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Towards facts in regional high-water projects: a comparative case study of the influence of authorities, stakeholders and uncertainties

Master Thesis

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Samenvatting

Het Nederlandse overstromingsbeleid is de afgelopen jaren verandert. Oorspronkelijk lag de focus van Nederlands waterbeheer op preventieve maatregelen in de vorm van dijken en dammen. Om Nederland te beschermen tegen overstromingen is een groot netwerk van dijken aangelegd. Door klimaatverandering neemt het overstromingsrisico toe waarbij er meer extreem weer verwacht wordt met meer en langere droge en natte perioden. Hierdoor neemt het risico op overstromingen toe. Omdat alleen maatregelen gericht op preventie van overstromingen niet voldoende zijn, is in 2009 het concept meerlaagsveiligheid geïntroduceerd. Dit concept voor het beheren van het overstromingsrisico is gebaseerd op drie strategieën: preventie, ruimtelijke ordening en crisisbeheersing. Door het toepassen van verschillende strategieën, zoals waterkeringen, maatregelen op het gebied van ruimtelijke ordening, mitigatie van het overstromingsrisico, evacuatieplannen en herstelplannen na overstromingen, worden stedelijke gebieden beter bestendig tegen overstromingen. Door de klimaatverandering en het toenemende overstromingsrisico zullen de komende jaren veel van de Nederlandse dijken verhoogd en versterkt moeten worden omdat ze niet voldoen aan de nieuwe normen. Omdat het verhogen en versterken van dijken duur is en soms ook moeilijk te implementeren, worden vaak ook andere alternatieven onderzocht.

Alternatieve maatregelen die regelmatig onderzocht worden als alternatief voor dijkversterking zijn systeemmaatregelen. Systeemmaatregelen zijn gericht op het verlagen van de afvoer en de hydraulische belastingen op waterkeringen. Systeemmaatregelen zijn overstromingsrisico mitigerende maatregelen. Deze maatregelen zijn gericht op het verminderen van de kans en omvang van overstromingen en kunnen preventieve maatregelen, zoals dijken, aanvullen. Ondanks dat het Nederlandse waterbeheer de afgelopen jaren veranderd is, blijkt dat in de praktijk er vaak alsnog gekozen wordt voor een dijkversterking in plaats van alternatieve maatregelen. Het doel van dit onderzoek is om inzicht te bieden in de stappen die leiden tot beslissingen over systeemmaatregelen in regionale hoogwaterprojecten, door voor twee projecten te analyseren en te vergelijken hoe feiten worden gevormd, en hoe autoriteiten, stakeholders en onzekerheden een rol spelen bij de vorming van deze feiten.

Voor dit onderzoek is een case study uitgevoerd bij het waterschap Drents Overijsselse Delta. Hiervoor zijn twee projecten geanalyseerd: het project Stadsdijken Zwolle en de Project Overstijgende Verkenning Hoogwaterperspectief Overijsselse Vecht (POV Vecht). In het project Stadsdijken Zwolle was oorspronkelijk gestart met het onderzoeken van alternatieven voor dijkversterking. Nadat bleek dat de versterkingsopgave sterk was toegenomen door de nieuwe normering (2017), werd besloten om ook systeemmaatregelen te onderzoeken. In het project POV Vecht werken de waterschappen Vechtstromen en Drents Overijsselse Delta samen met de Provincie Overijssel aan het onderzoek naar de effectiviteit van systeemmaatregelen in het stroomgebied van de Overijsselse Vecht. Voor beide projecten zijn de gegenereerde oplossingsrichtingen en alternatieven voor systeemmaatregelen geanalyseerd. Er is onderzocht om welke redenen oplossingsrichtingen of alternatieven afvallen of niet verder onderzocht worden en in hoeverre onzekerheden daarbij een rol gespeeld hebben in het besluitvormingsproces. Daarnaast is in kaart gebracht hoe bestuurders van regionale autoriteiten en stakeholders betrokken zijn geweest gedurende de besluitvormingsprocessen.

Op basis van literatuur zijn er drie aannames gemaakt over het besluitvormingsproces dat plaatsvindt: ten eerste zijn besluitvormingsprocessen opgebouwd uit kleine overwegingen en beslissingen. Het lijkt erop dat de beslissing voor de gunstigste oplossing wordt genomen aan het einde van een besluitvormingsproces, maar beslissingen worden genomen in alle stappen van een besluitvormingsproces. Ten tweede is de kennis die wordt gebruikt voor besluitvorming verspreid over verschillende actoren in een netwerk. Deze kennis kan geconceptualiseerd worden in drie sporen: het spoor van de beeldvorming, het spoor van de wilsvorming en het spoor van de feitenvorming. Deze drie sporen bevatten respectievelijk de beelden, percepties en interpretaties van actoren; de ambities,

bronnen en machtsmiddelen van actoren; en alle feiten en onderzoek. Ten derde zijn onzekerheden inherent aan waterbeheer en besluitvorming. Beleidsmakers beschouwen onzekerheden vaak als een complicerende factor en zijn niet bereid om onzekerheden in besluitvormingsprocessen te accepteren en omarmen.

De resultaten laten zien dat in beide projecten een vergelijkbare methode werd gebruikt voor de feitenvorming. Allereerst zijn alle oplossingen aan het begin van het project gegenereerd. Tijdens beide projecten zijn geen nieuwe oplossingen gegenereerd. Daarna, zijn voor sommige oplossingen alternatieven gegenereerd, wat opties zijn voor hoe oplossingen gerealiseerd kunnen worden. Vervolgens zijn de kansrijke alternatieven kwantitatief geanalyseerd. Beide projecten maakten gebruik van externe ingenieursbureaus om de effecten van de alternatieven te analyseren en te modelleren. Op basis van deze modelresultaten worden beslissingen genomen om oplossingen of alternatieven gedetailleerder te analyseren of om de meest gunstige oplossing of alternatief te kiezen. Bestuurders van regionale autoriteiten zijn vooral betrokken bij de uiteindelijke beslissing voor de meest gunstige oplossing. Tijdens de feitenvorming worden bestuurders op de hoogte gehouden van de belangrijkste resultaten van het project. In beide projecten waren vertegenwoordigers van regionale autoriteiten pas betrokken nadat de alternatieven waren geanalyseerd. Indirect zijn de verantwoordelijke autoriteiten al eerder bij het project betrokken, bijvoorbeeld via experts, beleidsadviseurs of ambtenaren die eerder bij het besluitvormingsproces waren betrokken. Stakeholders zijn vooral betrokken om input te krijgen over alternatieven en om het draagvlak voor bepaalde maatregelen te onderzoeken. In beide projecten waren stakeholders niet betrokken bij het genereren van oplossingen. Een van de interessante bevindingen van dit onderzoek is dat de bestuurders van regionale autoriteiten en stakeholders feitenvorming kunnen beïnvloeden, zonder een daadwerkelijke interactie. Sommige van de tussentijdse beslissingen die tijdens het besluitvormingsproces worden genomen zijn gebaseerd op verwachtingen van bepaalde stakeholders of groepen. Met betrekking tot de onzekerheden is geconcludeerd dat de onzekerheden niet expliciet worden gebruikt als argument voor het laten afvallen van bepaalde oplossingsrichtingen of alternatieven of dat ze gebruikt worden als onderbouwing voor het nemen van bepaalde beslissingen. Impliciet lijken onzekerheden echter wel een belangrijke rol te spelen in de tussentijdse beslissingen. In beide projecten lijkt er een voorkeur te zijn voor systeemmaatregelen die binnen het werkgebied van WDODelta en op kleine schaal gerealiseerd kunnen worden met relatief lage kosten.

Summary

The Dutch flood risk policy has changed in recent years. Traditionally the focus of the Dutch water management is on preventative measures in the form of dikes and dams. In order to protect the Netherlands a large network of dikes has been constructed. Due to climate change the flood risk in the Netherlands will increase. More extreme weather is predicted with longer and more dry and wet periods. This will increase the risk of flooding. Since only measures aimed at flood prevention are not sufficient, is in 2009 the multilevel flood safety concept introduced in the Netherlands. This concept for the management of the flood risk is based on three strategies: prevention, spatial planning and crisis management. By applying different strategies, such as flood risk prevention, flood risk mitigation, flood preparation and flood recovery, urban areas become more resilient to flooding.

Due to climate change many dikes in the Netherland need to be reinforced, since they do not meet the safety requirements. Since the reinforcement of dikes is expensive and sometimes difficult to implement often alternative measures are researched. Alternative measures that are often researched as an alternative for dike reinforcement are systemic measures. Systemic measures are flood risk mitigating measures that are aimed at reducing the likelihood and magnitude of floods and can complement flood defences. While decision-makers and policy makers often consider systemic measures, they eventually tend to decide in favour of dike reinforcement. The aim of this research is to provide insights into the steps that lead to decisions about systemic measures in regional-high water projects by analysing and comparing for two projects how facts are formed and how authorities, stakeholders and uncertainties play a role in the formation of these facts.

For this research a case study is performed at regional water authority Drents Overijsselse Delta. Two projects are analysed: the Stadsdijken Zwolle project and the POV (Project Transcendent Exploration) System Development High Water Perspective Overijsselse Vecht (POV Vecht). In the Stadsdijken Zwolle project at the beginning only alternatives for dike reinforcement were researched. After it became apparent that the number of dikes that did not meet the safety requirements increased considerably due to new norms (2017), it was decided to investigate systemic measures as a possible solution. In the POV Vecht project the regional water authorities Vechtstromen and Drents Overijsselse Delta work together with the Province of Overijssel to research the effectivity of systemic measures in the basin of the Overijsselse Vecht. For both projects the generated solutions and alternatives were analysed. It is researched for what reasons solutions and alternatives were rejected or not analysed in more detail and how uncertainties played a role in the decision-making process. Besides this, it is examined which interactions took place with the responsible authorities and stakeholders during the decision-making process.

Based on literature, three assumptions are made about the decision-making process that takes place: Firstly, decision-making processes are made up of small considerations and decisions. It seems that the decision for the most favourable solution is taken at the end of a decision-making process, but decisions are made in all steps of a decision-making process. Secondly, knowledge that is used for decision making is spread over various actors in a network. This knowledge can be conceptualised in three tracks: the track of image formation, the track of will formation and the track of fact formation. These three tracks contain respectively the images, perceptions and interpretations of actors; the ambitions, sources and means of power of actors; and all facts and research. Thirdly, uncertainties are inherent to water management and decision making. Policy makers often view uncertainties as a complicating factor and are unwilling to accept and embrace uncertainties in decision-making processes.

The results show that in both projects a similar method was used for the formation of facts. First, all solutions were generated at the beginning of the project. During both projects no new solutions were generated. Second, for some solutions alternatives were generated, which are options of how a

solution could be realised. Then the promising alternatives were analysed quantitively. Both projects used extern engineering firms to analyse and model the effects of the alternatives. Based on these modelling outcomes, decisions were made to analyse solutions or alternatives in more detail or to choose the most favourable solution(s) or alternative(s). Authorities are mainly involved during the final decision for the most favourable solution. During the formation of facts, authorities are kept informed about the main results of the project. In both projects representatives of responsible authorities were only involved after the alternatives were analysed. Indirect, responsible authorities were involved in the project earlier, for example trough experts, policy advisors or civil servants who were involved earlier in the decision-making process. Stakeholders were mainly involved in order to get input on alternatives and to research the public support for certain systemic measures. In both projects stakeholders were not involved in the generation of solutions. One of the interesting findings of this research is that the responsible authorities and stakeholders can influence the formation of facts, without an actual interaction. Since, some of the interim decisions that are taken during the decision-making process are based on expectations of certain stakeholders or groups. With respect to the uncertainties, it was found that the uncertainties are not explicitly used as an argument for rejecting the solutions or alternatives or used as a substantiation for making certain decisions. However, implicitly uncertainties seem to play an important role in the interim decisions that were made. In both projects there seems to be a preference for systemic measures that can be realised within the district of WDODelta, on a small scale and have relatively low costs.

Preface

This thesis has been the final part of my master Civil Engineering and Management, specialisation in Water Engineering and Management at the University of Twente. This report marks the end of my master and career as a student. I really enjoyed studying at the University of Twente and it helped me to successfully carry out this research.

This research was performed at regional water authority Drents Overijsselse Delta. I think I can say this master thesis has been one of the most interesting, inspiring and educational, but also one of the most challenging assignments I did during my study so far. At the moment of writing this I am about to finish my thesis and I am very happy I can present the results of my research in this report.

I would not have succeeded my graduation without the support of many people. First, I would like to thank my supervisors Denie Augustijn and Joanne Vinke-de Kruijf of the University of Twente. I want to thank them for their help and feedback during my thesis. Their comments really helped me to improve my research. Further, I would like to thank Dick van Pijkeren of Waterschap Drents Overijsselse Delta, who could always make time to have interesting discussions or to give me advice. I also would like to thank all my colleagues of WDODelta. A special thanks goes to Jessica Stoker who could always make time to help me out. Last but not least, I would like to thank my friends and family for supporting me during my graduation, reading my report and being there during the process of writing this thesis. They have been a great support!

Ellen Daamen
Hengelo, April 2019

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1. Introduction

This chapter provides an introduction on the background and content of this thesis. Section 1.1 provides the background of this research. The problem is defined in section 1.2. The research objective and the research questions are described in section 1.3. This chapter closes with a reading guide of the report.

