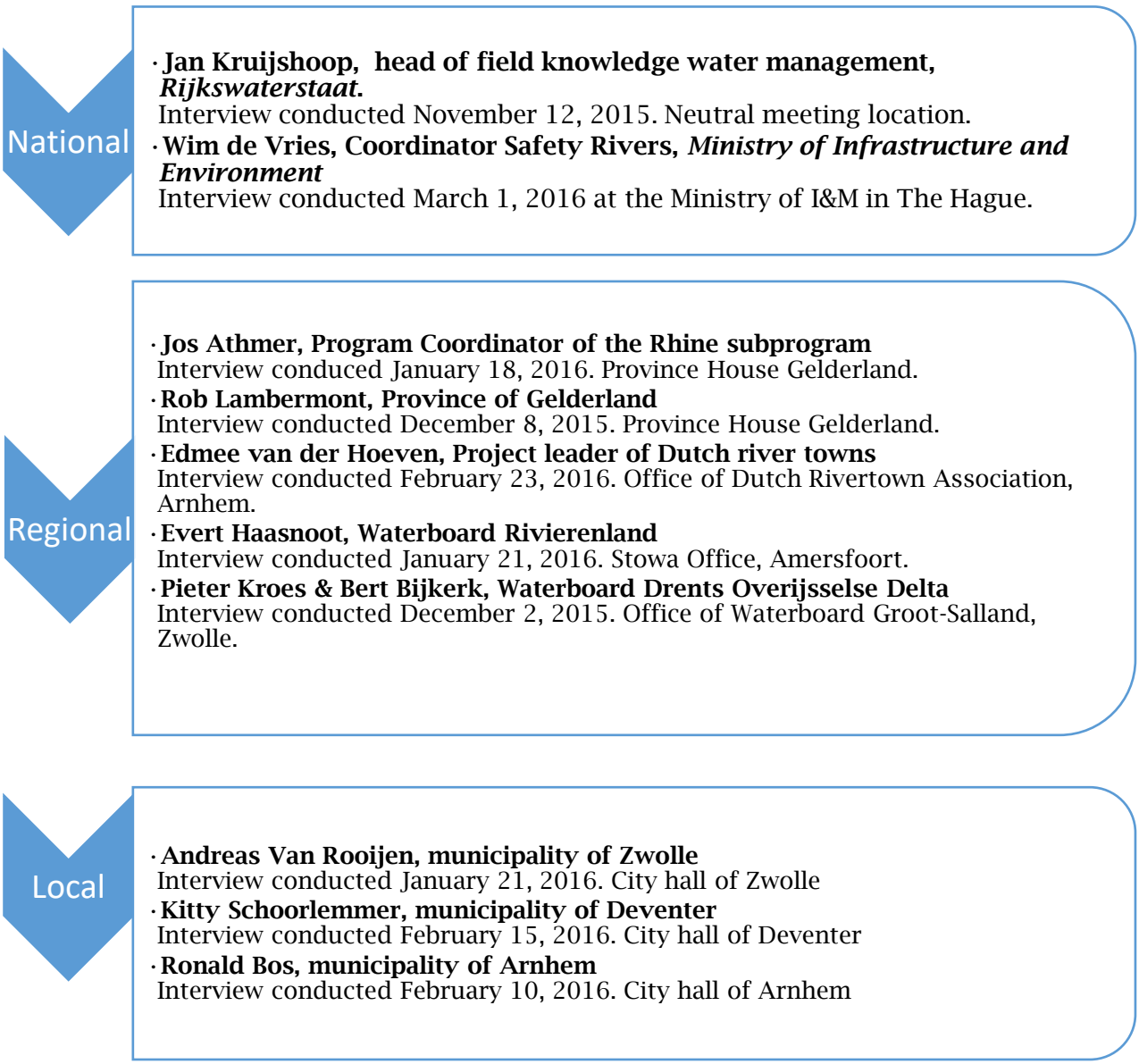

Figure 4 Respondents sorted on governmental layer in which they are active.

In analyzing the Delta Program, policy documents, and secondary literature about policy developments related to the Delta Program are consulted. In analyzing the organization of the Delta Program and the Adaptive Deltamanagement concept, policy documents and literature are being complemented with the respondent's input. The input of the respondents is of great importance to help explore the subject, with personal experiences and opinions complementing the official documents.

Next is an overview of the most notable policy documents and secondary literature related to the Delta Program that are used in this research:

Title	Author / Publisher
Samen werken met Water: *Een land dat leeft, bouwt aan zijn toekomst*	Deltacommissie, 2008
Europe Adapts to Climate Change Comparing National Adaptation Strategies	Swart *et all.*, 2009
Deltaprogramma 2011: Werk aan de Delta: Investeren in een veilig en aantrekkelijk Nederland, nu en morgen.	Ministerie van Infrastructuur en Milieu and Ministerie van Economische Zaken, Landbouw en Innovatie, 2010.
Deltaprogramma 2012: Werk aan de Delta: Maatregelen van nu, voorbereiding voor morgen	Ministerie van Infrastructuur en Milieu and Ministerie van Economische Zaken, Landbouw en Innovatie, 2011.
Deltaprogramma 2013: Werk aan de Delta: De weg naar Deltabeslissingen	Ministerie van Infrastructuur en Milieu and Ministerie van Economische Zaken, 2012
The Delta Programme and updated flood risk management policies in the Netherlands	Van Alphen, J. (2012).
Handreiking Adaptief Deltamanagement	Van Rhee, G (2012).
Deltaprogramma 2015: Werk aan de Delta: De beslissingen om Nederland veilig en leefbaar te houden.	Ministerie van Infrastructuur en Milieu and Ministerie van Economische Zaken, 2014
Deltaprogramma Rivieren: Synthesedocument Rivieren	Ministerie van Infrastructuur en Milieu and Ministerie van Economische Zaken, 2014
Deltaprogramma 2016: Werk aan de Delta: En nu begint het pas echt.	Ministerie van Infrastructuur en Milieu and Ministerie van Economische Zaken, 2015
Adaptive Delta Management for flood risk and resilience in Dordrecht, The Netherlands	Gersonius, B., Rijke, J., Ashley, R., Bloemen, P., Kelder, E. & Zevenbergen, C. (2016)

Next to the interviews and policy document analyses, the Delta Congress was specifically helpful to get information of the experiences of some of the involved parties, for example research institutes such as the Netherlands Environmental Assessment Agency. On this congress, specific emphasis was given on the current state of developments within the Delta Program, such as the development of the monitoring and evaluation program.

All these sources have contributed to exploring the practical application of Adaptive Delta Management, the experiences and methodologies on different governmental layers and ultimately help answer the central research question as stated in **Chapter 1**.

4. The Delta program

Climate adaptation strategies in the Netherlands take form in the national Delta Program. The Delta Program can be regarded as an adaptation strategy to keep the Netherlands safe from flooding and provide sufficient fresh water through increasing adaptability in the Dutch landscape. In this chapter, the process of Delta Program, its organization and the Delta Decisions will be analyzed. The decision-making in the Delta Program follows the Adaptive Delta Management approach, which was introduced in the first publication of the Delta Program in 2011. Emphasis will be given to the ADM approach, it's intended benefits and how it relates to the theoretical underpinnings of Adaptive Management

4.1 The national Delta Program

As a response to the flood disaster in 1953, the first Delta Commission was installed. This commission was appointed with the primary task to answer the question how to best protect the storm-stricken areas, by means of technical water management provisions (Delta Commission, 2008). This resulted in the first Delta Plan, which mainly consisted of technical measures, such as the Delta Works in the south west of the country closing off many of the open connections to the sea, the implementation of flood risk standardization and the raising of dikes (Zegwaard *et al.*, 2015).

This water safety plan laid the foundations for the second Delta Commission, which was installed in 2007. For the second Delta Commission there was no immediate crisis at hand, however with the emerging climate discussion and not knowing how exactly the future is going to develop, the development of a long-term water safety strategy was regarded as appropriate (Twist *et al.*, 2013). The commission was also shown documents of deterred maintenance of the Delta Works, so in order to prevent another flood disaster such as the one in 1953, this new Delta commission was founded to address the potential climate change impacts in the future, and increase the current water safety of the country through flood prevention (Delta Program, 2011; Twist *et al.*, 2013); so the commission Sustainable Coastal Development (in Dutch: Duurzame Kustontwikkeling) was founded led by former-minister Cees Veerman (also known as Commission Veerman). The commission aimed at water safety for the long-term, up to a 100 years, to better map the opportunities and anticipate on long-term developments (Twist *et al.*, 2013). This research ultimately led to the formulation of the Delta Program, which consists of a problem analysis followed by implementation measures on how to tackle the problem.

The Delta Program is a comprehensive national program comprising strategies to ensure long-term water safety across the country affected by a changing climate. The Delta Program is

executed under the responsibility of the Ministries of *Infrastructure & Environment* (I&M) *and Economic Affairs* (EZ). The supervisor of the Delta Program - the Delta Commissioner - is an independent government official who has the responsibility to draft, update and execute the Delta Program. The Delta Commissioner also drafts proposals for the development of the Delta Program, including the financial consequences of the measures (Delta Commissioner, 2015).

With new insights regarding changing weather patterns, rising sea levels and increasing subsidence, the Delta Program is installed to increase water safety and be prepared for more and longer periods of droughts (Delta program 2012). The Delta Program can be described as a comprehensive program, with a focus on the water safety of the country, by taking measures in the spatial physical domain (Delta Program 2011). The Delta Program is comprised of all the plans that are needed to guarantee water safety and a sufficient and sustainable fresh water supply, and states all necessary actions and developments needed to provide an attractive, livable and above all, safe country (Delta Program 2011). Each year this program is being updated and the progress is elaborated and is part of the annual state budget framework and is therefore also an investment policy document. This is therefore the most important moment for parliamentary policy-making, as Members of the Parliament can amend the budget to finance specific plans (Mostert, 2016). The Delta Program is therefore a legal policy framework, which is financially, politically and administratively embedded in the *Delta Act*. Though no exact costs were known at the time, up to the year 2100 the state estimates costs of €0,9 billion to €1,5 billion each year and are part of the Delta Funds (Delta Commission, 2008). From the publication of the first Delta Program in 2010, the program is designed to be updated and published every year on the same day the annual state budget is presented.