1.1. Background

The Netherlands is located next to the North Sea and Wadden Sea and has large rivers and lakes. This makes the Netherlands vulnerable to flooding. Without the dikes, dams, dunes and flood barriers, 60% of the Netherlands would flood. Besides this, the soil in the west of the Netherlands is subsiding and more extreme weather is predicted due to climate change, with more and longer wet and dry periods occurring. As a result, the flood risk in the Netherlands will increase in the future (Ministerie van Infrastructuur en Milieu & Unie van Waterschappen, 2014).

Dutch flood risk policy has changed in recent years. Traditionally, Dutch water management is aimed at flood prevention by using dikes and dams. The main strategy is focused on the control and resistance of water. In order to protect the Netherlands from flooding, a large network of dikes has been constructed (Hegger et al., 2016). However, due to the increasing flood risk, only measures aimed at flood prevention are not sufficient. This is why the traditional approach of using dikes and dams is gradually being replaced by a risk-based approach (Van Popering-Verkerk & Van Buuren, 2017). In 2009, the multilevel flood safety concept was introduced in the Dutch national water plan. Multilevel flood safety is based on three strategies: prevention, spatial planning and crisis management (Zethof et al., 2012). By applying different strategies, such as flood risk prevention, flood risk mitigation, flood preparation and flood recovery, urban areas can become more resistant to flooding (Hegger et al., 2014).

1.2. Problem definition

Traditionally, the focus of Dutch water management is on preventive strategies against flooding in the form of dikes and dams. These dikes are tested regularly for compliance with current standards. Reinforcing dikes is expensive and can sometimes be difficult to implement. Often, alternative measures are also examined instead of or in addition to dike improvement. Alternative measures that are regularly researched are systemic measures. Systemic measures are aimed at lowering discharges and hydraulic loads on flood defences. By taking systemic measures, water levels can be lowered to prevent extreme high-water situations. The purpose of systemic measures is to increase resilience, so that if a disaster occurs, the damage is limited and there can a quick recovery. Systemic measures are flood mitigating measures, which are aimed at reducing the likelihood and magnitude of flooding and can complement flood defences (Fournier et al., 2016).

While decision-makers and policy makers often consider alternative measures, they eventually tend to decide in favour of dike reinforcement. A probable reason for this preference could be the high level of expertise in the Netherlands on flood prevention. This high level of expertise makes the practical possibilities for implementing alternative measures smaller and makes investing in dike improvement often a more cost-efficient measure (Hegger et al., 2016). Another possible explanation for favouring dike reinforcement over alternative measures could be uncertainties. Warmink et al. (2017) state that the social and technical uncertainties that play a role in decision-making processes could stand in the way of implementing alternative measures. Yet, there are also indications that Dutch water management is not only focused on preventive measures, but has been broadened with aspects of water-robust planning and risk reduction (Van Buuren et al., 2016). Although much has been written about the Dutch water management and the benefits of alternative measures in the literature, there is still little insight into why it is difficult to realise these alternative measures. By providing insight in the decision-making process of systemic measures, the decision-making process for alternative measures will become more transparent, which could help the management of the decision-making processes and can help overcome difficulties with the implementation of these measures.

1.3. Research objective and research questions

The aim of this research is to provide insights into the steps that lead to decisions about systemic measures in regional-high water projects by analysing and comparing for two projects how facts are formed and how authorities, stakeholders and uncertainties play a role in the formation of these facts.

In order to provide this insight four main questions will be addressed:

1. Which theoretical framework is appropriate for analysing the decision-making process in regional high-water projects?
2. How are facts formed about systemic measures in regional high-water projects?
3. How do authorities, stakeholders and uncertainties influence the formation of facts?
4. Which recommendations can be made, based on the comparison of the results of the two projects, about the formation of facts of systemic measures and the influence of authorities, stakeholders and uncertainties?

For this research, a case study is performed at regional water authority Drents Overijsselse Delta (WDODelta). In the case study, two projects are analysed in which systemic measures as an alternative for dike reinforcements are examined. The first project that is studied is the Stadsdijken Zwolle project, in which systemic measures were examined as an alternative to the planned dike reinforcement. The second project is the POV (Project Transcendent Exploration) System Development High Water Perspective Overijsselse Vecht (POV Vecht) in which two regional water authorities and the province of Overijssel research what the best and most effective solutions are to solve water safety issues at the Overijsselse Vecht (e.g. by taking systemic measures). The focus of this study is on the steps that lead to the final decision and not on the final decision itself. The reason for this is that for every important final decision, many small decisions are taken by various parties or management organizations that are responsible for various aspects of a project (Loucks et al., 2017) The interim decisions can therefore have a major influence on the outcome of a decision-making process. For this research it is analysed how solutions and alternatives are generated, why they are rejected and what arguments are used. In addition, it is analysed which interactions with the authorities and stakeholders took place during the projects to investigate to what extent they played a role in the decision-making process.

1.4. Reading guide

In Chapter 2 the theoretical framework and the conceptual model that is used for this research are described. The method of this study is presented in Chapter 3. Chapters 4 and 5 provide the results of the Stadsdijken Zwolle project and the POV Vecht project. In Chapter 6 the results of the cross-case analysis are presented. Chapters 7 and 8 provide the discussion and conclusion. The documents that are analysed for the case study are referred to as follows: [D ...] for documents, [P ...] for presentations and [O ...] for observations. All analysed sources can be found in Appendix B and C.

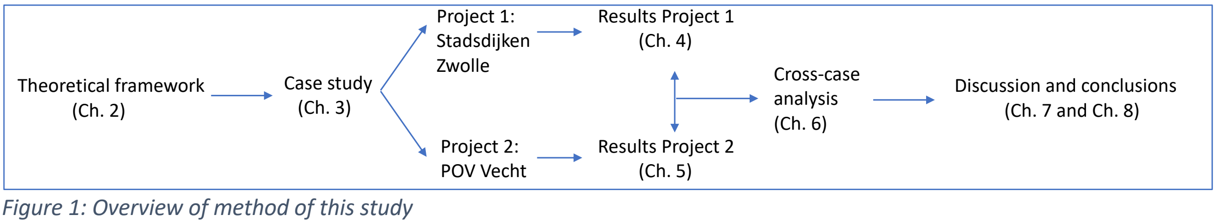

Figure 1: Overview of method of this study

2. Theoretical framework

This chapter provides theoretical insights into decision-making processes and models that describe decision-making processes. Based on the literature, a conceptual model is created, which is used as a basis for the case study. The conceptual model is presented at the end of this chapter.

2.1. Decision making as a problem-solving process

Koppenjan and Klijn (2004) conceptualize a decision-making process as a problem-solving process. Decision-making is often embedded in policy processes. Figure 2 shows a representation of a policy life cycle which is based on the process of problem solving. This model places the individual decision-maker and his decisions at the centre. The goal of a decision-making process is to solve a problem. A problem refers here to the gap between an existing or expected situation and a desired situation. In order to solve the problem, first the problem is defined, and the nature and consequences are defined. Then possible solutions are identified, evaluated and implemented. Whether the problem-solving process is successful depends on the degree to which the objectives are achieved or to what extent the gap is narrowed. When phases of the problem-solving processes are skipped or not properly applied, the problem solving can fail (Koppenjan & Klijn, 2004).

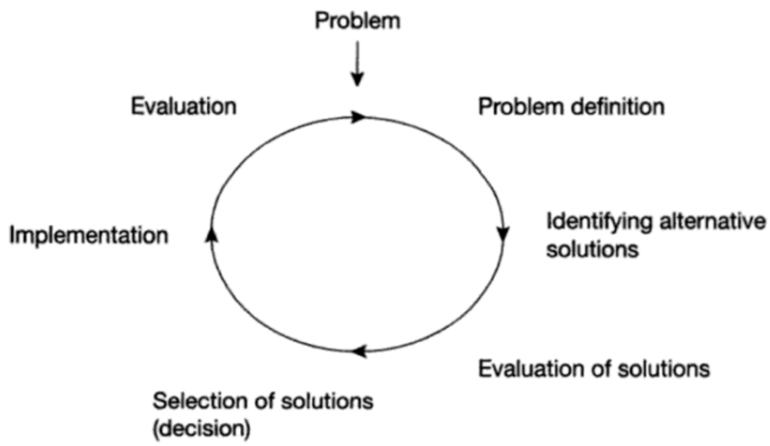

Figure 2: The policy life cycle (Koppenjan & Klijn, 2004, p. 43)

2.2. Conceptualization of decision-making processes

In the literature, many different models for decision-making can be found. For this research, three models are taken into account that each give a different perspective on the decision-making process. These perspectives are knowledge, networks and mental models.

Decision-making from a knowledge perspective

Knowledge that is used for decision making is spread over various actors in a network (Koppenjan & Klijn, 2004). Actors sometimes have conflicting knowledge, which can lead to miscommunication, controversies and conflicts (Van Buuren, 2009). In the knowledge used for decision making, a distinction is made between three types: scientific knowledge, bureaucratic knowledge and stakeholder knowledge (Edelenbos et al., 2011; Hunt & Shackley, 1999). Scientific knowledge is mainly produced by experts, bureaucratic knowledge is heavily intertwined with administrative and governmental practices and stakeholders knowledge is strongly related to the experiences of stakeholders (Edelenbos et al., 2011).

Van Buuren (2007) has conducted a literature study on well-known conceptual models of decision-making, including the phase model of Hoogerwerf (1998), the stream model of Kingdon (1984), the garbage can model of Cohen et al. (1972) and Peters (2002) and the theory of decision making rounds of Teisman (1992). Based on his literature review, Van Buuren (2007) concluded that all of these models provide a relatively one-sided view of the mutual process between knowledge formation and decision-making and that the multiplicity of both processes and their mutual dynamics are not sufficiently revealed. Therefore, Van Buuren (2007) created a model (shown in Figure 3) that included the intertwining and the dynamics between the processes of knowledge production and decision-making. In his model Van Buuren (2007) conceptualises a decision-making process as "a layered and composed process, consisting of three, interrelated and interdependent tracks that can also develop independently with their own dynamics. These tracks are the track of the image formation, the track of the will formation and the track of fact formation" (Van Buuren, 2007, p. 37). The track of image formation consists of the frames of actors and their perceptions and interpretations of the real-world. The track of will formation consists of the ambitions of actors, their sources and means of power, but also the possibilities they get and use to get their way and come to terms. The track of fact formation consists of facts and research that provide a scientific knowledge base for a policy. These three tracks are interconnected and intertwined, but also develop independently since they each have their own logic, speed, dynamics, context and infrastructure. The three tracks are not unchangeable quantities and can change as a result of mutual interaction. Images, views and ambitions of parties can change, but new facts can also lead to new questions. Van Buuren (2007) conceptualizes the decision-making process as a series of interaction rounds. Each round is marked by a decision moment. In new rounds the three tracks can change due to for example new research results or new stakeholders.

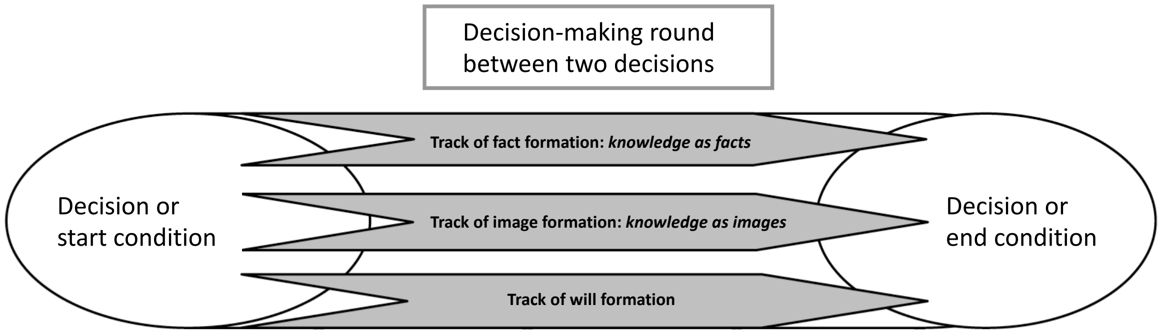

Figure 3: The link between knowledge and decision making translated from Van Buuren (2007, p. 53).

Decision making from a network perspective

Koppenjan and Klijn (2004) place networks central in their conceptual model. Their model is based on the rounds model of Teisman (2000). The rounds model of Teisman (2000) states that a decision-making process takes place in several rounds, where there is no central decision-making and no central decision. The round model focuses on the interaction between the different decisions taken by different actors. Koppenjan and Klijn (2004) describe decision making as a problem-solving process and policy game. Policy games take place in different arenas at the same time. An arena is a place where a specific group of actors make decisions based on their perceptions of the problems, solutions and strategies. Most actors are only part of one arena, some actors are part of multiple arenas and some actors are not part of any arena. A policy game develops in a fragmented context where parties rarely meet, and decisions are made at different locations. Policy games are complex because the wide range of actors involved make unpredictable strategic decisions. A policy game develops through a series of successive decisions concerning the nature and content of a problem, about solutions and about how decision-making takes place. Figure 4 shows the rounds of a policy game as described by Koppenjan and Klijn (2004) as a zigzag and erratic process. Policy games move through different rounds. Each round ends with a crucial decision. A crucial decision leads to a new round in which new actors can enter the arena. Policy games stretch over long periods of time, in which the conditions under which parties meet change over time. Because of societal, economic or political changes earlier decisions can be repealed and the process of problem solving can be broken or taken into a new direction. This leads to the erratic and zigzag appearance of the policy games (Koppenjan & Klijn, 2004).