The first Delta Program, published in September 2010, called 'Delta Program 2011 *working on the Delta, investing in a safe and appealing Netherlands, now and tomorrow'* can be seen as an exploration of approaches and measures that ought to be taken in the (near) future. In this first program the emphasis is put on preparing the so-called *delta decisions*, which get a 4-year period of development, so that the decisions can be definitive and published in the Delta Program of 2015. The development and implementation of the delta decisions and the corresponding developed strategies is a collaboration between the national, provincial and local governments and water boards. Other involved parties, such as community organizations, research institutes, and industries are actively being involved in strategy development. In the first Delta program, special attention is given on how the strategies, decisions and the research itself is to be conducted. Therefore, specific knowledge based programs and tools are developed that should improve the uniformity of decision-making; *Delta scenarios* and *Delta Instruments*. Future decisions and studies are based on these tools.

Delta Scenarios

The Delta scenarios comprise the most plausible future developments on the effects of climate change and socio-economic developments up to the period of 2100. However, the scenarios are not meant as a tool to predict future developments, but merely to give insight in future uncertainties and insight in possible future developments to consider in the decision-making process. The scenarios are split up in two periods, now-2050 and 2050-2100. The period up to 2050 is fairly detailed, where the period up to 2100 just consists of directions as to what situations should be accounted for. The Delta scenarios are based on the 2006 climate scenarios from the *Royal Dutch Meteorological Institute (*KNMI) (revisited in 2013) and the WLO-scenarios (*Welfare and Habitat*) from the collaborating planning bureaus (CPB & PBL). The Delta scenarios consists of four scenarios derived from the scenarios of these bureaus:

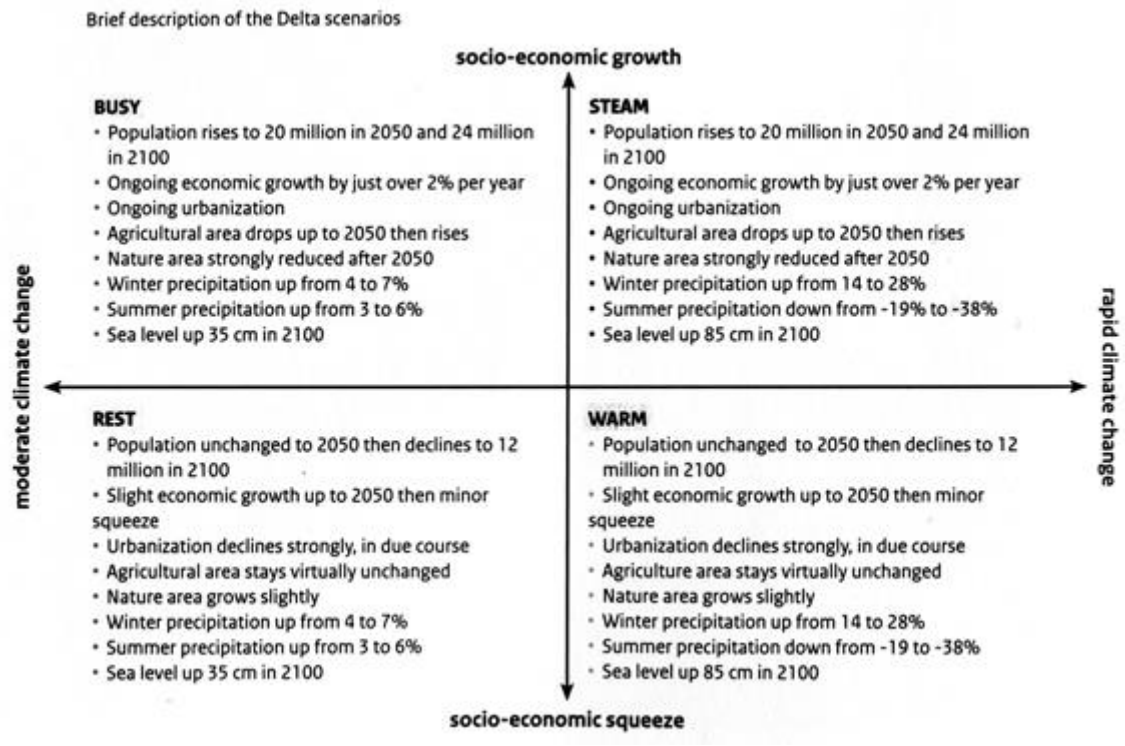

Figure 5 The Delta Scenario's (Delta Program 2010, 2011)

The Delta scenarios comprise of 4 different directions for future developments, with either fast or moderate climate change and either socio-economic growth or decline. The 2006 scenarios were used in the Delta Program 2010 and 2011 to analyze future opportunities and difficulties. The application of these scenarios made it possible to research possible solutions and approaches and served as inspiration for the development of strategies and innovations. In 2013 these scenarios were revised and used in the 2013-2015 period to check whether the proposed strategies and measures were still robust and effective enough in the four different future scenarios, so that the 2014 Delta decisions are sufficiently substantiated (Delta Scenario's, 2013). The Delta scenarios are intended as qualitative and quantitative data on

climate, water systems, water consumption and land usage (Deltacommissioner, 2015). For all purposes, the Delta scenarios are specifically designed to be used for 'the qualitative model set of instruments for long-term policy choices (Deltacommissioner, 2015; Delta Program 2011)', the Delta Model.

The *Delta Model,* a comprehensive model instrument focused on the main water system, is used for the underpinnings of long-term policy decisions of the water management sector and is used in the Delta Program for policy issues on water safety and the fresh water supply. It uses the Delta Scenarios to show the consequences of future developments on the supply and demand of fresh water and shows the relations between several hydrological developments, climate data, the water system and the measures to examine. Together, the delta scenarios, the delta model and other delta instruments allow for well-considered decision-making between possible measures, that integrate hydrological systems, societal and economic developments (Delta Model, 2010).

Subprograms of the Delta Program

The nationwide scale of the Delta Program resulted in the establishment of 9 subprograms, each with their own problems, risks and subsequently their own strategies. These 9 subprograms consist of 3 generic programs, which are national frameworks are developed and plays a major role in the Netherlands. The other 6 subprograms are regional programs (fig. 6), which are aimed at developing and implementing specific regional adaptation strategies that will function as a basis for the long-term water management tasks.

The three generic programs are (Delta Program, 2011):

- **Water Safety**; Updating water safety norms to prevent flooding and ensure safety for people behind dikes.
- **Fresh Water**; Securing a sustainable long-term supply of fresh water.
- **Urban (Re)development;** a strategy for urban (re)development on a climate proof manner.

The remaining six regional programs are:

- **IJsselmeer region**; the possibility of flexible water levels in the IJsselmeer. To increase water safety as well as manage the fresh water supply in the area.
- **Rhine Estuary-Drechtsteden**; The development of long-term water safety and fresh water tasks in anticipation of a rising sea level and increase river discharges.
- **Southwest Delta**; the development of a sustainable, resilient area in anticipation of increasing weather extremes, rising sea level and increased river discharges.
- **Rivers**; the development of an integral long-term strategy, with emphasis on safety, nature conservation, spatial quality and spatial development.

- **Coast**; Ensure water safety against rising sea levels and development of a coastal expansion strategy.
- **Wadden Region**; The development of a water safety strategy and a monitoring program to map the impacts of climate change on the Wadden sea.

Figure 6 The 6 regional subprograms (Delta commissioner, 2012)

Each of the different subprograms fall under the responsibility of the *Ministry of I&M*, nevertheless each different subprogram consists of its own organizational structure with its own program coordinator and staff (Delta Commissioner, 2015). However, a national approach is still evenly important, so the national, regional and local governments and water boards share responsibility and ownership and form the basis of the national approach (Delta Commissioner, 2015). The regional administrative governments are an important factor to keep the Delta tasks coherent. In the new phase of the Delta Program, the scales of interventions and planning approaches will be different per subprogram and therefore the sizes of the administrative steering committees will be different per subprogram as well. For the execution of the *water safety* program the steering committee of the *'high water protection program'* (HWBP), a collaboration between Rijkswaterstaat and different water boards, will perform a central role. The *Fresh Water* program planning is being executed by the steering committee *Fresh Water* (Delta Commissioner, 2015)

4.2 The approach of the Delta Program

The Delta Program is first and foremost about water safety and the fresh water supply (Delta Program 2011). However, another key issue is the relation of the water system to societal, economic and ecological developments. Therefore, the Delta Program choses to operate from an integrated approach, because the developments in one part of the country affect other parts of the country. The Delta organization operates from basic values *solidarity, flexibility and sustainability* and serve as a beacon of decision-making and to connect the different parties involved in the decision-making process (Delta Program 2011).

Solidarity puts emphasis on the distribution of costs and benefits between three distinct areas; *generations, regions and sectors*, so that the costs and consequences of choices are distributed evenly. *Flexibility* refers to the ability and the need to be able to adequately adapt to changes in climate and social-economic circumstances and to apply innovative methods at any given time in the future. *Sustainability* refers to the principle of *People, Planet & Profit*, with emphasis on active involvement of people, quality of the physical environment and the economic opportunities for local businesses and the nation internationally. Apart from these basic values, the Delta Program also operates from a set of basic principles; *coherency, consistency and transparency* and serve to connect the broad spectrum of activities of the Delta Program together, which contributes to the efficiency and familiarity of the Delta Program.

Together these values and principles form the framework of the Delta Program which, on the publication of the first delta program in 2010, distinguished two different components. Firstly, the execution of ongoing programs, which served to improve urgent the safety tasks. Most of these projects, such as the *Room for the River* program, have been completed by now and therefore the focus lies with the second component, which is the implementation of the long-term strategies to keep the Netherlands habitable in the future (up to 2100), these strategies are translated as the Delta decisions presented in the 2015 Delta Program.