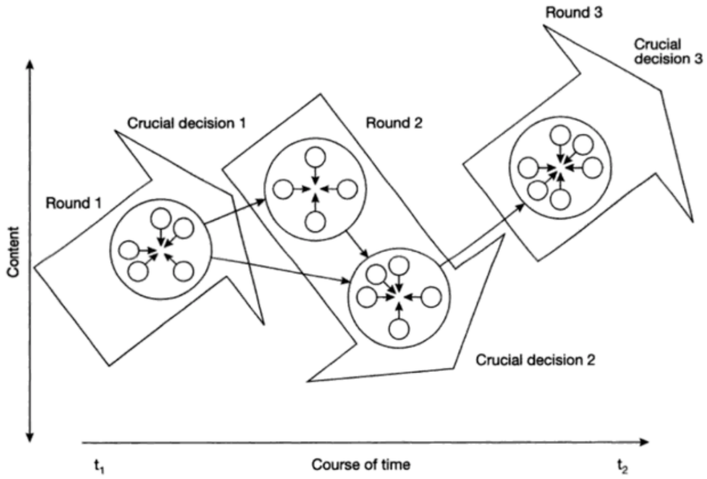

Figure 4: The rounds in the policy games: problem solving as a zigzag and erratic process (Koppenjan & Klijn, 2004, p. 61)

Decision making from a mental model perspective

Kolkman et al. (2005) describe decision-making as an iterative process, in which iterations are made until the objectives are achieved or until the project resources are depleted. This model is focussed on a water engineering context. It seems as if the decision for the most favourable solution is made at the end of the decision-making process. However, many decisions are already made during the process. Policy development and decision-making is a process of systematic problem-solving. Decisions are taken in all steps of a problem-solving cycle. Decisions are driven by the perspectives of actors, where the perspectives of an actor are determined by the mental models. Mental models determine how an actor experiences the real world and what knowledge an actor derives from it. Figure 5 shows the steps that are generally taken in decision-making processes. The steps can partly overlap with each other and sometimes interact with each other. It seems like the choice for the most favourable solution is taken at the end of the cycle. However, decisions are taken in all steps of the cycle.

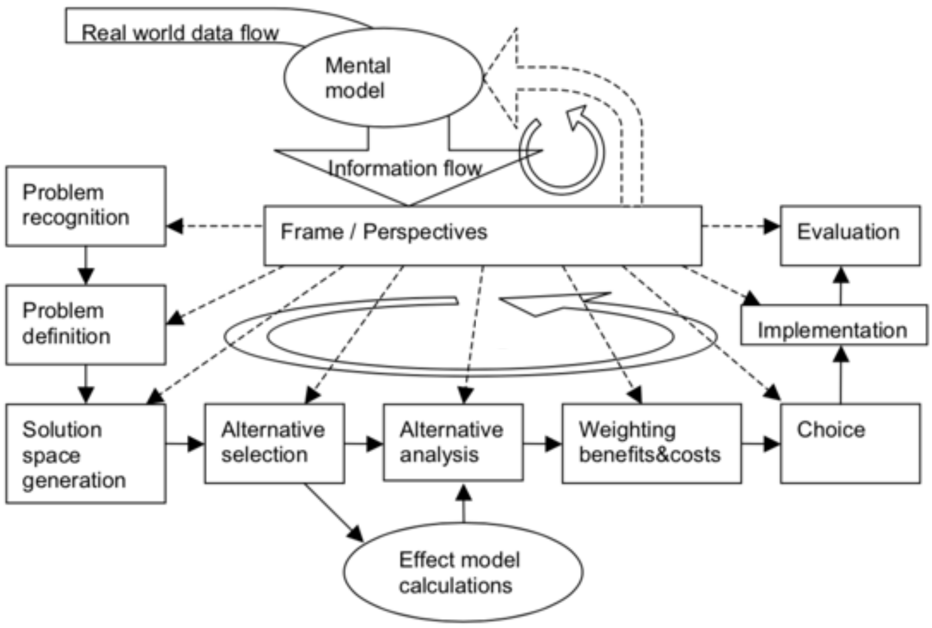

Figure 5: The steps of the problem-solving cycle which is influenced by the frames/perspectives and indirectly by the mental model. The mental model acts as a filter that selects information from the real world to be used in the frame (Kolkman et al., 2005, p. 321).

2.3. Uncertainties in decision-making processes in water management

Decision-making in water management does not only take place in an environment where there is a lack of certainty about the future situation and about the possible outcomes from policy changes, but also the remaining possible changes are not certain (Walker et al., 2003). In the literature many definitions of uncertainty can be found: some authors see uncertainty only as a lack of information (Sigel et al., 2010; Winch, 2010), while other authors link uncertainty to not knowing what the outcome of a certain event or decision will be (Kok et al., 2017; Koppenjan & Klijn, 2004; Refsgaard et al., 2007). In these definitions, uncertainty is not bounded to just the absence of information. It is possible that more information even increases uncertainty, since new uncertainties can be revealed due to new information (Koppenjan & Klijn, 2004; Sigel et al., 2010). An overview of the considered definitions can be found in Appendix A.

Warmink et al. (2017) state that dealing with uncertainties is inherent to water management and policy-making. Both social and technical uncertainties may impede the decision-making process and the implementation of measures or policies. Walker et al. (2003) distinguish two types of uncertainties: 1) Epistemic uncertainty, which is the uncertainty as a result of an imperfect knowledge base. This type of uncertainty can be reduced by gaining more knowledge, for example, through research. 2) Ontological uncertainty, which is the uncertainty due to inherent variability. This uncertainty cannot be reduced by gaining more knowledge. Brugnach et al. (2008) identify a third type of uncertainty, namely 3) Ambiguity, which is the degree of confusion that exists between actors in a group due to the presence of multiple, valid and sometimes contradicting frames and interpretations. These three types of uncertainties are not independent of each other. They are often interrelated, which means that what is known or unknown in a system is influenced by the frames through which they are perceived (Warmink et al., 2017).

2.4. Synthesis of theoretical framework

Based on the literature study, the following three assumptions are formulated with respect to decision-making process that takes place in the field of water management:

1) Decision-making processes are made up of small considerations and decisions. It seems that the decision for the most favourable solution is taken at the end of a decision-making process, but decisions are made in all steps of a decision-making process (Kolkman et al., 2005). Prior to every major decision, many small decisions are made by various bodies or management organizations that are responsible for various aspects of a project (Loucks et al., 2017).
2) Knowledge that is used for decision making is spread over various actors in a network (Koppenjan & Klijn, 2004). Actors sometimes have conflicting knowledge, which can lead to miscommunication, controversies and conflicts (Van Buuren, 2009). In the knowledge used for decision making, a distinction is made between three types: scientific knowledge, bureaucratic knowledge and stakeholder knowledge (Edelenbos et al., 2011; Hunt & Shackley, 1999). Van Buuren (2007) conceptualises the knowledge that is used for decision making in three tracks: the track of image formation, the track of will formation and the track of fact formation. These three tracks contain respectively the images, perceptions and interpretations of actors; the ambitions, sources and means of power of actors; and all facts and research. The tracks are interconnected and interdependent, but also develop independently of each other with their own dynamics.
3) Uncertainties are inherent to water management and decision making. Policy makers often view uncertainties as a complicating factor and are unwilling to accept and embrace uncertainties in decision-making processes (Walters, 2007; Warmink et al., 2017).

2.5. Conceptual model

The conceptual model used in this research integrates insights from the track model of Van Buuren (2007) and the cycle for problem-solving described by Kolkman et al. (2005). Van Buuren (2007) describes the decision-making process as a process that takes place in various rounds. However, Van Buuren (2007) does not define which steps are taken in a decision-making process. For this reason, a connection was made with the model of Kolkman et al. (2005) in which the general steps taken in a decision-making process are described. Figure 6 shows the conceptual model that is used in this research for the analysis of the two projects at the regional water authority WDODelta.

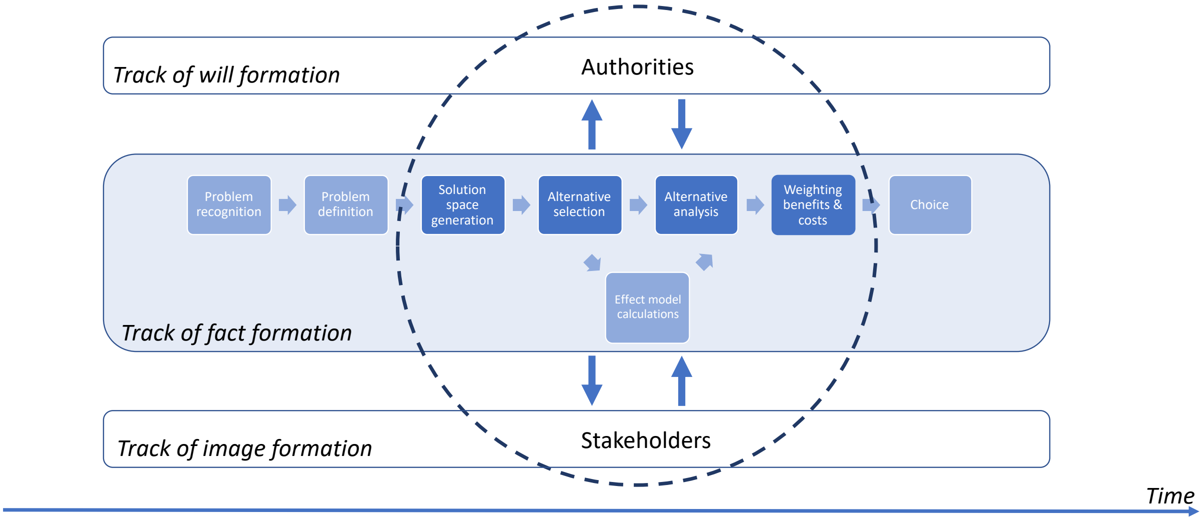

Figure 6: Conceptual model, based on the track model of Van Buuren (2007) and the problem-solving cycle of Kolkman et al. (2005).

The core of the conceptual model is the track of fact formation. In this track, knowledge that is used for decision-making is generated. The track of fact formation develops independently of the track of image formation and the track of will formation, but also develops through interactions with these two tracks. In order to analyse how the track of fact formation develops, the interactions with the track of image formation and the track of will formation is analysed. Also, the interactions within the track of fact formation will be analysed, by taking into account the interactions with (extern) experts. The focus of this study is on the interim decisions that are taken in a decision-making process and how they affect the final decision. Therefore, the focus will be on the four steps prior to the choice for a final solution: solution space generation, alternative selection, alternative analysis and weighting benefits and costs. In this conceptual model, the steps of the decision-making process described by Kolkman et al. (2005) of the conceptual model were used. The four phases prior to a final decision are described as follows:

- Phase 1 - Solution space generation: During the first phase, the solutions are generated. At the end of the first phase all solutions are known, and no solutions are rejected
- Phase 2 - Alternative selection: During the second phase alternatives are generated for the solutions. At the end of the second phase, it is qualitatively determined which solutions are potentially promising and it is decided which alternatives will be modelled. Possible solutions and alternatives may already be rejected during this phase.
- Phase 3 - Alternative analysis: During the third phase, the alternatives are modelled and examined in more detail. In this phase, the alternatives are quantitatively analysed. At the end of the third phase it is known which alternatives are effective, and which alternatives are not.
- Phase 4 - Weighting benefits and costs: During the fourth phase the alternatives (or variants of alternatives) are assessed on the basis of established criteria.

The interactions with track of will formation, the track of image formation and within the track of fact formation will be examined in this research. In Table 1 the considered groups that will be analysed within the three tracks are described.

Table 1: Considered groups in the tracks of will formation, the track of image formation and fact formation

Tracks		Description
Track of will formation		
	Responsible authority	A decision-making process never takes place in an institutional vacuum but is in some way institutionally embedded in existing government organizations (Edelenbos et al., 2009). Authorities that are responsible (e.g. municipalities or regional water authorities) are in charge of major decisions (Krywkow, 2009).
	Experts	Experts in the tracks of will formation are experts of responsible authorities that are involved in the formation of facts. Experts are here defined as "(groups of) individuals who have a (higher level) cognitive knowledge about (aspects of) the project" (Krywkow, 2009, p. 43).
Track of image formation		
	Public	The public are the people who live in the vicinity (i.e. in the municipality or the river basin) of project activities or who can be affected by a decision process. "The public includes individuals and groups with a general interest of specific interest" (Krywkow, 2009, p. 42)
	Stakeholders	Stakeholders are "all persons, groups and organisations with an interest or "stake" in an issue, either because they will be affected or because they may have some influence on its outcome. This includes individual citizens and companies, economic and public interest groups, government bodies and experts". (Cernesson et al., 2005, p. 2)
	Experts	Experts within the track of fact formation are individuals or groups that are also a stakeholder in the project, but who have a higher cognitive knowledge about (parts of) the project (Krywkow, 2009, p. 43).
Track of fact formation		
	External experts	Independent experts - Usually, extern experts are employed to conduct or support research, and evaluate the impact of certain decisions on the physical and social environment (Krywkow, 2009, p. 43).

3. Method

This chapter describes the method of this study. First, the case study and the two analysed projects are presented. Subsequently, the method for data collection and data analysis that are used for this research are described.

3.1. Case study

Case studies are suitable for obtaining qualitative and in-depth data (Yin, 2009). The aim of a case study is to thoroughly study one or a few cases in their natural environment. This research has an exploratory goal. Case studies are a suitable method to get a holistic view of a subject. In order to gain insight into the formation of facts in regional high-water projects, a case study has been conducted at regional water authority WDODelta. WDODelta is one of the 21 regional water authorities in the Netherlands. WDODelta was formed on the 1st of January 2016 following a merger between the regional water authority Reest and Wieden (in province of Drenthe and Overijssel) and the regional water authority Groot Salland (in province of Overijssel). The district of WDODelta is located in the provinces of Drenthe and Overijssel. Regional water authorities in the Netherlands are responsible for regional waters. They ensure that there is sufficient and clean water. They also ensure that fish stocks are maintained and that farmers have sufficient water for agriculture. In addition, they are responsible for the treatment of waste water (Rijksoverheid, 2019).

For this research, two projects were selected at WDODelta. Both projects were carried out by WDODelta and both are part of the Flood Protection Program (the program in which the government cooperates with regional water authorities in order to protect the Netherlands against flooding - In Dutch: “Hoogwaterbeschermingsprogramma”). In both projects, it is examined whether systemic measures could be an alternative to dike reinforcement. By combining the analyses of both projects, it is possible to get a more holistic view of the decision-making process concerning systemic measures. The first project that is analysed is the Stadsdijken Zwolle project. At the beginning of this project, WDODelta did not research systemic measures, but only examined alternatives for dike reinforcement. After the new standards for water safety (2017) were introduced, it appeared that the number of dikes that did not meet the safety standards increased considerably. It appeared that alternative measures (e.g. systemic measures) could be cost-effective. At the time of this study, the examination for alternative measures and their effectiveness was already completed. For the Stadsdijken Zwolle project it was decided, after the analysis of the systemic measures, that a dike reinforcement was the best solution. The second project that is studied is the POV (Project Transcendent Exploration) System Development High Water Perspective Overijsselse Vecht (POV Vecht). The aim of this project is to examine the effectivity of systemic measures. The POV Vecht project is an ongoing case, which makes this case very suitable for doing observations during the decision-making process and analysing how facts that are used for the decision-making process are formed. Table 2 shows the general information about the two projects. Both projects are not typical cases for regional high-water projects. Usually when dikes did not meet the safety requirements this was solved by a dike reinforcement. In both projects systemic measures are researched as an alternative that could be implemented instead of a dike reinforcement. Therefore, these cases are considered as deviant cases. The goal of a deviant case is to find a causal processes within the deviant case, which could also be applicable to other (deviant) cases (Gerring, 2007).

Table 2: General information about the two projects

	Project Stadsdijken Zwolle	Project POV Vecht
Initiator(s)	Regional water authority Drents Overijsselse Delta	Regional water authority Vechtstromen Regional water authority Drents Overijsselse Delta Province of Overijssel
Problem definition	7.5 km of the dike trajectory of in total 9 km does not meet the new norms (2017) [D1].	54.8 km dike op a trajectory of 66.1 km does not meet the new norms (2017). In total 93% of the southern Vecht dikes and 76% of the Northern Vecht dikes is rejected [D103].
Location	The dikes along the Zwolle-IJsselkanaal and the southern bank of the Zwarte Water to the lock at Zwolle. From the lock along the north and east banks of the Zwarte Water to the mouth of the Vecht [D1].	The dikes along the Overijsselse Vecht [D103].
Timeline	Project started in 2014. In 2015 the research into alternative measures in the water system is started. In September 2018 the final decision is made to reinforce the dikes instead of taking systemic measures [D1, D9].	The plan of action is definitive on the 1st of June 2017 [D128]. The project started the 13th of July 2017 [D127].
Goal	The protection of Zwolle against high water, by strengthening the city dikes or taking systemic measures, so that the dike trajectory meets the new standards (2017) by 2050 [D9].	Investigate whether measures in the water system are hydrologically effective and explore whether it is possible to reduce the number of dikes that need to be reinforced [D103].

3.2. Research approach

The research approach that is used for this research is shown in Figure 7. The analysis of the two projects took place on the basis of the conceptual model, presented in section 2.5, and with the help of the following questions:

1. How were the solutions and alternatives generated?
2. What reasons were given for rejecting solutions and alternatives?
3. How did uncertainties play a role in this process?
4. Which interactions with track of will formation, track of image formation and within the track of fact formation took place?

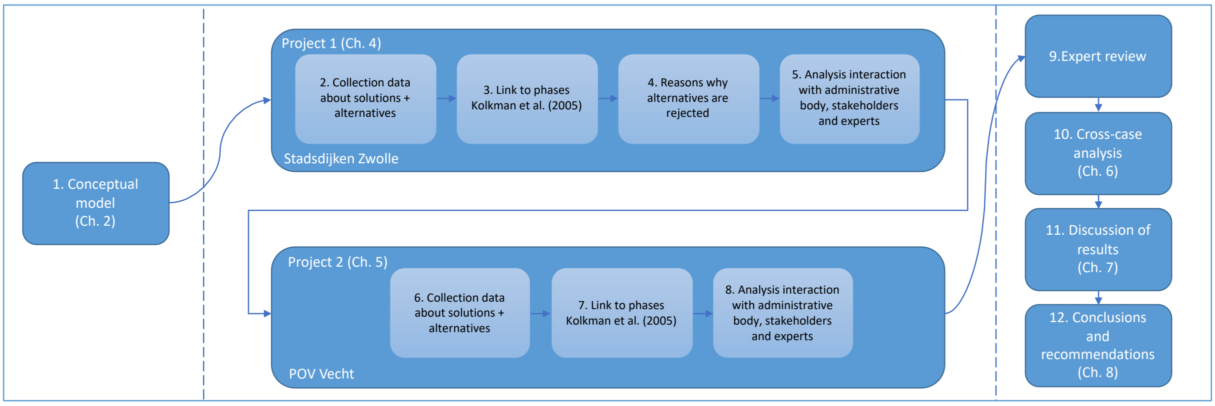

Figure 7: Research approach

Based on the literature study, a conceptual model, which is described in section 2.5, was established (step 1). First of all, the conceptual model was applied to the Stadsdijken Zwolle project. For this project, the generated solutions and alternatives were analysed with document analysis, including presentations, general reports and technical reports. All documents that were used for the Stadsdijken Zwolle project can be found in Appendix B (step 2). The solutions and alternatives were then linked to the phases described by Kolkman et al. (2005) (step 3). Because a decision-making process is not linear and is often an iterative process, the phases for generating solutions and alternatives were considered as a black-box. It is investigated which alternatives were considered at the beginning and which alternatives are considered at the end of a phase. The extent to which an alternative is analysed within a phase was not taken into account. The phase transitions were approached as closely as possible on the basis of document analysis and dates of documents. After the phases have been identified, the reasons why solutions and alternatives were rejected have been examined. This is done on the basis of document analysis, including final reports and decision memos. The reasons why solutions or alternatives were rejected were then divided into categories on the basis of the results. These categories were not predetermined but were determined inductively (step 4). In order to find out to what extent interactions with the tracks of image formation and track of will formation played a role in the formation of facts, the interaction moments with the authorities and stakeholders were analysed. In order to take the possible indirect influence from the authorities and stakeholders into account, interactions with experts were also included in this research. During both projects, experts from other (possibly interested) organizations were invited to think along and gave advice. Based on reports from stakeholder sessions, expert sessions and minutes of administrative consultations, the interaction moments with the authorities, stakeholders and experts were mapped (step 5). A similar method was used for the POV Vecht project as for the Stadsdijken Zwolle project (step 6-9). Because the project POV Vecht was ongoing during this study, it was possible to do observations during some interactions with stakeholders, authorities and experts. The documents, presentations and observations used for the POV Vecht project can be found in Appendix C.

After the analysis of the two projects, the results are verified by experts. For both projects, two experts are asked who were closely involved in the project. The results are checked by the technical manager, who is responsible for the technical and substantive input to the project, and by the stakeholder manager, who is responsible for the contact with stakeholders (step 10). After the results of both projects are checked, a cross-case analysis is carried out in which the results of the two projects are compared based on their similarities and differences (step 11). By searching for the differences between the two projects, simplistic frames can be broken, in addition, the search for similarities can lead to a better understanding of the subject (Eisenhardt, 1989). The results are then discussed (step 12). Finally, based on the results, cross-case comparison and discussion, a conclusion is drawn on how facts are established in regional high-water projects, and how the authorities, stakeholders and uncertainties play a role in this decision-making process and some recommendations to practice are formulated (step 13).

3.3. Method of data collection

Data is collected for the Stadsdijken Zwolle project by document analysis and for the POV Project by document analysis, observations and participant observations. At first, an analysis of the available documents was made. By using exploratory interviews additional documents became available. For both project general reports, technical reports, assessment notes, reports of expert sessions, minutes of meetings, administrative documents like proposals and agendas e.g. are used to reconstruct the formation of facts and the corresponding decision-making process. Since the POV Vecht project was an ongoing case during this study, some documents were not yet available at the beginning of this study. Therefore, it was decided to examine the Stadsdijken Zwolle project first. The benefits of using documentation as a source of evidence is that it is stable (it can be reviewed repeatedly), it is unobtrusive and exact (contains exact names, references and details) and it offers a broad coverage of a subject (long time span, many events and many settings). There are also some weaknesses that come with document analysis as a method. It can be difficult to find some documents (retrievability), and it is also possible that not all documents are available (due to accessibility). Also reporting bias (reflection of bias of author) or biased selection (incomplete selection) can be weaknesses of document analysis as a method (Yin, 2009). During this study, it was noticed that some of the interim decisions and considerations are poorly documented. However, by combining documents with final decisions and summaries of the process, it was possible to reconstruct the decision-making process and the interim decisions. Since the POV Vecht project was an ongoing case it was possible to do observations (direct observations and participant observations). Observations can be useful in providing additional information about the subject that is being studied. Benefits of observations are that it covers events in real time (reality) and that it covers the context of the case (contextual) (Yin, 2009). For this research, (participant) observations are mainly used to cover the context of the case. During the observations notes were made, but no protocol was used. The observations are mainly used as a guideline for the document analysis. Since the focus of this research was on the formation of facts and the corresponding decision-making process, it is decided not to do in-depth interviews. The disadvantage of doing interviews is the response bias and the possibilities of inaccuracies due to poor recall. Besides this it is also possible that the interviewees give answers that the interviewer wants to hear (Yin, 2009). The goal of this study was to reconstruct the decision-making processes and the steps that lead to the final decision, therefor document analysis was considered a more reliable source.

3.4. Method of data analysis

In order to analyse the decision-making process, a form of process-tracing is applied (Gerring, 2007). For process-tracing the known information is causally connected. Process-tracing methods are aimed at studying causal links in single case studies (Beach & Pedersen, 2013). This method is usually applied to understand how 'X' (motive of change) causes a series of conditions (sequence of events) that do or do not come together to cause 'Y' (decision) (Knüppe et al., 2016). In this research process tracing is applied by analysing the interim decision in a chronological way, in which both reasons why alternatives are rejected as why they were chosen can be examined. For both projects for each phase the major events (e.g. the generation, rejection, and analysis of alternatives) are researched and it is examined which drivers influenced these events (e.g. modelling results, expert, stakeholders). By doing this, it can be reconstructed who or what lead to the outcome of the project. In Figure 8 an overview is shown of how the process-tracing is applied.

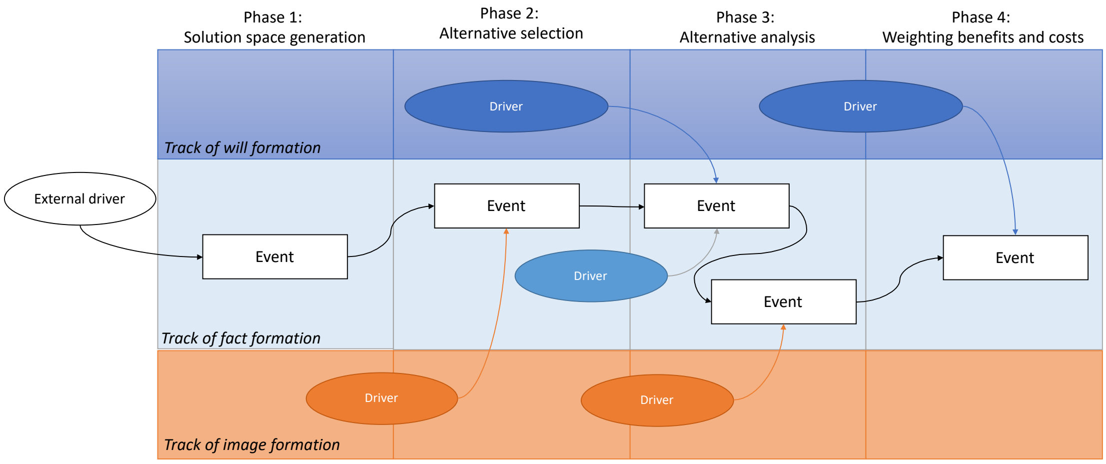

Figure 8: Overview of how process-tracing is applied

In order to structure and analyse the collected data in a systematic way, a database was created using Microsoft Excel. For each project a separate database is created. In the databases all analysed sources were stored. The database is mainly used to structure the results and the sources that were analysed for this research. The database contains general information about the projects, a timeline with the interaction moments with authorities, stakeholders and experts, the division in the four analysed phases, the general information about the solutions and alternatives, the reasons why solutions and alternatives were rejected and the interaction moments with authorities, stakeholders and experts and when they took place, what was discussed and who were present. In this report there is referred to the documents that are stored in de the data base by [D…] for documents, [P…] for presentations and [O…] for observations. The numbers between 0-99 are used for the sources of the Stadsdijken Zwolle project and for 100-199 for the POV Vecht project. In Appendix B and C all analysed sources can be found.