Figure 7 Process of the Delta Program (up to 2015) (Delta Program 2012)

4.3 Adaptive Delta Management

The decision-making process employed by the Delta Program, and the general methodology within the Delta Program, based on its values and principles, is complementary with the sober attitude of the Delta Program. This means a realistic approach to climate scenarios (don't assume the worst possible scenario) and keeping options open for future developments (don't focus on a definitive blueprint for the year 2100) (Delta Program 2012). This approach is deemed necessary because of the great uncertainty of climate change developments and to prevent unwanted costly investments in case the future turns out different than anticipated. Within the Delta Program this approach is labelled as *Adaptive Delta Management* (ADM), which was introduced in the first Delta Program in 2010.

Over the years the Delta commissioner has elaborated more on this approach and described it as ***"a way to include uncertainty over future developments on a transparent way in the decision-making processes."*** (Delta Program 2011: 48).
Adaptive Delta Management has four important characteristics (Delta Program 2012; Van Rhee, 2012):

- Combining and connecting short-term decisions with long-term challenges;
- Flexibility in solutions;
- The use of multiple strategies and the ability to switch between strategies (Adaptation Pathways);
- Combining and connecting different investment agenda's.

The head of field knowledge water management from Rijkswaterstaat, Jan Kruijshoop (2015) describes this process as:

"Work in an adaptive way, that means exploring future developments before taking a decision, so that in 20, 30, 50 or 70 years – depending on the decision – you are not running into any major difficulties"

Therefore, it shows that one of main characteristics of the ADM approach is to increase flexibility in the short-term decisions and to increase robustness in the decisions (Delta Program 2011). In this way, there is more control over *tipping points* in the water system and to move these tipping points to more appropriate times (Delta Program 2011). The rationale

of this approach is that in at the same time new information and new developments can be processed, which increases efficiency and effectiveness. This line of thought corresponds to the sober attitude of the Delta Program, which put emphasis on appropriate and financially sound investments (Delta Program, 2011). Adaptive delta management recognizes the time scale of policy preparations and the implementation of large projects can be incredibly long, while spatial, social and economic developments continue (Delta Program 2012). Some of these developments will influence the project costs, either negatively (cost increase) or positively (cost decrease). Therefore, adaptive short-term decisions should prevent unwanted cost increases and be cost-efficient.

The ADM approach propagates the ability to adjust to changing circumstances, combining current and new insights in a changing climate and changing developments and translate them into a strategy with multiple outcomes through the means of *adaptation pathways*. Adaptation pathways assume a system state in the future and through back-casting, current and future decisions are mapped that correspond with the future state, i.e. guarantee water safety, thus combining the short-term measures and long-term tasks. This shows that this adaptive reasoning is meant to make the complexity of the physical and organization more comprehensible and thus better manageable. The adaptation pathways and the ADM approach also improve the efficiency and effectiveness of decision-making, through the ability to introduce multiple follow-up decisions (Delta Program 2011, 2012). The 2012 Delta Program describes the ADM concept as an approach that *"…consists of doing what is necessary now, not too much nor too little, without excluding future possibilities."* This means that whatever measures or investments are made, make sure these are appropriate *(no-regret)*. Make decisions at exactly the right time. To accomplish the timing of decision-making, adaptive delta management distinguishes three 'crucial' steps (Delta Program 2013):

- Which short-term developments of other policy-fields affect the tasks for fresh water supply and water safety;
- To gain insight in the flexibility of possible adaptation measures. Are they easily executed and adjustable in a step-wise manner if the actual developments ask for it?
- Which of the short-term decisions are necessary to allow for the adaptive approach?

The ambition of Adaptive Delta Management is that the entire water system is fully in place at any given moment, and that solutions can 'grow' with new insights and conditions, while keeping options open that prove necessary in the future (Delta Program 2012). This means that when large-scale investments need to be made in the period after 2050, when new climate insights about possible sea level rise or increased river discharges are more clear, current decisions about adaptation measures must take these possibilities into account. For example, making spatial reservations or accounting for high water levels in the development of new housing.

4.4 The Delta Decisions – An agile governance process

Central to the ADM approach, and consequently for Dutch cabinet, to ensure long-term control over the Delta Program and its developments, 5 key elements have been set up; the so-called 5 D's (Delta Program 2011, 2012). These 5 D's stand for ***Delta*** *Program,* ***D****elta Commissioner,* ***D****elta Act,* ***D****elta Fund* and ***D****elta Decisions*.

With the establishment of the Delta Program, a special government official has been appointed to oversee the progress of the Delta Program; The Delta Commissioner. He is particularly responsible for involving all relevant parties and guaranteeing the coherence of developed strategies (Restemeyer *et al.*, 2016). The commissioner plays a central role in the triangle of politics, administration and society (Delta Program 2011).

Shortly after the publication of the 2012 Delta Program (Jan 1st, 2012), the program has been officially anchored in Dutch law under the Delta Act. This act provides a legal foundation for the actions in the Delta Program. The Delta Act states that provisions, measures, research and ambitions of the next 6 years, and the following 12 years are recorded in the Delta Act and Delta Program (Delta Program 2011, 2012, 2013).

Crucial to the delta organization and the implementation of measures is the availability of financial resources. This task is executed through Delta Fund, which is legally embedded in the Delta Act and serves as the financial foundation of the Delta Program. The second Delta Commission advised the formation of the Delta Fund, so that a structural flow of financial resources would be reserved and made available to invest in water safety and fresh water. The Delta Fund was made official at the same time as the Delta Act in 2012. As a result, the economic analyses are being executed in the Dutch '*Multi-annual program for Infrastructure, Space and Transport* (MIRT), which focuses on the financial investments of programs and projects and bring more consistency and transparency in large infrastructural projects (Rijksoverheid, 2015).

For the Delta Program this means clear phasing and decision-making processes (Delta Program 2011). Combined with the *Faster & Better* program, to improve the implementation speed of large infrastructural projects and to streamline the decision-making processes, these two instruments form important policy frameworks for the development and implementation within the Delta Program. Within the Delta organization there is a wide consensus in applying the *Faster & Better* methodology within the Delta program. The administration, organization and methodology of the Delta Program are designed to be able to have a wide and integral scope.

These nine subprograms form the core for the entire Delta Program; the formulation of five Delta decisions on water safety and fresh water supply to the period of 2100. The following 4 years after the publication of the first Delta Program, these five decisions were designed, researched and formulated and form a framework of the 6 regional subprograms mentioned earlier (Delta Program 2011; 2015; Van Alphen, 2012):

- **Water safety**; The o*ptimization of safety norms for primary flood defenses;*
- ***Freshwater;*** *A freshwater strategy to ensure an adequate long-term freshwater supply in the Netherlands;*
- **Spatial Adaptation;** *A national policy framework for the (re)development of the built environment;*
- **IJsselmeer Region;** *Long-term water-level management of the IJsselmeer, concerned with the freshwater supply and safety tasks in the area***;**
- ***Rhine-Meusedelta****; The protection of the Rhine-Meuse Delta.*

The Delta decisions are developed to ensure the safety and habitability of the Netherlands over a period of 35 years; 2050 is the target year where the primary embankments meet the current safety requirements, the fresh water supply is robust and the spatial development is 'as climate proof as possible' (Delta Program 2015).

The decisions have been set up with a long-term perspective, which stimulates the combination of investment agendas of different policy fields or authorities (Van Alphen, 2012). The Delta Decisions consist of an objective, set of measures - the preferred strategies (see figure 5) – and a timetable. The development of promising strategies is incorporated in the ADM approach. In setting up strategies, an explicit emphasis is given to connecting the development pathways with other agendas and plans. These are so-called *integration opportunities* (Van Rhee, 2012). With these opportunities, emphasis is put on combining and connecting planned actions of different developments, choices, initiatives and ambitions.

In setting up adaptive strategies within the Delta program, six steps are identified (Van Rhee, 2012):

- Making an inventory of opportunities of other agendas;
- Mapping regional and local windows of opportunities, and dependencies for opportunities;
- Establishing savings through an integral analysis (synergy);
- Defining the optimal sequence of decisions;
- Making an inventory of risks and indicators which must be monitored;
- Formulating promising strategies.

These Delta decisions form a coherent framework of structured choices to increase national water safety, limit water shortages, and making the country more robust and less vulnerable to extreme weather conditions (Delta Program 2015).

4.5 Flexibility in strategy and plan-making

Finding a balance between (uncertain) climate, environmental, societal and economic developments and the need for tailor-made, flexible, strategies is essential for the success of the Delta Program and subsequently the ADM approach. Within Adaptive Deltamanagement a distinction is made between four different degrees of uncertainty (Van Rhee, 2012):

Type A – Factors that are sufficiently certain to consider them certainties, and for which a limited sensitivity analysis suffices. A strategy for this type of uncertainty does not need to be made adaptive;
Type B – Factors which are uncertain, but with limited outcomes. This depends on decisions that must, or not have to be taken and depends critically on the results of research on the subject.
Type C – Factors with a certain range of uncertainty, which increases over time. This is an example of the predicted sea level rise, economic developments and the number of inhabitants at a certain point in time.
Type D – Factors of which almost nothing is certain.

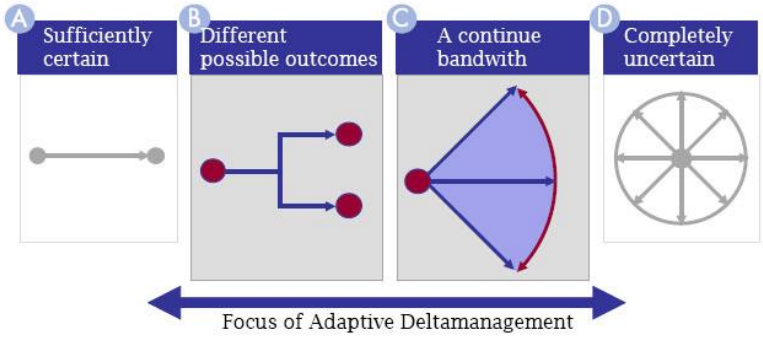

Figure 8 - 4 types of uncertainty (Van Rhee, 2012)

Within the Delta program, adaptive delta management focusses on the types B and C. Type C is prominent in the different Delta scenarios, in which future developments are mapped and are increasing uncertain over time. As mentioned in the theoretical framework, adaptive management (**chapter 2.5**) adaptive management is primarily used for situations with low controllability and high uncertainty (Allen *et al.*, 2011).