3.5. Validity of the results

Internal validity

To improve the internal validity of this research, four strategies have been applied:

1. A triangulation of data sources is applied. The results of the case study are based on two projects: the Stadsdijken Zwolle project and the POV Vecht project. Results of the Stadsdijken Zwolle project are based on document analysis and the results at POV Vecht project are based on document analysis and observations during interactions with experts, authorities and stakeholders. The results of both projects are later on compared in a cross-case analysis. For triangulation of data, information is collected from multiple sources of evidence to corroborate the same fact of phenomenon. Validity of the research will be improved, since multiple sources provide multiple measures of the same phenomenon (Yin, 2009).
2. A chain of evidence is made. For all results both in the database as in this report it can be traced how they are established. In this report and the database references are made to the analysed documents.
3. A case study database is maintained for both projects in Microsoft Excel in which all data and sources are recorded. See section 3.4 for the description.
4. The results of the projects have been reviewed for each project by two experts (stakeholder manager and technical manager). During these reviews it was concluded that the results were correct and there were only a few minor additions.

External validity

A disadvantage of case studies is the limited external validity and the difficulty to reproduce the results. This makes it difficult to come up with generalisations (Van Tulder, 2012). However, if the case is selected on the basis of its representativeness for a particular issue or problem, it is easier to make generalisations and this will increase the external validity (Eisenhardt & Graebner, 2007). Both projects that are studied for this research could be considered as deviant cases. Causal process that are studied in deviant cases, could also be applicable to other deviant cases. This means that if a general proposition comes out from a deviant case study, this could also be applied to other deviant cases in the population (Gerring, 2007). At the moment more than 1300 km of dikes do not satisfy the current safety standards (Koenen, 2019). The Directorate-General for Public Works and Water Management ('Rijkswaterstaat') and the regional water authorities are together responsible for reinforcing these dikes. Multiple regional water authorities are currently researching systemic measures as an alternative. E.g. The leading initiator of the POV Vecht project is regional water authority 'Vechtstromen'. The regional water authority WDODelta has researched systemic measures in the Stadsdijken Zwolle project as an alternative for the planned dike reinforcement and at the moment regional water authority 'Rivierenland' is researching systemic measures in order to create a robust and climate proof water system (Waterschap Rivierenland, 2018). Also the regional water authority Limburg researched the effects of systemic measures on their water system (Waterschap Limburg & Ministerie van Infrastructuur en Waterstaat, 2017). This means that the outcomes of this study can also be interesting and representative for other regional water authorities.

4. Results Project 1: Stadsdijken Zwolle

This chapter presents the results of the Stadsdijken Zwolle project. Section 4.1 provides a general introduction and gives an overview of all generated solutions and alternatives. In section 4.2 the formation of facts is described. Section 4.3 describes how interactions influenced the formation of facts. Section 4.4 shows an overview of the process and the drivers of the major events. Section 4.5 contains a synthesis regarding the results of the Stadsdijken Zwolle project.

4.1. Introduction Stadsdijken Zwolle project

The first project is the Stadsdijken Zwolle project. The dikes of this project are part of the more than 100 km of dikes that need to be reinforced by WDODelta before 2050 (WDODelta, 2019). The dikes are located along the Zwolle-IJsselkanaal and the south bank of the Zwarte Water to the lock of Zwolle. From the lock the dikes run along the north and east banks of the Zwarte Water to the mouth of the Vecht. The total dike trajectory has a length of almost 9 kilometres. For the project, it is determined that 7.5 km of dikes on the east bank of the Zwolle-IJsselkanaal and the Zwarte Water do not satisfy the new safety standards (2017). For this project, most dikes do not meet the safety standards because their height is too low, but there are also dikes that have insufficient stability and/or there have a risk for piping. In addition, a total of five structures do not meet the safety standards [D9, D13]. The aim of the project is to protect Zwolle from flooding by means of dike reinforcement or by applying systemic measures so that the dikes meet the new safety standards (2017) before 2050 [D9].

The Stadsdijken Zwolle project started in 2014. During first phase (exploratory phase) of the project, the problem was analysed in more detail and possible solutions and alternatives were generated, assessed and rejected. Initially, only alternatives for dike reinforcement were researched for this project. After it became clear that the number of dikes that did not meet the safety standards increased considerably due to the new safety standards (2017), it was concluded that alternative measures such as systemic measures could also be cost-effective. For this reason, research for systemic measures started in 2015. During the exploratory phase, a funnelling process was used to determine the most favourable alternative. This funnelling process took place in two separate tracks: a track for dike reinforcement and a track for systemic measures. This led to two preferred alternatives: a preferred alternative for dike reinforcement and a preferred alternative for a systemic measure. In the end, it was decided that the most favourable decision is a dike reinforcement [D9]. The focus of this research for this project is on the decision-making process that took place in the track in which alternatives for systemic measures were examined.

All possible solutions and alternatives of the systemic measures for the project Stadsdijken Zwolle are shown in Figure 9. The solutions and alternatives are linked to the four steps of the decision-making process described by Kolkman et al. (2005): solution space generation, alternative selection, alternative analysis and weighting benefits and costs. For each phase, the figure shows which solutions and alternatives were considered and when they were rejected.

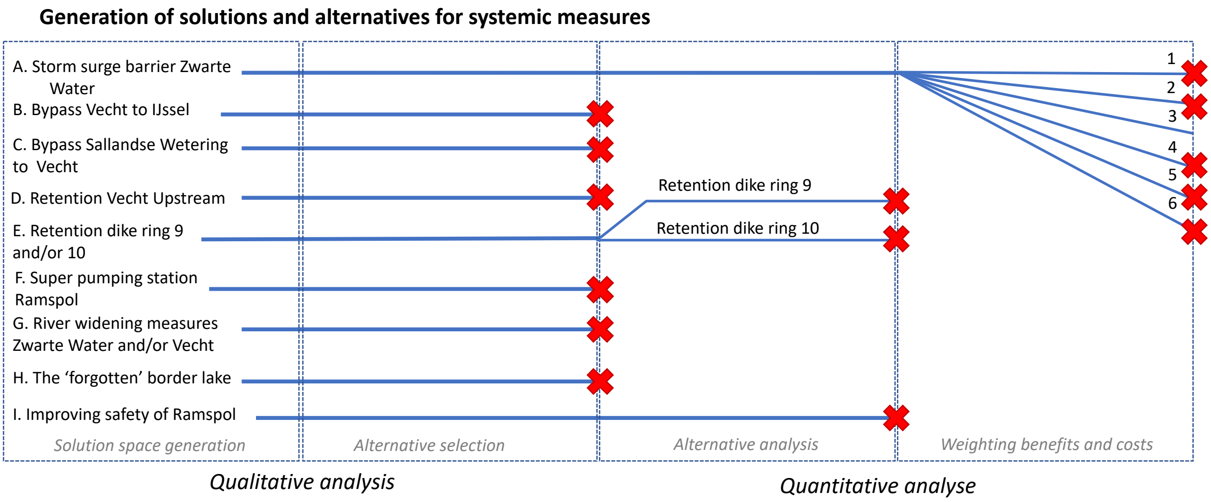

Figure 9: Generated solutions and alternatives for systemic measures for the Stadsdijken Zwolle project. A red cross shows when an alternative was rejected. Six variants were created for the storm surge barrier in the Zwarte Water: a variant with pumping station and with a ship lock on location North (1), a variant with pumping station and ship lock on location south (2), a variant with pumping station without a ship lock at location north (3), a variant with pumping station without a ship lock at location south (4), a variant without pumping station and without ship lock at location north (5) and a variant without pumping station without a ship lock at location south (6).

4.2. The formation of facts

For the analysis of the track of fact formation the four phases for decision-making described by Kolkman et al. (2005) are analysed: solution space generation, alternative selection, alternative analysis and weighting benefits and costs. For each phase the generated solutions and alternatives are described, and it is analysed which alternatives were rejected and for what reason.

Phase 1: Solution space generation

For Stadsdijken Zwolle project nine solutions for systemic measures were generated at the start of the project. Table 3 shows the nine generated solutions with a short description. The nine solutions were generated in one expert session on the 29th of September 2015 in which representatives from Regional water authority Groot Salland (predecessor of WDODelta), Province of Overijssel, Rijkswaterstaat and Zwolle Municipality were present [D2, D13]. During the expert session and shortly after, a first estimate was made of the effectiveness and feasibility of the solutions [D33]. All solutions were generated during this expert session, no new solutions were generated during the project.

Table 3: Generated solutions in the project Stadsdijken Zwolle [D1, D2]

	Solution	Description
A	Storm surge barrier in Zwarte Water	Realisation of a Storm surge barrier on the north side of Zwolle, between the Zwarte Water and the river Vecht. This prevents the occurrence of very high-water levels on the Zwarte Water.
B	Bypass Vecht to IJssel	Realisation of a bypass From the Vecht, below the city of Zwolle, to the IJssel, where the water of the Vecht is boosted by a pumping station in order to limit the discharge on the Vecht.
C	Bypass Sallandse Wetering to Vecht	Bypass from the Sallandse Wetering outside Zwolle to the Vecht where the water of the Wetering is boosted by a pumping station to limit water pollution in Zwolle.
D	Upstream Retention Vecht	Water is extracted upstream of the river Vecht by using retention or overflow areas to limit the discharge from the Vecht to Zwolle.
E	Retention dike ring 9 and/or 10	Measures aimed at retention and/or earlier flooding of the dike rings on the other side of the Zwarte Water, as a result of which the pressure on the Stadsdijken along Zwolle decreases.
F	Super pumping station Ramspol	Placing a large pumping station on the Ramspol to be able to realise lower water levels on the Vecht.
G	River widening measures Zwarte Water en/of Vecht	Expansion of the discharge capacity of the Zwarte Water and/or the Vecht by expanding the major bed, basin storage or by relocating the dikes.

H	The 'forgotten' border lake	Realisation of a sort of bypass between the Zwarte Meer and the IJsselmeer, via the Kadoelermeer and the Vollenhovermeer to reduce the water level on the Zwarte Water.
I	Improving safety Ramspol	Measures aimed at reducing the probability of failure of the Ramspolkering.

Phase 2: Alternative selection

The nine solutions that are shown in Table 3 were evaluated in a second expert session on the 10th of November 2015 in which representatives from the Groot Salland regional water authority (predecessor of the Drenthe Delta regional water authority), the province of Overijssel and the municipality of Zwolle were present [D6]. During the expert session, the first assessment of effectiveness and feasibility was further discussed with experts. At the end of the expert session, the storm surge barrier (A) was assessed as potentially promising and the solutions retention dike ring 9 and/or 10 (E) and improving safety Ramspol (I) were assessed as questionable but were not rejected. The other solutions (B, C, D, F, G, H) were assessed as not promising and were rejected [D1]. Table 3 shows a summary of the arguments that were used for the rejection of these solutions. During this phase, five types of arguments were used to explain why a solution is rejected:

- Costs: the estimated costs of the solution are very high (F, H) or (much) higher than other solutions (B, G).
- Effectiveness of the measure: the solution does not address the cause of the problem (B, C, D, F, H), has (too) little effect on reducing water levels (D, G) or other measures are estimated as more efficient (B, C).
- Uncertainty: Uncertain whether a sufficiently large retention area can be realized (D).
- Spatial fit: There is not enough space to realize the solution (D, G).
- Environmental impact: large impact on the environment in the form of soil transport (B).

Table 4: Overview of argumentation why alternatives are rejected [D1, D2, D7, D8, D9]

Solution	Costs	Effectivity	Uncertainty	Spatial fit	Environmental impact
B. Bypass Vecht to IJssel	x	x			x
C. Bypass Sallandse Wetering to Vecht	x	x			
D. Upstream Retention Vecht		x	x	x	
F. Super pumping station Ramspol	x	x			
G. River widening measures Zwarte Water and/or Vecht	x	x		x	
H. The 'forgotten' border lake	x	x			

Phase 3: Alternative analysis

After the selection of the alternatives, it was decided to analyse three alternatives in more detail: the storm surge barrier (A), retention dike ring 9 and/or 10 (E) and improving safety of Ramspol (I). For the analysis of the alternatives the focus was on the technical feasibility, administrative and legal feasibility and permissibility of the alternatives [D9]. During this phase three alternatives were rejected: retention in dike ring 9 (E1) and retention in dike ring 10 (E2) and improving safety Ramspol (I). Retention in dike ring 10 was not investigated further after an initial analysis, because it was expected that retention in dike ring 9 would be more promising. After further analysis, retention in dike ring 9 was rejected because the overflow height in a T300-situation was too low to fill the retention area [D5]. For the alternative improving safety Ramspol (I) sensitivity calculations were carried out. The calculated profit that could be achieved by reducing the probability of failure is marginal: the reduction of the water level is between 2 and 4 cm. This reduction was too small to further analyse this alternative [D1, D7]. In Table 4 an overview is presented of the used arguments for rejecting the alternatives. During this phase four types of arguments were used for rejecting an alternative:

- Effectiveness: The alternative has (too) little effect on reducing the water levels (E1, I) or other alternatives are expected to be more effective (E2).
- Uncertainty: Effect on the water safety is uncertain (E1)
- Environmental impact: Large impact on the environment (E1)
- Public support: Expectation that the public support for the alternative is small (E1).

Table 5: Overview of argumentation why alternatives E1. Retention dike ring 9, E2. Retention dike ring 10 and I. Improving safety Ramspol are rejected [D1, D5, D7].

Alternative	Effectivity	Uncertainty	Environmental impact	Public support
E1. Retention dike ring 9	x	x	x	x
E2. Retention dike ring 10	x			
I. Improving safety Ramspol	x			

During the phase 'alternative analysis', only the Storm surge barrier (A) was considered a feasible alternative. The other alternatives were rejected. In a request for advice from the ENW ("Expertise Netwerk Waterveiligheid") on the 21st of June 2016 the research for the feasibility of systemic measures was summarized. In this request it was concluded that the storm surge barrier (A) is the only feasible systemic measure [D39].

Phase 4: Weighting benefits and costs

For the alternative Storm surge barrier six variants were created:

1. Storm surge barrier with pumping station, with shipping lock at location north
2. Storm surge barrier with pumping station, with shipping lock at location south
3. Storm surge barrier with pumping station, without shipping lock at location north
4. Storm surge barrier with pumping station, without shipping lock at location south
5. Storm surge barrier without pumping station, without shipping lock at location north
6. Storm surge barrier without pumping station, without shipping lock at location south

The six variants of the Storm surge barrier (A) were assessed on three criteria: technical feasibility, impact on the environment and costs. Finally, the decision was made for the variant of the storm surge barrier with pumping station, without a shipping lock at location north (A3). A variant with pumping station was preferred because without a pumping station a part of the dikes still need to be heightened or reinforced. In addition, there was the expectation that the public support for a variant with pumping station will be higher, because it was expected that inhabitants will feel more insecure when a variant without a pumping station is constructed. When future perspectives are taken into account it was expected that a pumping station can offer the possibility to prevent future dike reinforcements along the regional water system. A variant without a shipping lock would have a negative impact on shipping and therefore less public support. The realisation of a shipping lock costs 13 million euros and comes with additional costs for management and maintenance. The limited benefits of building a shipping lock were disproportionate to these costs. With regard to the location, the decision was made for the variant at location north, because a variant at location south had more negative environmental effects. In addition, if the storm surge barrier was realized at location south a part of the dikes still needs to be reinforced. A storm surge barrier at location south was also more expensive than at location north [D1]. In summary, five types of arguments were used during this phase to substantiate why the variants of the Storm surge barrier (A) are rejected [D1]:

- Costs: The realisation of a shipping lock is 13 million more expensive than a variant without shipping lock and comes with additional costs for management and maintenance (variants with shipping lock A1, A2)
- Public Support: Low public support because of the negative impact on shipping (variants without a shipping lock A4, A5, A6) or expected low public support because there is a feeling of insecurity (variants without pumping station A5, A6)
- Remaining dike reinforcement: Dikes must still be reinforced in addition to realizing this variant (variants on location south, variants without pumping station A2, A4, A5, A6)
- Robustness: If water levels increase in the future it is not possible to extend this variant (variants without pumping station A5, A6).
- Environmental impact: It has more negative environmental effects and thus a greater impact on the environment (variants on location north A1, A5)

Based on these arguments, a storm surge barrier with pumping station without a shipping lock at location north was chosen as the most favourable variant. In summary, Table 6 shows the argumentation for rejecting the variants of the Storm surge barrier (A).

Table 6: Overview of argumentation why variants of A. Storm surge barrier are rejected [D1]

Variants van alternative A. Storm surge barrier	Costs	Public support	Remaining dike reinforcement	Robustness	Environmental impact
A1. Storm surge barrier with pumping station, with shipping lock at location north	x	x			
A2. Storm surge barrier with pumping station, with shipping lock at location south	x	x	x		x
A4. Storm surge barrier with pumping station, without shipping lock at location south	x	x	x		x
A5. Storm surge barrier without pumping station, without shipping lock at location north		x	x	x	
A6. Storm surge barrier without pumping station, without shipping lock at location south	x	x	x	x	x

4.3. How interactions influenced the formation of facts

Interactions with the track of will formation and the track of image formation and within the track of fact formation took place during the formation of facts about systemic measures. Figure 10 shows a timeline of the interaction moments that took place during the project. During the Stadsdijken Zwolle project, possible solutions were divided into two tracks: a track for dike reinforcement and the track for systemic measures. Because both tracks developed simultaneously, the interaction moments have an overlap and some interaction moments only concerned dike reinforcement. The interaction moments with regard to dike reinforcement are shown, because outcomes of these interactions about dike reinforcement could also have an effect on the track for the systemic measures. Figure 10 shows the first interaction moment with the track of image formation with arrow a and the first interaction moment with the track of will formation with arrow b. Interaction with experts concerning systemic measures are circled in black.

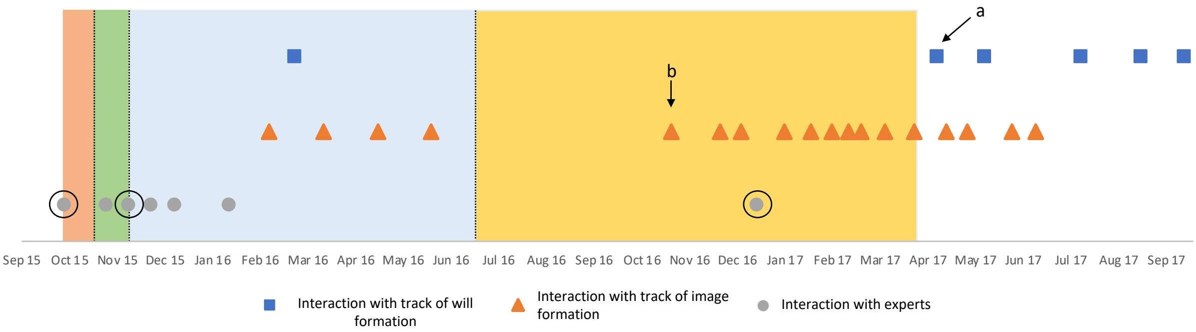

Figure 10: Stadsdijken Zwolle – Overview of interaction moments with the track of will formation, the track of image formation, and experts linked to the phases: Solution space generation (orange), alternative selection (green), alternative analysis (blue), weighting benefits and costs (yellow). The interactions with experts about systemic measures have been circled in black. Arrow a indicates the first moment where alternatives of systemic measures have been discussed with the authorities. Arrow b indicates the first moment where alternatives of systemic measures have been discussed with stakeholders.

Interaction with the track of will formation

For the interactions with the track of will formation four type of interactions can be distinguished. Table 7 shows the four types of interaction, the purpose and a short description.

Table 7: Interactions with the track of will formation

Type of interaction	Purpose	Description
Administrative Support Group - ASG (Bestuurlijke Begeleidingsgroep)	Policy advisors	The Administrative Support Group consists of administrators of the Province of Overijssel, the Municipality of Zwolle, Rijkswaterstaat and WDODelta. The administrative support group advises the General Board on important decisions and milestones during projects [D27].
Executive Board – EB (Dagelijks Bestuur)	Decision making	The Executive Board consists of the dike warden and five members from the General Board. The Executive Board makes decisions about day-to-day matters, executes decisions taken by the General Board and makes proposals for the General Board.
General Board – GB (Algemeen Bestuur)	Decision making	The General Board has 29 members of which 21 members are elected by residents of the district of WDODelta. The General Board is responsible for the budget, the taxes and determines which major investments will be made.
Experts sessions - EXP	Technical experts and policy advisors	Technical experts and policy advisors of the Province of Overijssel are involved during the generation of the solutions and the selection of the alternatives.

Figure 11 shows the interactions with the track of will formation that took place during the four phases: Phase 1 - Solution space generation, Phase 2 - Alternative selection, Phase 3: Alternative analysis and Phase 4: Weighting benefits and costs. Both the interactions concerning dike reinforcement (in grey) and systemic measures (in black) are shown. The dotted lines implicate an indirect interaction with the track of will formation through experts.

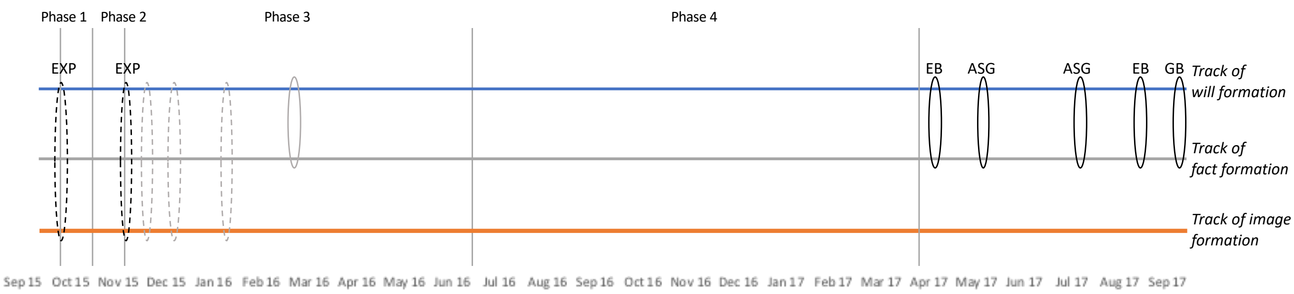

Figure 11: Interactions with the track of will formation

Experts and policy advisors of the Province of Overijssel are involved during the first and second phase of the project. They gave input and advice on the generation of solutions and the selection of the alternatives during two expert sessions on the 29th of September 2015 and the 10th of November 2015. In the expert session on the 10th of November 2015, the nine solutions were qualitatively assessed for feasibility. During this session it was concluded that one of the solutions (storm surge barrier (A)) is promising and two others are considered questionable (retention dike ring 9 and/or 10 (E) and improving safety Ramspol (I)) [D1, D6, D12, D13]. The first interaction with the Executive Board of WDODelta with regard to the systemic measures took place on the 18th of April 2017. This is after the phase weighting benefits and costs and at that moment the Storm surge barrier was the only systemic measure left. During this meeting it was stated that the board of WDODelta prefers a dike reinforcement [D32, D34]. In the subsequent interaction moments, the trade-off between a dike reinforcement and a systemic measure was discussed in two meetings of the Administrative Support Group on the 19th of May 2017 and the 21th of July 2017. During these meetings the public developments were discussed after it was announced that a dike reinforcement was the preferred solution of WDODelta [D30, D31]. On the 29th of August 2017, the Executive Board stated that storm surge barrier (A) was rejected and that a dike reinforcement would be realized [D35, D38]. This decision was made definitive during the meeting of the General Board on the 26th of September 2017 [D36, D38].

Interaction with the track of image formation

For the interactions with the track of image formation four type of interactions can be distinguished. Table 8 shows the three types of interaction, the purpose in the process and a short description.

Table 8: Interactions with the track of image formation

Type of interaction	Purpose	Description
Official Support Group - OSG (Amtelijke begeleidingsgroep)	Policy advisors	The Official Support Group consists of civil servants from the Province of Overijssel, the Municipality of Zwolle, Rijkswaterstaat and WDODelta. The Official Support Group prepares the Administrative Support Group and is used for project related discussions.
Design workshops - DW	Input generating, sharing results and assessing public support.	Throughout the project, eight design workshops are organized in which stakeholders are invited to participate in the design process. The first three design workshops with stakeholders took place during the phase 'alternative analysis' of the systemic measures. During these three sessions, the possibilities regarding dike reinforcement are discussed with stakeholders [D40-46]. The stakeholders invited to the design workshop are delegates of the following: the municipality of Zwolle, business associations located in the area, residents association, shipping associations and water sports associations.
Extra interaction moments in response to the decision for dike reinforcement - EI	Explaining decision for dike reinforcement	A number of residents and business associations felt insufficiently included in the process and asked for an extra consultation moment [D30].
Experts sessions - EXP	Technical experts	Experts of the municipality of Zwolle are involved during the generation of the solutions and the selection of the alternatives.

Figure 12 shows the interactions with the track of image formation that took place during the four phases: Phase 1 - Solution space generation, Phase 2 - Alternative selection, Phase 3: Alternative analysis and Phase 4: Weighting benefits and costs. Both the interactions concerning dike reinforcement (in grey) and systemic measures (in black) are shown. The dotted lines implicate an indirect interaction with the track of image formation through experts.