To deal with uncertainty, the ADM concept has been embraced by the joint governments, social institutions, knowledge/research institutions and businesses as "*… a sober solution for dealing with problems of which the direction is fairly clear, but the speed of developments still uncertain"* (Delta Program 2015: 7).

To deal with uncertainties, the Delta program utilized the concept of *Adaptation Tipping Points* (ATPs). ATPs are defined as the points on which current conditions, be it technical, societal, economical or environmental are no longer able to meet policy objectives and alternative strategies need to be implemented (Gersonius *et al.*, 2013; Kwadijk *et al.*, 2010; Haasnoot *et al.*, 2011). In this way the Delta Scenarios are used to provide insight at what point in time adaptation tipping points are most likely. This has a major influence on decision-making as is shows the time frame and need of alternative actions. This emphasizes the need to think in adaptation pathways as Wim de Vries (2016), coordinator of river safety at the ministry of Infrastructure and Environment, described as essential to adaptive delta management:

> *"… **To look ahead, what can be done now, and what are the subsequent steps depending on the developments."*** and "***To be aware of the moments of when to take an alternative path, and acting on the right alternative through looking at the different scenarios."***

In the Delta program, these moments are pinpointed in so-called adaptation pathways. These pathways are developed using the ATP methodology and give insight in the degree of changes in water management through climate change or social-economic developments, at a point of which the current policy approach is (still) effective (Van Rhee, 2012). These ATPs come forth when comparing current water management practices to the expected changes, because of climate change. When these two cross, the current situation cannot cope with the change in the system. The prediction of both the future changes in the system as well as the current water management is not a linear process, both can change over time (Van Rhee, 2012). For example, the rate at which peak river discharges will grow is uncertain. It could be more than anticipated, as well as it could be less. The same goes for the current water management system. Water usage can change; safety norms can be adjusted and even the social sense of urgency and consequently the commitment towards climate proofing can change.

Therefore, the strategies developed in the Delta Program are designed to cope with uncertainty through flexible decision-making. In the Delta program is a specific tool for testing flexibility in decision-making; the comparison system (Vergelijkingssystematiek) (VGS) (Delta Program 2013). This tool offers the opportunity to describe a strategies flexibility and at the same time the added value of the flexibility. A special 'comparison perspective' is therefore embedded in the VGS. The added value in this case is measured in cost reduction, and if the measures can

be connected to other agenda's. Considering this model, it is not surprising that it is mentioned (Delta Program 2013: p90) that strategies *'…do not, per definition, have to be flexible. But also, other criteria influence the final choice."*

4.6 Conclusion

Reflecting on the theoretical characteristics of adaptive management as elaborated in chapter 2, some interesting observations can be made in analyzing the ADM approach. The ADM concept offers similarities to the theoretical underpinnings of AM, but has also its quite distinct features. In the first place, it is clear that combining new insights, increasing knowledge in the face of uncertainty plays a central role in the developed adaptation strategies. Even the ambiguity in interpretation, as Wim de Vries (2016) describes:

"The idea of ADM lives, and the idea is that it is the good thing to do, however ideas on how to operationalize this idea diverge, or the exact meaning of the idea is often very vague"

The first part of AM cycle of **fig. 1** has been set up in the steps leading towards the delta decisions. In the publication of the 2015 Delta Program, these steps have been translated to physical adaptation strategies and measure. Though not all options are currently definitive and a lot of research is still being done, most of the measures have been developed in 5 years' time. In this time the ADM approach has been more elaborated and developed, and adaptation pathways have been published in the preferred strategies (VKRS, 2015).

The Delta Program stresses the notion for flexibility, in not taking incremental steps toward a desired state. However, the relation with flexibility and its added value is still unclear. At what point is cost reduction more important than a certain degree of flexibility and how exactly is it measured? Few concrete steps are proposed in measuring flexibility and in applying the adaptive management approach in general. This means that, apart from the guidelines in the program, there is not a universal approach towards mainstreaming adaptive delta management in decision-making, and how the different projects fulfill their obligations will be highly contextual. Therefore, the biggest challenge within the national Delta Program is to apply the ADM concept within all the generic and within the regional subprograms. It is essential for this research to take a closer look on how the ADM concept is translated to practical, physical measures in regional and local decision-making. This way, it will provide a clearer image as to what adaptive delta management means in practice and how it contributes to the decision-making processes in increasing adaptivity.

5. Delta Program, the River subprogram

In different regional subprograms, the ADM approach has been given a more practical and concrete meaning. In the ADM theory of the Delta Program there have been few concrete steps of how to implement successful ADM in practice. The theory on ADM offer some theoretical benefits, so it is interesting to discover at how this is put into practice, through an in depth analysis. However, implementing and acting to the adaptive approach will inevitably come with restrictions, difficulties or dilemmas in local and regional decision-making. To look at the development and implementation of a specific subprogram, a closer look will be given to the River subprogram. The Dutch landscape knows many large rivers, such as the rivers of focus in the Delta Program, the Meuse and Rhine. The focus of this regional case study is put on the river Rhine and its branches, the Waal and the IJssel and how the ADM approach is put into practice.

5.1 The River subprogram

Much of the Dutch landscape is influenced by the large rivers that flow through the land. The main Rivers of focus in the Delta Program are the Meuse and the Rhine, and are not only different in size and shape, but also in natural conditions, the use of space around the riverine area's and economies (Delta Program 2015). Therefore, these riverine areas will be differently affected by the expected effects of climate change, and require area specific interventions. Current climate scenarios expect an increase for (peak) river discharges up to the year 2100. For the Rhine, this means an increase from 16 000 m3/s to 18 000 m3/s (Delta Program 2012). This results in a major safety task for the riverine areas, as currently the river area has by far the highest flood risk (75%) of the country (Delta Program, 2015b). Floods can cause large numbers of victims and high economic damage. However, many factors influence the strategies taken towards a safe river area. It is therefore interesting to examine how the ADM approach has been put into practice in this particular program.

Considering the size and the connectedness of the rivers and the Dutch water system, the River sub-program is closely interlinked with other sub-programs, such as the IJsselmeer area, South-Western Delta and Rhine estuary-Drechtsteden. Changes that affect the rivers will in turn also affect the specific sub-programs, which can result in high water on the Ijsselmeer area, but also cause freshwater shortages in the summer (Delta Program 2014). Therefore, the generic subprograms Water Safety and Freshwater play important parts within the development of new strategies. However, within the River sub-program, main emphasis is put on long-term water safety against flooding (Delta Program 2012).

For the Rhine, this means that the future discharge distribution over the Rhine branches, such as the Waal, Nederrijn-Lek and IJssel is crucial, as it influences the safety tasks in the entire area (Delta Program, 2015b). The Room for the River program plays an important role in the

safety task of the Rhine branches, as it conforms to the short-term safety tasks within the area. However, the program alone is not enough to process the anticipated peak river discharges (Delta Program, 2011b). Although anticipated peak river discharges play an important role, there are other factors that have major influence on the long-term safety task of the riverine areas. One prominent factor is the review of the primary flood defenses set out in 2011, which resulted in a large number of dikes to be rejected (Delta Program 2012; 2013).

Figure 9 Discharge distribution Rhine branches (Delta Program, 2015b).

The preferred strategy policy document highlights the factors stressing the river area and asks for nationwide priority (Delta Program, 2015b): *"The combination of rejected dikes, climate change, subsidence and the new safety norms causes the water safety in the river area for the coming decennia to be under heavy pressure."* And hence resulted in a strategy that puts emphasis on a 'powerful interplay' between dike enhancement and river widening (Delta Program, 2015b). This interplay is developed in an integrated way, in which the area will still be attractive for living, working, investing and recreating (Delta Program, 2011).

5.2 Organization of the River subprogram

Developing strategies in an integrated and coherent way as said in the Delta Program requires extensive coordination between all the involved actors. The nationwide interest, but also regional nature of the riverine area's makes that water management in the Netherlands requires effective management of interdependencies between multiple actors and stakeholders (OECD, 2014), such as national, regional and local governments, water boards, societal organizations and research institutes. Especially since the high degree of territorial and institutional fragmentation within the Dutch water management sector, land use, spatial planning and water management must be carefully coordinated.

Therefore, the sub-program Rhine has its own program organization with involvement of the Ministry of I&M, Rijkswaterstaat, multiple Water Boards, Provinces and the larger municipalities. The administrative coordination of large safety tasks within the river area of the Rhine will be done separately for each river branch, in accordance with the overarching Rhine program organization (Delta Commissioner, 2016). This program organization is the main link between the regional decision-making and the national government. Jos Athmer, Program Coordinator of the Rhine subprogram (2015) describes the program organization and its key objective as a:

"…***partnership of all involved parties involved in the climate adaptation program for the Rivers, specifically the Rhine, IJssel, Lek and Waal. Our main concern is the execution of the preferred strategy, which consists of river widening and dike enhancement. Practically, the coordination of those two is what the program organization concerns itself with."***

To get a better understanding of how regional water management is organized, it is interesting to analyze the layers of water management of the Netherlands. Within the Netherlands, many different organizations are involved in water management, ranging from the European Union to municipalities. On European level, general legislation is drafted for water, flooding and environmental purposes. Then, the Netherlands is involved with international River Basin commissions, regarding the four international rivers that discharge in the Netherlands (Rhine, Meuse, Ems, Scheldt). At the national level, two main governmental authorities are

distinguished; the ministry of Infrastructure and Environment (I&M), and the national water authority Rijkswaterstaat. The ministry of I&M is concerned with water, spatial planning, flood protection and is concerned with policy coordination with other policy areas on the national level. Rijkswaterstaat is concerned with the operation and maintenance of the national water system (OECD, 2014). Then provinces are concerned with integrated spatial and environmental planning, groundwater control and supervise the regional water authorities. Then at a more detailed regional level come the municipalities and the water boards.

Water boards (or regional water authorities) are generally perceived as essential for Dutch water management. The water boards have long been established in the Netherlands, designed to keep the Netherlands safe and livable. Up until the floodings in 1953, there were nearly 2670 water boards established. After that, in the bill drafted by the Dutch Parliament, the State would take over supervision of the water boards from the provinces (Mostert, 2016). Because of the waterboards importance for water safety and its central role, the function of the water boards will be shortly elaborated upon.

Water Boards

The Netherlands has a total of 22 water boards, with each their own region. Water boards are regional water authorities, concerned with water management tasks such as the building and maintaining of dikes, water level management, water quality management, dredging and wastewater treatment (Mostert, 2016; Dutch Water Authorities, 2016). Within the Delta Program, their main task is high water safety, which resulted in the foundation of the *High-Water protection program,* hereafter HWBP (in Dutch: Hoogwaterbeschermingsprogramma).

This program is central to the River sub-program and the Rhine branches as it is concerned with the dikes protecting the riverine area. The program management HWBP is a collaboration between Rijkswaterstaat and the involved Water Boards and has the responsibility to develop a coherent program of the water safety tasks (Delta Commissioner, 2016). The essence of the program consists of fixing the embankments that were deemed insufficient at the Third Assessment. As part of the Delta Program, the HWBP is updated annually, for a period of 6 years, with a forward view of 12 years. This program is especially important for the River subprogram and for the Rhine branches such as the Waal and the IJssel, because of the large number of rejected dike trajectories.

Together, these governmental authorities have to work together to bring about water safety. These authorities have prepared the preferred strategy of the Rhine area of ensuring water safety, by a range of measures. These measures vary from large spatial and physical interventions as well as some minor ones, like small dike enhancements. These decisions are guided by the ADM approach and therefore it is interesting to see how these measures have been developed and what ADM means for the Rhine and its branches; Waal and IJssel.

5.3 Adaptive Delta Management in the River Subprogram

The years of research since the first publication of the Delta Program have resulted in the preferred river strategy (in Dutch: Voorkeursstrategie) (VKRS) published in the 2015 Delta Program. In these years, strategies have been developed and decisions have been taken about how to best manage the riverine areas in combination with the three generic themes; water safety, fresh water and spatial adaptation. Within this preferred strategy, it is noted that '*there is indeed room for adaptive delta management'* (Delta Program, 2015b: p5). For the River subprogram, the ADM approach is mainly concerned with the ''*periodically testing of the coherency between dike measures and river widening'* and the *"Testing of urgency from a water safety perspective, and the possibilities of connecting spatial ambitions, financing and new knowledge"* (Delta Program, 2015b: p5, p73).

For the Delta program, this approach provides insight to what measures are most effective and efficient at the time of testing. Adaptive Delta Management then is mainly about knowing when to make decisions or even when to start thinking about possibilities. Kruijshoop, head of field knowledge water management of Rijkswaterstaat (2015) emphasizes on translating Adaptive Delta Management into '*tangible parameters, by closely monitoring developments that indicate changes in the system*'. These parameters for example can be found in the dike assessments which take place every 8 years, the climate-/delta scenario's or in the annual Delta Programs.

Specifically for the Rhine, this resulted in 4 crucial points in making adaptive decisions, namely (Delta Program, 2015b):

- How is the discharge distribution developing?
- How can we best manage this distribution over the Rhine branches
- What spatial reservations must be made?
- Are we using the Rijnstrangen retention area?

The development of the river discharges is crucial in the Rhine strategy-making, as it is decisive for all considered strategies (Delta Program, 2015b). The development is mainly focused on the long-term and it influences strategy-making after 2050. If future developments make it clear that the river discharge will be much lower than expected, many of the strategies will become obsolete. The discharge distribution won't be as interesting anymore, spatial reservations can be cancelled and the Rijnstrangen retention area won't be needed anymore (Delta Program, 2015b). However, if the river discharge will be (much) higher than the expected 18.000m3/s, then the discharge distribution over the Waal, IJssel and Nederrijn-Lek will have to be revised, which might alter the IJsselmeer water level management and consequently might affect Delta decisions such as Water Safety, IJsselmeer region and Rhine-Meuse Delta.

While it is clear that connecting dike measures and river widening, and connecting these with spatial ambitions, financing and new knowledge is leading for the ADM approach within the River program, each river branch has their unique identity in tackling the future adaptation measures. The three Rivers; Waal, IJssel and Nederrijn-Lek each cope differently with the expected effects of climate change.

For example, on a regional scale the Nederrijn-Lek is least interesting for this research, because the expected Rhine discharge of 18000m3/s does not influence this river, as this river is deliberately spared from more water. This means that from now until 2100, the river discharge stays the same. Therefore, no additional measures regarding the expected river discharge of the Rhine are needed. This means that for the Nederrijn-Lek area, the current task is mainly improving current dikes, as they are rejected on stability and piping. However, this river also deals with problems related to sea level rise, which means that downstream the current dikes are too low and need to be raised (Delta Program, 2015b).

For the Waal, the tasks are entirely different. There is a major task in enhancing the rejected dikes. In this area river widening is hardly efficient, because there are hardly any cases of a height deficit on the dikes. So therefore, this area will be mainly concerned with urgent dike enhancements (Delta Program, 2015b).

Finally the IJssel, which is the smallest river branch of the Rhine. On this river, safety measures are being integrated with the characteristics of river, namely small scaled, special emphasis on scenic and natural values, and many economical, culturally and historically significant city fronts. This area is therefore more focused on enhancing the spatial and environmental quality. In this area, many Room for the River projects have been carried out and with the upcoming Delta Programs, the IJssel will continue with the same body of thought.

With all of these unique characteristics, the ADM approach will give substance to these areas in different ways. It is therefore not surprising that with different levels of urgency, the focus of the measures can be different. Implementing large spatial measures such as river widening cost way more (in terms of money and time) than ‘simple’ dike enhancements.

Dike enhancement within the Delta Program is for the most part considered well regulated (Mostert, 2016; Athmer, 2016). Dike enhancement - building the actual dikes - is the responsibility of the national government and regional water boards, and plans already largely made. Even the expenses for dike reinforcement projects have been organized, as a collaboration between the national government and the water boards, each paying half (Athmer, 2016). River widening on the other hand is different, since there is not any substantial funding for those projects, therefore Program Coordinator of the Rhine subprogram, Jos Athmer (2016) states, there is also less commitment:

"River widening is of a more non-committal nature and both measures are vastly different. Compared to dike enhancements, river widening is more expensive, but also offers more chances for natural development, tourism, economic stimulus and spatial quality. Also with their water level lowering nature, they add to the robustness of the water system"

Finding a balance between river widening and dike enhancement and therefore finding more commitment for river widening plays an important role within the Delta Program, but is also one of the difficulties that arise. River widening is not always useful, whereas dike enhancement is not always desirable.

Analyzing the ADM approach in the River program, ADM seems largely based on applying short term measures, while also looking at the future. So for now, the developments that are 'certain' are integrated in the preferred strategy (up to 2030), while decisions with a certain degree of uncertainty are being postponed till new knowledge becomes available. Within the Delta Program, these moments have been anchored in adaptation pathways. Lambermont, Project team Delta Program in Gelderland (2015) confirms this thought by saying:

"There is no immediate cause to take a measure, but if we don't act now, we have to ask ourselves if it will still be possible in several years. By knowing that a minor adjustment takes place now, we are challenged to follow up on a situation that occurs decennia away. That way we can see how the knife cuts both ways."

River sub-program Adaptation Pathways

The adaptation pathways within the Delta program show the time scope of the Delta program and through a method called back-casting (see chapter 2.5), with specific points in time, show when certain decisions must be made. **Figure 10** shows the adaptive decision-making process of the future discharge distribution of the Rhine branches. As the effects of climate change are uncertain, the option of changing the discharge distribution is kept open. If in 2030 the research shows that the river discharges have increased or are expected to increase significantly, up to a point where the current distribution no longer suffices, the discharge distributions can be altered.

A rise in discharge distribution might also alter the balance between river widening and dike enhancement, as dikes may need to be altered again or the water level reduction achieved by river widening might not be enough. This adaptation path is therefore also part of the adaptive decision-making process of the interplay between dike reinforcement and river widening (**Fig. 10**). This means that, as mentioned in section 5.2, the discharge distribution is decisive for developing further measures. If in 2030 the option to alter discharge distribution stays open, and in 2050 it gets altered, it will affect the strategy for dike enhancements or river widening (see fig. 11).

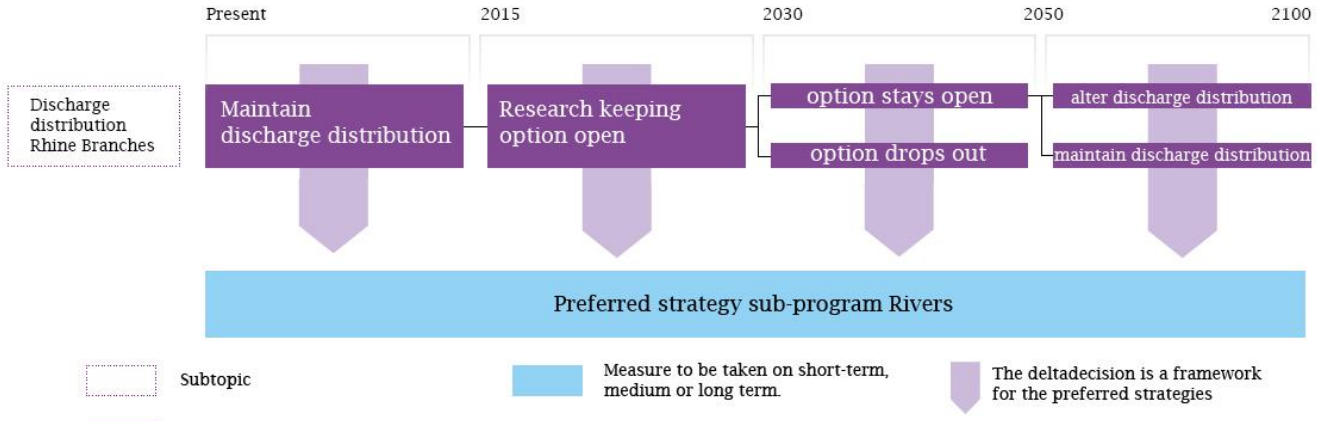

Figure 10 – Adaptation pathway discharge distribution Rhine (Delta Program, 2015)

However, the consideration of river widening or dike enhancement is complex. Within the Rhine sub program, the consideration depends on several factors, each of which are influenced again by other factors. It appears one of the more influencing factors is the investment amount needed for either river widening or dike enhancement. For example, a more technical measure, such as sluices are long term investments for over 20 years, while dike reinforcement can be maintained for a shorter period.