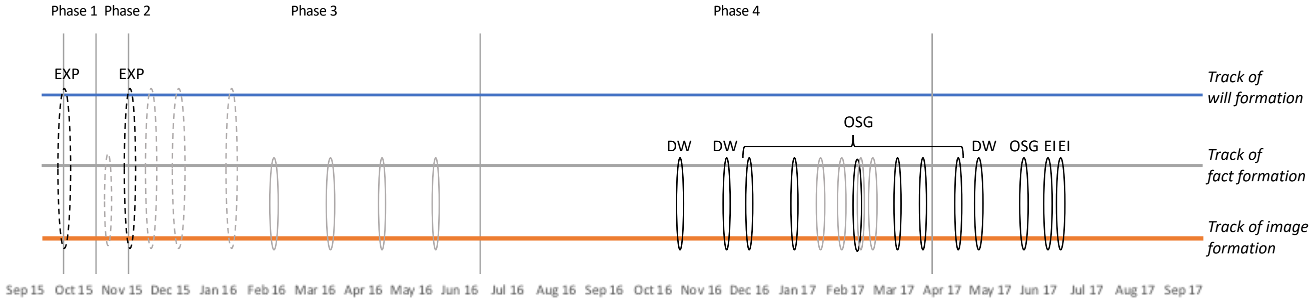

Figure 12: Interactions with the track of image formation

Experts of the municipality of Zwolle were involved during the first and second phase of the project. They gave input on the generation of solutions and the selection of the alternatives during two expert sessions on the 29th of September and the 10th of November 2015. In the expert session on the 10th of November 2015, the nine solutions were qualitatively assessed for feasibility. During this session it was concluded that one of the solutions (Storm surge barrier (A)) is promising and two others were considered questionable (Retention dike ring 9 and/or 10 (E) and Improving safety Ramspol (I)) [D1, D6, D12, D13]. Throughout the project, in total eight design workshops were organized in which stakeholders were invited to participate in the design process. During the design workshops on the 27th of October 2016 and the 28th of November 2016 the systemic measures were discussed for the first time with stakeholders. At that moment, only the Storm surge barrier (A) was the only systemic measure left. During the session on the 27th of October, stakeholders were asked whether there is support for this systemic measure [D47]. On the 28th of November 2017, a brainstorming session was organized during the fifth design workshop in which stakeholders were asked to share their ideas about the storm surge barrier (A) [D48].

The first meeting of the Official Support Group where systemic measures were discussed took place on the 12th of December 2016. At that moment, the storm surge barrier (A) was the only systemic measure left. During this meeting, the methodology for assessing the dike reinforcement and the storm surge barrier (A) was addressed. During this meeting, the municipality of Zwolle and the Province of Overijssel indicated that they still did not have enough insight in the process and the ongoing research into the Storm surge barrier (A) [D18]. In the subsequent meeting of the Official Support Group on the 9th of January 2017, it was concluded that on the basis of the workshop session with experts, the preference of WDODelta was a dike reinforcement instead of a systemic measure [D19]. Up to and including June 2017, monthly meetings of the Official Support Group took place. During these meetings, subjects and documents relating to dike reinforcement and the Storm surge barrier (A) were discussed [D18-26].

After it was announced by the Executive Board in April 2017 that the preferred solution was a dike reinforcement and to reject the Storm surge barrier (A) as a solution, two additional interaction moments with stakeholders took place. A number of residents and business associations felt insufficiently included in the process and asked for an extra consultation moment [D30]. For this reason, a meeting with residents and a meeting with the business associations is organized in June 2017 to clarify the decision of rejecting the Storm surge barrier [D11].

Interactions within the track of fact formation

Besides the experts from the province of Overijssel and the municipality of Zwolle, also some extern experts were involved in the formation of facts. For the interaction with experts three types of interactions can be distinguished. These interactions are described in Table 9.

Table 9: Interactions with extern experts

Type of interaction	Purpose	Description
Expert sessions - EXP	Input generation	The expert sessions are used to generate the solutions and to assess the alternatives. Experts of The Directorate-General for Public Works and Water Management (Rijkswaterstaat) were involved during the generation of solutions for systemic measures.
Workshop session - WS	Assessing solutions	During the workshop session, experts of WDODelta shared knowledge about the storm surge barrier (A). Experts from Witteveen+Bos (engineering and consultancy firm) and Twynstra Gudde (organisational consultancy firm) were present during this session.
Design Workshops - DW	Input generating	During the design workshops experts from Witteveen+Bos are involved.

Figure 13 shows the interactions with extern experts that took place during the four phases: Phase 1 - Solution space generation, Phase 2 - Alternative selection, Phase 3: Alternative analysis and Phase 4: Weighting benefits and costs. Both the interactions concerning dike reinforcement (in grey) and systemic measures (in black) are shown.

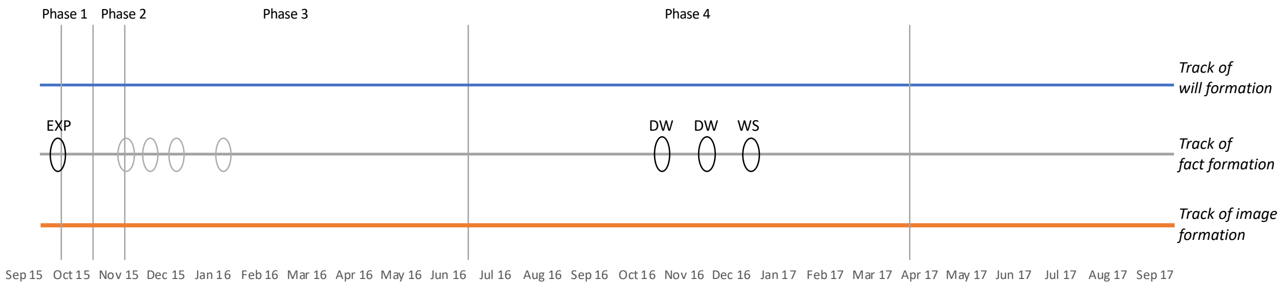

Figure 13: Interaction with extern experts

During the expert session on the 29th of September 2015 all nine solutions were generated. During this expert session an expert from The Directorate-General for Public Works and Water Management (Rijkswaterstaat) was involved in the generation of solutions [D1, D12, D13]. The second and third expert interaction where extern expert were involved was during the design workshops about the storm surge barrier (A). During a workshop session that took place in the fourth phase 'weighting benefits and costs' on the 22nd of December 2016 experts from Witteveen+Bos and Twynstra Gudde were involved. At that moment, the storm surge barrier (A) was the only remaining solution. During this workshop session, experts of WDODelta shared knowledge about this solution [D10]. On the basis of this session it was later concluded by the Official Support Group that the WDODelta has a preference for dike reinforcement instead of realizing the storm surge barrier (A) [D19].

4.4. Process-tracing Stadsdijken Zwolle

In Figure 14 an overview of het process of the examination of the systemic measures in the Stadsdijken Zwolle project is shown. The reason to investigate the systemic measures was that the number of dikes that do not meet the safety requirements had increased due to the new safety standards (2017). This could make systemic measures a cost-effective alternative to dike reinforcement. During the examination of the systemic measures during the project, nine major events can be distinguished:

1. The generation of the nine solutions: Storm surge barrier (A), Bypass to IJssel (B), Bypass Sallandse Wetering to Vecht (C), Upstream retention Vecht (D), Retention dike ring 9 and/or 10 (E), Super pumping station Ramspol (F), River widening measures (G), The 'forgotten' border lake (H) and Improving safety Ramspol (I).
2. The rejection of Bypass to IJssel (B), Bypass Sallandse Wetering to Vecht (C), Super pumping station Ramspol (F), River widening measures (G) and The 'forgotten' border lake (H).
3. The analysis of Storm surge barrier (A), Retention dike ring 9 (E1), Retention dike ring 10 (E2) and Improving safety Ramspol (I).
4. The rejection of Retention dike ring 9 (E1), Retention dike ring 10 (E2) and Improving safety Ramspol (I).
5. The generation of six variants for the Storm surge barrier (A1-A6).
6. The rejection of five variant for the Storm surge barrier (A1, A2, A4, A5, A6)
7. The decision to make the variant of the Storm surge barrier with pumping station, without shipping lock at location north (A3) as the most favourable alternative which will be compared with the solution dike reinforcement.
8. The rejection of the variant of the Storm surge barrier (A3).
9. The decision for a dike reinforcement as the most favourable solution.

Based on the arguments why solutions and alternatives were rejected and the interactions that took place with the track of will formation and the track of image formation, the drivers for the nine events are reconstructed. The generation of the nine solutions (1) and rejection of the first six solutions (2) were based on inputs of experts of WDODelta, experts and policy advisors of the province of Overijssel and experts of the municipality of Zwolle. During the generation of the nine solutions also an expert from the Directorate-General for Public Works and Water Management ('Rijkswaterstaat' - RWS) was involved. After the first six solutions were rejected, the remaining three solutions were further analysed (3). The storm surge barrier (A) and retention in dike ring 9 and/or 10 (E) were modelled and analysed by engineering agency HKV [D5]. Based on the modelling results of HKV it was concluded that the alternatives retention in dike ring 9 and 10 (E1, E2) did not have the required effect on lowering the water levels, have a large impact on the environment and it was expected that these alternatives would have a low public support [D1, D5, D39]. The solution improving safety Ramspol (I) was further analysed by experts of WDODelta. From this analysis it was concluded that the effect of this alternative on lowering the water levels is very small and therefor this alternative was rejected [D1, D7]. So, after the analysis the alternatives E1, E2 and I were rejected (4) based on the modelling results and the expectation of public support. After it was concluded that the storm surge barrier (A) was the only systemic measure left, six variants of the storm surge barrier (A1-A6) were created (5). These variants are further analysed by engineering and consultancy agency Witteveen+Bos (W+B) [D8]. Based on input from experts (WDODelta, Witteveen+Bos, Twynstra Gudde, Rijkswaterstaat) the modelling results of Witteveen+Bos, input of stakeholders (delegates from business associations, residents associations, shipping associations and water sports associations), the expectation of a low public support for variants without pumping station it was decided that variant A1, A2, A4, A5 and A6 were rejected (6) and that the variant of the Storm surge barrier with pumping station, without shipping lock at location north (A3) was the most favourable variant (6). This variant is therefore chosen as the preferred alternative (7) and is compared to a dike reinforcement. Based on this comparison it was decided that the preference of WDODelta was a dike reinforcement, which meant that the storm surge barrier alternative (A3) was rejected (8) and the final decision was to reinforce the dikes.

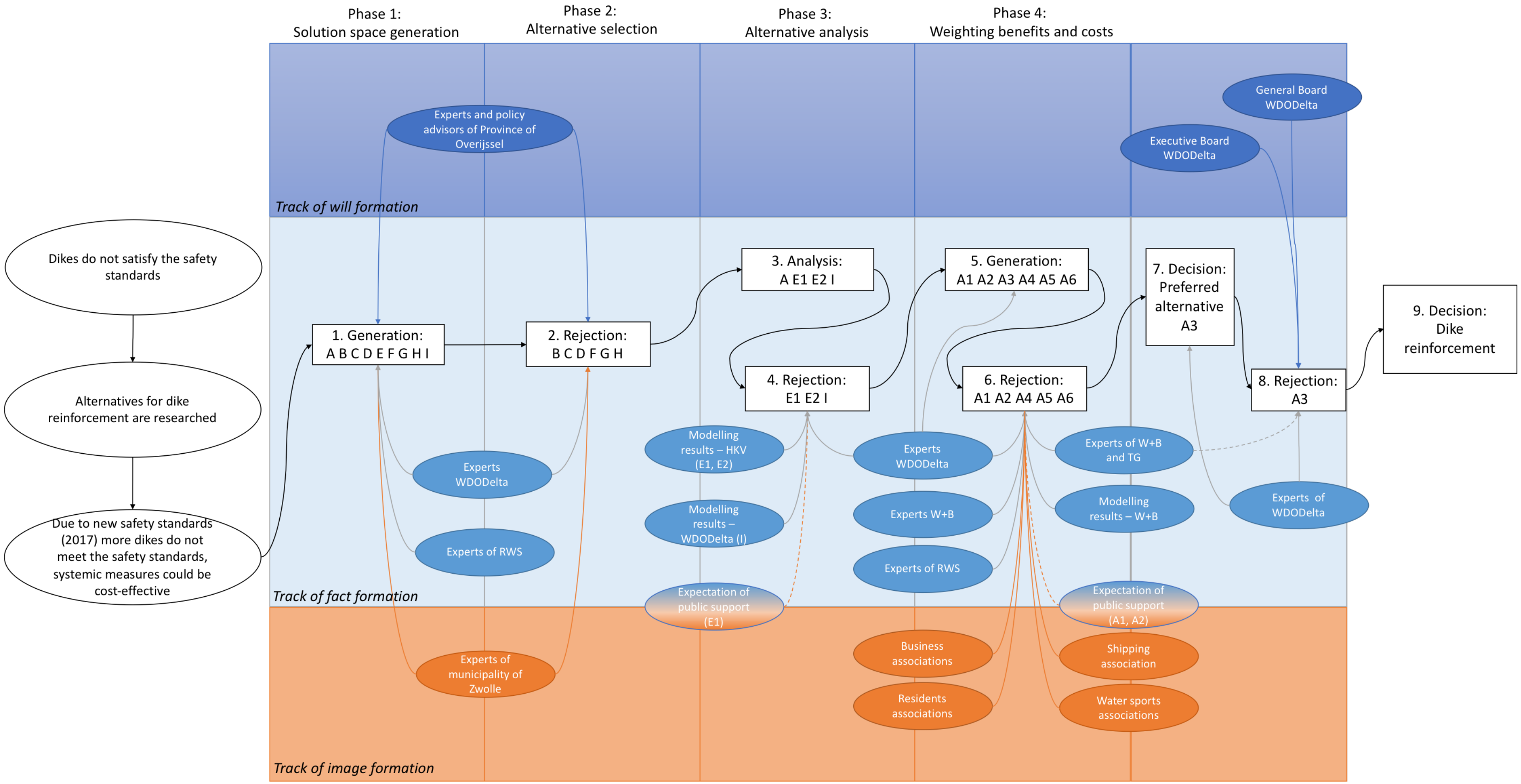

Figure 14: Analysis of Stadsdijken Zwolle project

4.5. Synthesis results of the Stadsdijken Zwolle project

This synthesis contains a summary on the results of the project Stadsdijken Zwolle. The four case study questions that were used to analyse the cases will be answered here.