Dike enhancement and river widening each have their pros and cons and it is important to note that depending on the regional circumstances and river characteristics, each are needed to reach the desired water safety level. The preferred strategy distinguishes different 'pros' for dike enhancement (Delta Program, 2015b):

- Functionality – Dikes are generally very cost effective and greatly reduce risks;
- Linkage and added value – Options for multiple space uses and consequently more cost units in the urban area;
- Innovation – The development of innovative dike concepts.

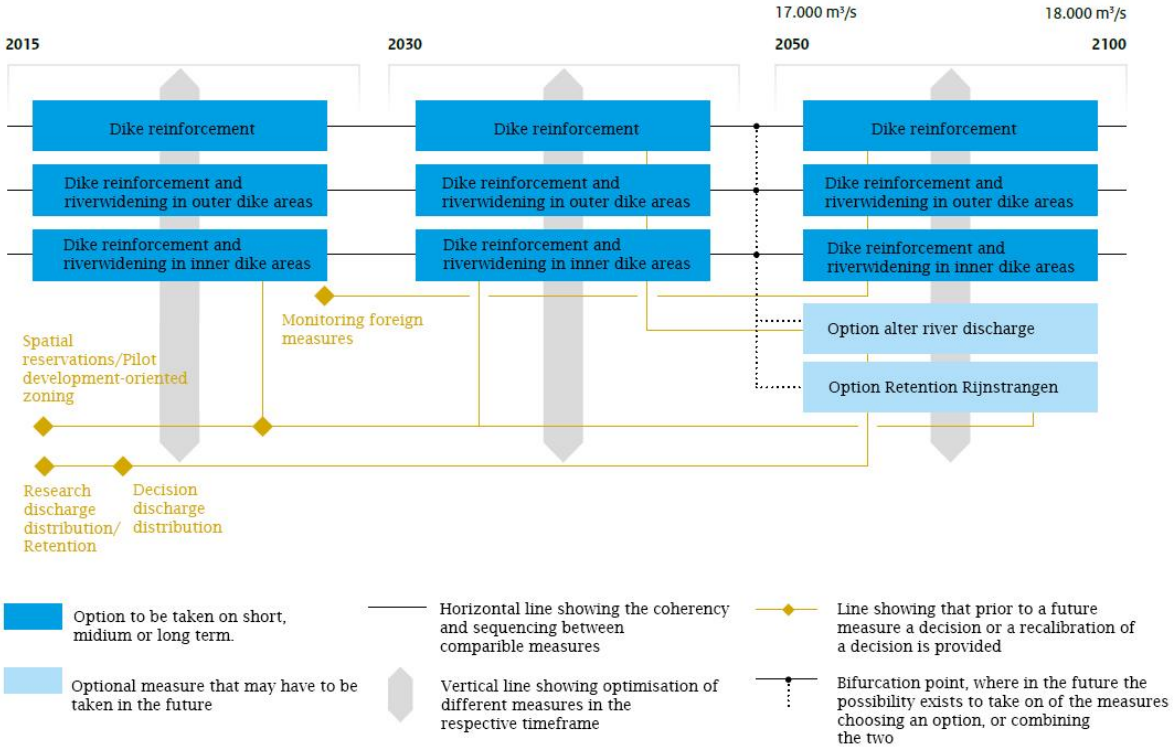

Figure 11 - Adaptation Pathway water safety strategies (Delta Program, 2014)

Dike enhancement mostly focuses on preventing subsidence and in part the water safety improvement. The improvement of the rejected dike trajectory is a short-term measure, as it is obligated by the Dutch Water Act. However, because of climate change, high water levels are expected to increase and therefore many of the current dikes have a height deficit. This height deficit can be mitigated by dike enhancement as well as river widening. In the preferred strategy, the following 'pros' are distinguished (Delta Program, 2015b):

- Water level reduction – River widening increases the discharge capacity of the river, making it robust;
- Putting less emphasis on dike enhancement – With river widening and thus water level reduction, the dikes are less affected by high water levels, thus decreasing the need for higher dikes;

- Flood risk reduction – A significant water level reduction leads to slower flooding, lower flood levels, and consequently less damage and victims;
- Linkage and added value – River widening is generally perceived to be better able to link different functions than dike enhancement and can be used to improve nature development, spatial quality and recreation and activities.

With this consideration, different choices have been made for the Rhine and its area specific branches, with the incorporation of the adaptive delta management principle (Delta Program, 2015b); combining long term with short term. However, in practice, incorporating the adaptive deltamanagement principle is not so straight forward as combining short with long term, and many difficulties appear in shaping adaptive management, considering dike enhancement or river widening and implementing the delta decisions. In the next paragraph, some of the surfaced difficulties experienced by the respondents will be discussed.

5.4 Difficulties in shaping the Adaptive Delta management concept

Considering the focus of ADM in the Rhine subprogram, specific contextual factors have to be taken into consideration that play at the national, regional and local levels. As mentioned in the previous paragraph, the three Rhine branches are different in size, scope and measures. While ADM is formulated and elaborated extensively within the Delta Program, this does not necessarily mean that the ADM approach is experienced the same by the government officials. For instance, the Waal is mainly concerned with urgent dike reinforcements while the IJssel is more concerned with spatial and environmental quality. Does this mean then that one is applying the ADM correctly, and the other is not? Therefore, it is interesting to take a closer look at how the government officials interviewed for this research experience working with the ADM concept.

Starting with the adaptive deltamanagement concept on the national level, Jan Kruijshoop of Rijkswaterstaat (2015), as mentioned in chapter 5.3, puts emphasis on translating adaptive management to more practical parameters, with a focus on the timing of plan- and decision-making, which are closely connected to the developments of the four Delta scenarios. He also puts emphasis on the integral way of working with different layers of government, water boards, businesses and knowledge institutes and recognizes these as a *'delta community'*, "***Alone, sometimes you go faster. But together, it will take you further."***, This is a more nuanced ideal, which mostly matches with the description in the Delta Program and is one of the commonalities shared among the different respondents.

In addition, Wim de Vries, Coordinator Safety Rivers, Ministry of Infrastructure and Environment (2016) puts major emphasis in the development of adaptation pathways. However, he does not consider the adaptation pathways published in the Delta Program as *'very'* adaptive and should be more elaborated in the future publications:

"In my opinion, those paths are little adaptive. And I think the pathways should be more elaborated… perhaps in 2018".

The general notion of adaptive delta management and pathways, triggers and sign-posts are familiar concepts on the national level. Kruijshoop, head of field knowledge water management at Rijkswaterstaat (2015):

"… So it is a narrative, about how long your investment, - given the changes in circumstances, either climatologically or economically or even socially – can last. And do it in a way in which you don't get stuck on a dead end, but – these are the adaptation pathways – always have the opportunity to continue on subsequent steps." "And you should provide these with a number of – they call it – triggers, as to where to place your attention, are you still on the right path…"

However, how this is developed and what it exactly entails is often unclear and less even so on regional and local levels. Rob Lambermont, Project team Delta Program in Gelderland (2015) states to not have heard of adaptation pathways, triggers or sign-posts. However he describes it as:

"…***It has nothing to do with triggers or points in the future when a certain change occurs or a point of no return arises. This is purely a political approach. People do not want to live in uncertainty, and therefore we want measures that are urgent to be implemented straight away."***

The interpretation of the adaptive delta management concept shows a clear line from national to local governments, which is not unexpected. Government officials who work for the national government; Rijkswaterstaat and the Ministry of infrastructure, show a more general and overarching idea of adaptive delta management, which is closely matched to the description in the Delta Program. Factors such as linking the short term with long term, taking decisions in a stepwise manner, and taking decisions through an integral approach are the general characteristics within the Delta Program and by the respondents of the national government (Kruijshoop, 2015; De Vries, 2016).

Following that line towards regional governmental bodies, such as water boards, adaptive management takes a different form. Kroes and Bijkerk from the Waterboard Drents Overijsselse Delta (2015) describe it as *"old wine in new bottles"*:

"Every sane human being looks ahead and links what we do now with the long term. Because if not, you're not being functional."

Van der Hoeven, Project leader of Dutch river towns (2016) confirms this by saying that a more integral approach, seeing what linkages can be made with other fields, being flexible and if it

then **"coincidentally can be called adaptive delta management"** is unclear. Being adaptive, or practicing adaptive delta management is therefore more an implicit undertaking, because long term strategies, connecting different fields, being flexible and cost efficient is and has been common practice (Lambermont, 2015; Kroes and Bijkerk, 2015; Van der Hoeven, 2016). Adaptive Delta Management then seems to be more of a name assigned after the fact than it is a distinguished policy approach developed specially to deal with the effects of climate change. Van der Hoeven, project leader of Dutch river towns (2016) says:

"The term Adaptive Delta Management does ring a bell, but the exact meaning and what we are supposed to do with it, for me is still not entirely clear. And ***"I'm not even sure whether or not this term has landed at the different governmental agencies, let alone act towards it. Nevertheless, whenever you are acting towards something, it can be considered to be some form of Adaptive Delta management. It's a bit like the chicken or the egg situation"***

Haasnoot of the Waterboard Rivierenland (2016) distinguishes adaptive delta management between water safety and water management, in which the water boards are on the water safety 'side' of the approach:

"If you look at the chances it offers, then basically there are 2 trains of thought coming together. The first one, in my opinion, is the train of thought of the provinces and municipalities, who think this is a unique opportunity to connect plans with spatial ambitions. And then there are the National government and waterboards, who are in a more nuanced position. Of course they see chances and opportunities, however, they also see the costs. And if you decide that river widening is nice and you want it, but don't have the funds, then who is paying for it?"

The whole premise of adaptive delta management is of course in linking and bringing water management and water safety together. However, Haasnoot recognizes that the term can be differently interpreted and that it affects the way in which it takes form in practice. Which for the water boards means mostly the focus on technical measures such as dikes and other flood control measures. This image is reflected by the municipalities, as Van Rooijen states (2016) that:

"The waterboard is in charge of the water safety measures such as the High water protection program. We think with them, work with them, but more from a city perspective. Nevertheless, the waterboard is in charge, and we think that is a bit of a disappointing translation of the entire Delta Program and things are going. I don't consider that really Adaptive Delta Management."

This stresses the fact, that from a 'city perspective', adaptive delta management is different than from a water safety perspective. Therefore, an important difference is the degree of linkage between several strategies and implementation measures. The regional water boards Rivierenland and Drents Overijsselse Delta put major emphasis on the high-water safety, as is their task. However, municipalities put more emphasis on linking those measures to nature development, recreation etc. Linkage of opportunities is one of the most important things for municipalities, as it also gives them the opportunities to enhance spatial quality, nature purposes and a multitude of other spatial enhancements

Perhaps the different interpretation of the adaptive delta management concept, or the lack of practical definition for it, is also characteristic for the institutional fragmentation within the Delta Program organizations. With each governmental layer having other responsibilities, for example the Waterboards and municipalities, and therefore shifting the emphasis on different aspects of the concept, makes it hard to give a certain uniformity to the concept, let alone a uniform interpretation. Jos Athmer, Program Coordinator of the Rhine subprogram (2016) stresses the fact that this collaboration between water boards and municipalities is often not very flexible:

"It has to do with the different interests parties have. The preferred strategy contains a number of large river widening measures, which have been included too easily in the process without looking at the funding. So a number of those measures aren't even feasible. And especially from the water boards, the general opinion is: "It's not our problem that there isn't any funding", while other parties say: "It's a water safety measure, so you should" and that is problematic."

However, it is important to note that the clear majority of the respondents agree that the cooperation and communication are working very harmoniously, despite some natural differences in opinion. Jan Kruijshoop of Rijkswaterstaat states that:

"…but if you see which parties are executing the measures, it is a collaboration of water boards, provinces, municipalities, businesses… Your goal is to make this community as big as possible, to have as many hands on the wagon as possible, that is the power to get things done, but also to spread ideas and the way of doings things"

The balance between river widening and dike enhancement

Within the Delta Program decisions have been made about the future river discharges. The HWBP and consequently the Water Boards have mapped areas which neither currently meet the safety standards as well as trajectories that are not future proof. On top of that, new safety norms will be introduced and new research has questioned the validity of river widening in some areas (Delta Program, 2015; Haasnoot, 2016; Van der Hoeven, 2016).

As a result, uncertainty increases, the balance between river widening and dike enhancement, as established in the preferred strategy, can change. For one, the urgency of rejected dike

trajectories can shift towards new areas, which will shift the planned enhancements or river widening projects toward areas that were originally set for a later date. This gives development and room for linkage with provinces and municipalities a shorter time frame, which can negatively impact the development for linkage opportunities. The same goes for projects that after more research, do not have the expected effect and thus its effectiveness is put in question. Van der Hoeven, Project leader of Dutch river towns (2016) confirms this:

"The whole of idea of the Delta Program was a powerful interplay between dike enhancement and river widening, but after more research the effects of river widening measures on the Waal are not as large as we expected. So with this new data, it is important to think about the consequences and which options contribute to an effective balance between river widening and dike enhancement"

This balance is furthermore upset by the discoveries of so called *macro-stability* and *piping* issues, which have caused a great distance of dike trajectories to be rejected (Delta Program, 2015). This means that the dike trajectories must be enhanced to take away the issues. Consequently, this means that enhancing dikes, by making them stronger, higher and wider will be relatively cheap in comparison to river widening. Jos Athmer, Program Coordinator of the Rhine subprogram (2016) mentions the effect of the new safety norms and what it can mean for river widening:

"Much has to do with the new safety norms, which is taking a different perspectives to dikes than before. Now it is not so much the height of the dikes in question, but rather the width and stability. In the next decennia, many dikes have to be enhanced, and once you're there, an extra 20, 30, 40 or 50 centimeters on top of the dike is relatively cheap, because you're already working on the dike. And for a river widening measure, it's a bit like… well, too bad…"

De Vries (2016), Coordinator Safety Rivers of the Ministry of Infrastructure and Environment responds to this question about whether the role of river widening is being compromised through these developments:

It depends on the river branch in question. Because this problem is characteristic for the Waal, because on this trajectory, large measures have to be taken already to ensure water safety, because of macro-stability and piping and apart from climatological reasons even height. This means that at the same time, the climatological effects are relatively limited.

When gaining new information and new knowledge, in the process of adaptive management, insights can drastically change, so much that earlier developed strategies are seemingly undesirable. For the Delta Program, this means that the balance - and interplay between dike enhancement and river widening as stated in the program – seems to shift in favor of Dike

enhancement and much less to river widening. However, these are all contextual factors, different per Rhine branch.

Financial resources

It is clear that the Delta Program puts major emphasis on cost-efficiency, which also leads to major difficulties, which have to be overcome. Many of the respondents from regional and local governmental organizations stress that there is too much emphasis on cost-efficiency, and converting added value due to linkage with nature development, recreation, businesses, is hard to put in exact numbers (Van Rooijen, 2016; Bos, 2016; Van der Hoeven, 2016).

A great deal of the conflict of financial resources is about linking between different governmental layers and consequently on project emphasis. The national government and water boards are mainly concerned with national water safety, with a focus on being sober and expedient (Kruijshoop, 2015; Kroes and Bijkerk, 2015; Haasnoot, 2016), while others stress that the fact that while it may be more expensive, linking water safety with other fields is nearly as essential (Van Rooijen, 2016; Bos, 2016; Schoorlermmer, 2016; Van der However, 2016). However, the problem currently is that there is no hard financing available for specifically for linkage opportunities or (not enough for) river widening, and consequently it is also having less commitment (Athmer, 2016). There are no official rules of who is responsible to finance what, be it the national government, the provinces or municipalities, and therefore a lot of debating must be done. As of now, the national government has issued some money for river widening projects, but compared to the costs it takes to actually implement such a measure, it is not enough (Athmer, 2016; Van der Hoeven, 2016).

It has become clear that many of the measures from the preferred strategy are still clouded in uncertainty. While even more so for river widening, even the degree of dike enhancements is as of yet not entirely clear. While it is apparent that many of the dike trajectories will definitely have to be repaired and adjusted, the exact degree and urgency can still chance or be added when the new safety norms will take effect (Van der Hoeven, 2016).

The question remains how future developments will add to the development and the balance between river widening and dike enhancement. While it has become apparent that the idea of adaptation and adaptation pathways live within the different governmental agencies, it is still largely unclear as to how they explicitly come forward. The theory of AM propagates clear benefits in dealing with uncertainty and complexity in long-term decision-making (chapter 2.3), in practice there seems to be little explicit awareness for the ADM concept on the regional and local governmental levels, at least not on the short term. While the Delta decisions have already been taken, a general path has been laid out, it has proven difficult to estimate to deal with new insights such as the new safety norms, dike issues like piping and macro-stability and recently the effectiveness of river widening for water level reduction. It is important to notice that these difficulties do not specifically come from the application of the ADM concept

itself, but rather from the different contextual factors influencing adaptive decision-making. For all that its worth, the ADM concept within the river sub-program lives, perhaps not explicitly, but nonetheless it exists. The need for a more step-wise approach as compared to large long term measures is followed in regional and local decision-making (Kroes and Bijkerk, 2015; Athmer, 2016). At the same time, successful application of the ADM approach seems to be largely restricted by unclear financial policy, the explicit need for expediency and cost-effectiveness, and by the conflicting interests from governmental parties. The Rhine river area is in danger of putting too much emphasis on dike enhancements, falling back to the traditional and technocratic decision-making, mostly dominated by the HWBP program. In this sense, the Netherlands is already largely 'locked-in' or 'path dependent' on the enhancement of dikes, as it is still the most effective and sometimes only way of guaranteeing water safety in some of the heavily impoldered areas in the Netherlands.

6. Conclusion and reflection

In this chapter, the findings from the previous steps will be brought together in order to answer the central research question by drawing well-founded conclusions. A short overview of the previous chapters and line of argumentation will serve as a summary, leading up to the conclusion, which answers the central research question formulated in chapter 1. After that, a reflection of this research will be given to give insight into the value and shortcomings of this research. Finally, options for further research will be outlined to strengthen the incorporation and development of adaptive decision-making in complex and uncertain situations within the Delta Program.

6.1 Thesis overview

The main research question as introduced and formulated in **chapter 1**, was to gain insight in how the adaptive deltamanagement approach helps to improve regional and local decision-making and improve the quality of the riverine areas. To put the development of the ADM concept in perspective, figure 3 describes the research structure and the connection between the different topics. The theoretical framework as elaborated in **Chapter 2**, together with the empirical research strategy as elaborated in **chapter 3** has proven essential in conceptualizing the ADM concept in the Delta program as laid out in **Chapter 4**. To get a clearer understanding of how the ADM is being put to practice, **Chapter 5** serves as a more practical approach to ADM and elaborates on how it is experienced on the regional and local levels.

The first part of chapter 2 (2.1, 2.2) elaborated on the concepts of decision-making in uncertainty and complexity and the need for adaptive strategies in the face of climate change. This has led to the notion of Adaptive Management. Within adaptive Management, 3 key concepts have been introduced; flexibility, agility in the governance process and preventing lock-ins. Together these three concepts help make long-term water policies more adaptive.

For this research, we have looked at how Dutch water policies are being made more adaptive. In the face of climate change, the Dutch are coping with a series of developments that, if left unchecked, could jeopardize the safety in the Netherlands. The most prominent development is the increasing water discharge levels from the Dutch rivers. The Delta Program is developed to proactively climate-proof the Netherlands through a range of measures. With three main themes, water safety, fresh water and spatial adaptation, the Netherlands aims for a safe country through an integral and sustainable way. Within the River Rhine Sub program, scenarios consider increases in river discharges, which lead to new high water safety tasks. Through setting up an interplay between river widening and dike enhancement, the riverine areas will be prepared for the increases in river discharge.

Chapter 4 elaborates more on the manner on which the Dutch Delta Program aims to achieve a safe and sustainable country; through a concept called ***Adaptive Delta Management***. This chapter elaborates on the structured decision-making process and consequently to the Delta Decisions formulated in the Delta Program. These delta decisions focus on primarily on long term water safety and connect several of the area specific programs.

Following from the delta decisions is the implementation phase of the Rhine sub program, which aims to climate proof the Rhine Delta and is discussed in **chapter 5**. However, with these decisions, many different experiences with the ADM approach appear and difficulties arise in successfully shaping the adaptive Delta Management concept in practice.

These topics serve as a structured approach to finding the answer to the research question. The analysis of the policy documents and the interviews serve to make a clear argument and to provide insight into how policymakers from the different governmental scales experience the implementation of the Delta Program and consequently the adaptive management approach.

6.2 Conclusion

Looking at the research findings from the thesis, through the application of the ADM concept within the Delta Program, it is clear that adaptive plan-making is a complex undertaking. The Rhine riverine area is still clouded in uncertainty because of the ongoing processes of research and developments. The answer to the question whether the ADM has actually contributed to flexible and long-term decision-making is complex. While striving for flexibility in decision-making using adaptation pathways, the pre-set time-period of the delta decisions and subsequently the preferred strategies have ultimately led to many difficulties. It has turned out that while flexibility is propagated in the Delta Program, it is also directly restricted by the timeframe in which it operates. Compared to the theoretical underpinnings of adaptive management, the ADM concept seems to fall short on a this critical aspect of adaptiveness. With the timeframe in which the Delta Program operates, there is limited time for feedback, learning, and collaborative action. On a regional level this has resulted in major ambiguity of the ADM concept, and as a result the ADM approach has not been fully applied within decision-making. It can be noted that perhaps the preferred strategies were drafted in a too short period of time, as many of the ongoing research, such as the new safety norms and recent findings on the effectivity of river widening might prove that the preferred strategies were draft up to quickly. Thus, the interplay between river widening and dike enhancement might be upset and go into one direction; dike enhancement (Athmer, 2016; Van der Hoeven, 2016).

Many things are still uncertain, and a lack of clear financial policy is furtherly influencing the interplay between river widening and dike enhancements. Furthermore, the efficiency of current policies is still largely unclear. With conflicting time-scales and the different responsibilities of the different governmental agencies, it is still questionable as to what extent

the measures will prove cost-efficient (Athmer, 2016; Van der Hoeven, 2016). For example, the chance that a dike is being reinforced on the short term and relatively shortly thereafter has to be altered again is increased through current uncertainty in developments.

This may be a result of the ambiguity surrounding the concept of adaptive delta management. While relatively clearly formulated and elaborated by the national delta programs, its practical meaning and use are often not widely recognized. The idea that policy-makers are to act *adaptive* lives, however in practice it has proven insufficiently emphasized. As a result, policy-makers are not sure whether their policies can be considered *adaptive* in the sense of adaptive delta management. The analysis of the ADM concept in practice showed that on a local level 'doing ADM' seems accidental, rather than a structured planned endeavor. Also, the different interpretations of adaptive management can lead to further fragmentation of decision-making as it does not promote a general approach in the Delta Program. With broad characteristics, such as combining short-term and long-term and gaining flexibility in decision-making, it can still cause a dichotomy between adaptivity in water safety and spatial development (see for example Haasnoot, 2016; Van Rooijen, 2016; Schoorlemmer, 2016). This only accentuates the ambiguity surrounding the concept of adaptive delta management further.

It is also important to note that the monitoring strategy is only currently being developed. This raises serious questions as to how seriously and effectively the progress of the Delta Program is being monitored and evaluated. The new approach to monitoring and evaluation, called 'Measuring, Knowing & Acting' aims for a program wide monitoring, to give insight in how measures must be controlled. Only this step would complete the theoretical underpinnings of adaptive management and consequently the adaptive management cycle (Nyberg, 1999). Future publications of the Delta Program will have to prove how effective learning actually is obtained.

The analyses has showed that the riverine land scape is still largely under influence of traditional policy practices, as dike enhancement is still, and perhaps always will be, dominant in the riverine area. This is unmistakably due to the fact that dikes are indispensable from the Dutch riverine landscape and are for some areas the only effective methods of increasing water safety, without changing and rearranging large parts of the Netherlands. Perhaps this is the result of the centuries old habits of the Dutch such as making polders. Many of these polders are so far below water level, that the practical use of river widening in some areas is close to nothing (Haasnoot, 2016). In this sense, the ADM approach has proven to not be a panacea for long-term decision-making. Rather, ADM has proven to be subservient to traditional planning approaches in some instances, mainly in the water safety task.

However, there are also positive characteristics of the adaptive delta management concept. Though the general experience of the respondents may be that adaptive management is more of an implicit rather than explicit undertaking, its effects are certainly noticeable. For example, the flexibility in decision-making through the use of adaptation pathways. Though it is

stressed that these are not completely developed yet (De Vries, 2016), it helps to map future directions and options. It also promotes more awareness of future developments and the consideration of lock-ins and path dependencies.

Last but not least, the integral approach of the Delta Program is widely accepted among the policy-makers and the general notion is that they are quite satisfied in the way different governmental agencies are communicating and cooperating. With the strategies being developed in an integral way, the opportunities for linkages with different fields than water safety seem to be getting more emphasis on the longer term. It has been proven over the publications of the Delta Programs and through the analysis of policy-makers, the ADM concept is still evolving. Dealing with uncertainties and complexity has proven difficult, however, policy-makers are still positively working on further improvement and development for the ADM-concept, to enhance the Rhine riverine area.

6.3 Reflection

This research has specifically focused on how the Dutch delta program strive for adaptiveness in long-term water safety strategies. This research has shown that while there is a clear definition of the ADM approach, it's intended benefits and how this approach can be applied across different governmental layers, the practical applicability of the ADM concept is perceived as vague and ambiguous. Especially on a regional scale, adaptive delta management seems to have a different meaning as compared to water boards. The idea that long-term plan-making should be 'adaptive' lives, however the translation of the theoretical benefits into practice is lacking. As mentioned in Chapter 2.3, the definitions of adaptive management are widespread. This has proven to also be the case for the concept of adaptive delta management. While there is a broad theoretical foundation of the ADM approach in the Delta Programs, there is no structured approach in operationalizing ADM in practice. In finding a balance in the usage between the practical experiences and the official policy-documents, the danger exists that one overshadows the other, and as a result the research can be very normative or subjective. Therefore, the introductory chapters of the Delta program and consequently the River sub-program serve as a frame of reference according to 'how it is intended', while the following chapters serve to elaborate on experiences. This includes in giving a normative description of the adaptive delta management concept and how it is intended in national decision-making, while on the other hand the interpretations and difficulties serve to show experiences of the concept.

It is important to keep in mind, that while this research has specifically focused on the process of ADM and how it is applied in practice, the Delta program is still evolving. With more emphasis on learning in the 2017 and 2018 Delta programs, there can be adjustments of research goals and outcomes in later stages. For ADM to reach its full potential in regional and local decision-making, the notion of adaptiveness in long-term plan-making requires more emphasis in all layers of government.

6.4 Recommendations for future research

As the ADM-concept within the Riverine area has proven to be such a dynamic process, there are lots of possibilities for future research. Within the Delta Program further research and elaboration on the meaning of the adaptive management concept within governmental agencies is needed to improve coherency in decision-making and give a clearer image of adaptive policy-making. Even though the dilemma's experienced in this subprogram do not necessarily have to be the same for other subprograms, the outcomes of this research might still serve as opportunities for improvement in for further research. While this research specifically focused on the Rhine, the same problems are likely to occur for the Maas program. It is therefore interesting to furtherly investigate how the ADM concept is perceived in other subprograms, and what dilemma's occur in translating the ADM concept in other regions. It is therefore important that the use and value of the ADM concept should be monitored closely, in order to draw more meaningful conclusions and gain a deeper insight of the concept.

Comparable research might be useful in a number of years, to see how the subprogram evolves and how the Delta program as a whole progresses. With the total lack of monitoring and evaluation programs of value in this research, it is interesting to further investigate the progress of the new monitoring and evaluation program Measuring, knowing and acting introduced in the 2016 Delta Program. It might be interesting to see how the subprogram end up using adaptiveness when the more of the plans (such as the flood channel in Varik-Heesselt) are more concrete and ready to be implemented.

Besides that, the implementation of the new safety norms in January, 2017, more research could be done to the implications of these new safety norms and what it means to the HWBP the Delta Program in general. The same goes for the research on the effect of river widening on rivers such as the Waal and what this means for the interplay between river widening and dike enhancement. If in two years from now, after the first MIRT-trajectory concludes, research proves that the costs of the flood channel Varik-Heesselt do not weigh up to the intended benefits, what will this mean for water safety tasks and the development of river widening measures in general.

This research has aimed to contribute to the knowledge of the practical application of the ADM concept, showing how different government layers interact and what it means to improve adaptiveness in long-term plan-making. This research has mapped experiences of government officials, and how the theoretical benefits of the approach come forward in practice. While not specifically clear everywhere, the notion of adaptiveness is alive. This research has hopefully created some awareness that the gap between theory and practice is still large, and that it requires special attention of all governmental layers to bridge this gap. Only time will tell how the Delta Programs progress and how adaptivity becomes an integral part in long-term decision-making.

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