1. How were the solutions and alternatives generated?

For the project Stadsdijken Zwolle, a total of nine solutions were generated for which hardly any alternatives were generated. Only the retention in dike ring 9 and/or 10 was divided into two alternatives, since they are calculated separately. During the project no new solutions or alternatives were generated. The solutions that were rejected first were mainly solutions that have large dimensions or had to be realized on a large scale and therefore had a lot of impact on the environment (e.g. bypasses (B and C), a large retention area (D), super pumping station (F), large-scale river widening (G) and the 'forgotten’ border lake (H)). All solutions were generated at the start of the project during one session. For the generation of solutions, experts from WDODelta, the province of Overijssel, Rijkswaterstaat and the Municipality of Zwolle were invited. The generation of all solutions and alternatives took less than two months. The assessment of the solutions and the choice of alternatives took place by experts of WDODelta in the presence of representatives from the province of Overijssel and the municipality of Zwolle.

2. What reasons were given for rejecting solutions and alternatives?

The majority of the solutions (six out of nine) was rejected early in the process. This happened before they were quantitatively analysed. The most used argumentation for rejecting solutions were expected costs and expected effectiveness. It was expected that the costs were very high or (much) higher than other solutions and it was expected that the solution did not address the cause of the problem, it had too little effect on decreasing the water levels or it was expected that other measures were more effective. For the three solutions that were analysed in more detail it appeared after investigation and modelling that two of them did not have sufficient effect on lowering the water level. Only the storm surge barrier (A) was considered feasible. For the variants for the Storm surge barrier (A1-A6) additional research took place. Based on the modelling results, expert input and expectation of public support for a variant with pumping station, five variants of the storm surge barrier (A) were rejected.

3. How did uncertainties play a role in this process?

For the rejection of solutions and alternatives, uncertainties were not explicitly used as an argument. Only in the solution direction retention Vecht upstream (D) uncertainty was mentioned since it was uncertain whether a sufficiently large retention area could be accommodated. However, implicitly uncertainty seems to play a role in the decision-making process. For example, there seems to be a preference for measures that can be taken within the district of WDODelta, namely the storm surge barrier (A) and retention in dike ring 9 (E1). From the beginning of the project there seems to be a preference for the Storm surge barrier (A), since it was the only alternative that was described as potentially promising.

4. Which interactions with track of will formation and track of image formation took place?

The first interactions with track of will formation regarding the systemic measures took place after the phase weighting benefits and costs. At that moment there was only one variant of the Storm surge barrier (A) left. The interactions with the executive board and the general board of WDODelta mainly focussed on the decision between a dike reinforcement and the storm surge barrier (A). The other eight systemic measures were not discussed during these meetings. Through indirect interactions the province of Overijssel was included from the beginning of the project through technical experts and policy advisors that were involved in the generation and assessment of the solutions.

The first direct interaction with the track of image formation regarding systemic measures took place during the fourth phase weighting benefits and costs. At that moment the storm surge barrier (A) was the only systemic measure left. In total, twenty interactions took place with stakeholders, of which twelve relate to the systemic measures. Seven of the twelve interactions of these were interactions with the Official Support Group. These interactions mainly related to the preparation of the Administrative Support Group and project related topics were discussed. The Official Support Group mainly discussed the trade-off between the Storm surge barrier (A) and the dike reinforcement. In two design workshops, stakeholders (delegates of the municipality of Zwolle, business associations located in the area, residents association, shipping association and water sports associations) were actively involved in the storm surge barrier (A). During these design workshops, stakeholders gave input and were able to ask questions about the storm surge barrier (A). In response to the decision to favour a dike reinforcement over the Storm surge barrier (A), a number of stakeholders (business associations and residents) felt insufficiently involved in the process. For this reason, there were two additional interaction moments with business associations and residents to explain the decision for a dike reinforcement.

During the project also extern experts were invited. The first interaction with extern experts took place at the start of the project. An expert from ‘Rijkswaterstaat’ was involved in the generation of the solutions during the first phase. During the third phase alternative analysis, extern experts were involved in the workshop sessions and design workshops are form the engineering and consultancy agencies that are asked to analyse the alternatives (HKV, Witteveen+Bos). During the design workshop also an extern expert from organisational consultancy agency Twynstra Gudde was invited.

5. Results Project 2: POV Vecht

This chapter presents the results of the POV Vecht project. Section 5.1 provides a general introduction and gives an overview of all generated solutions and alternatives. In section 5.2 the formation of facts is described. Section 5.3 describes how interactions influenced the formation of facts. Section 5.4 shows an overview of the process and the drivers of the major events. Section 5.5 contains a synthesis regarding the results of the POV Vecht project.

5.1. Introduction project POV Vecht

The second project is the POV (Project Transcendent Exploration) System Development High Water Perspective Overijsselse Vecht (POV Vecht). For the POV Vecht project regional water authorities Vechtstromen and WDODelta and the Province of Overijssel researched what the best and most effective solutions are to solve water safety issues at the Overijsselse Vecht [D125]. The POV Vecht officially started in July 2017 [D127]. Throughout the project, stakeholders were actively involved in the project during four workshop sessions. Stakeholders were invited to give their input and thoughts about the solutions and alternatives, the assessment and scoring the solutions [D129]. In addition, administrative consultations took place to inform the administrators of both regional water authorities and the province of Overijssel about the progress of the project and the results [D112, D122]. In December 2018, an administrative decision was made to include the results of the POV Vecht project into the explorative phase of the projects related to the planned dike reinforcements at the Overijsselse Vecht [D123].

The Overijsselse Vecht is a rainwater river that flows from Münsterland Germany to the mouth of the Zwarte Water near Zwolle. The Vecht has a total length of 167 km, of which about 60 km is located in the Netherlands. During the third dike assessment round (2006-2011) of the Flood Protection Programme (“Hoogwaterbeschermingsprogramma”) in which the primary flood defences were inspected whether they meet the safety standards, many dikes of the Overijsselse Vecht were rejected. Since the implementation of the new standards for water safety (2017), the majority of the dikes (76% of the northern Vecht dikes and 93% of the southern Vecht dikes) located along the Overijsselse Vecht did not meet the safety standards [D103]. The dikes were located within the in the district of WDODelta, so WDODelta was responsible for ensuring that these dikes meet the new safety standards by 2050. WDODelta should therefore reinforce and/or increase the dikes. A total of 60% of the northern and the southern Vecht dikes did not comply with height. Usually when dikes do not satisfy the safety standards, it is solved by a dike reinforcement. However, it is also a possibility to lower water levels by taking systemic measures. By lowering the water level, the normative load is reduced, with the result that a dike does not need to be reinforced or heightened [D106]. In the POV Vecht project, research was carried out whether the number of rejected dikes along the Overijsselse Vecht could be reduced and the social value could be increased by including systemic measures into the design. The solutions could be established in the entire catchment area of the Vecht, both in the Netherlands and in Germany [D103].

All solutions and alternatives that were generated in the POV Vecht project are shown in Figure 15. The solutions and alternatives are linked to the three steps of the decision-making process described by Kolkman et al. (2005): solution space generation, alternative selection and alternative analysis. Since the actual weighting benefits and costs of the alternatives for this project did not take place, this phase was not taken into account. However, during the project a start has already been made on an assessment framework that can be used to assess the feasibility of the alternatives [D125]. Due to the fact that the POV Vecht project aims to investigate the effectiveness of systemic measures, solutions are not officially rejected. Since the results of this project could be included in a subsequent project, in which all possible solutions and alternatives can be reconsidered and re-analysed. However, during the project it was decided that some alternatives would not be analysed and calculated in more detail. For this reason, these solution directions and alternatives are represented with a black block.

Generated solutions and alternatives

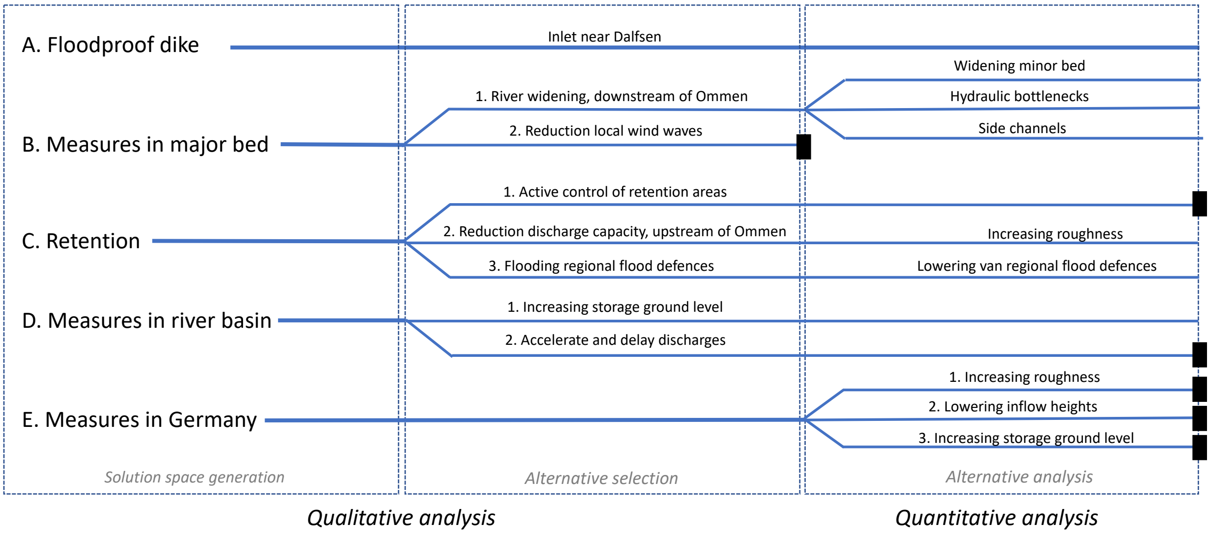

Figure 15: Generated solutions and alternatives for systemic measures for the project POV Vecht. The solutions and alternatives that are not modelled or not analysed or not analysed in more detail are shown with a black block. Because the results of the POV Vecht project are likely to be used for a subsequent project, all possible solutions and alternatives could be taken into consideration later and therefore are not officially rejected.

5.2. The formation of facts

For the analysis of the track of fact formation the four phases for decision-making described by Kolkman et al. (2005) are analysed: solution space generation, alternative selection, alternative analysis and weighting benefits and costs. For each phase the solutions and alternatives that are generated are described and which ones are not analysed (in more detail). Due to the fact that no solutions or alternatives were officially rejected in this project, it is analysed which interim decisions were made and which alternatives were not analysed in more detail.

Phase 1: Solution space generation

The POV Vecht project officially started in July 2017. Before the start of the project a planned approach was written in which a set-up is made for potential solutions: 1) River-expanding measures and measures aimed at reducing waves in the area that is protected by primary flood defences and 2) Measures in the catchment upstream of Ommen (e.g. in the capillaries, regional flood defences, retention areas) [D103]. This set-up for possible measures was later on divided into five types of solutions during a team meeting on the 27th of September 2017. The five generated solutions are shown in Table 10 with a short description.

Table 10: Generated solutions project POV Vecht [D101, P112]

	Solution	Description
A	Floodproof dike	A water barrier that is resistant for wave overtopping which functions as a pressure valve
B	Measures in the major bed	Taking measures in the major bed downstream of Ommen, which lowers the water levels down stream of Ommen and increases the water levels upstream of Ommen
C	Retention	By lowering regional flood defences or increasing the water level by increasing the roughness of the Vecht water can be stored in former flood plains
D	Measures in the river basin	Measures in which water is retained in the capillaries of the water system
E	Measures in Germany	Measures such as C (retention) and D (measures in the river basin) can also be realized in Germany.

Phase 2: Alternative selection

During the second phase several alternatives were generated for the solutions. In various sessions, which took place within WDODelta (e.g. technical team consultations, team meeting on the 27th of September 2017) and with experts (e.g. session at Provinciehuis on the 7th of November 2017 [D104]), various alternatives were generated and discussed. On the basis of these sessions, it was decided which alternatives were going to be analysed. This is documented in the official request in which an overview can be found of alternatives that have to be calculated [D101]. The generated alternatives and their description can be found in Table 11.

Table 11: Alternatives of POV Vecht project for the Floodproof dike (A), Measures in the major bed (B), Retention (C), Measures in river basin in NL (D) and Measures in Germany (E) [D101]

	Alternative	Description
A	Inlet near Dalfsen	The Vecht dikes on the north side have a lower standard (1/300) than the dikes on the south side of the Vecht (1/3000). By constructing an overflow-resistant dike on the north side at height of the standard, the discharge of the Vecht can be limited at extreme water levels (> 1/300)
B	1. River widening, downstream of Ommen	Possible options for river widening are the removing of hydraulic bottlenecks, lowering the major bed or minor bed or relocating dikes
	2. Reduction local wind waves	Wind waves have a relatively large influence on the hydraulic loads at flood defences. Wind waves can be reduced using line elements parallel to the flow direction.
C	1. Active control of retention areas	Increasing the use of retention along the Vecht in low-lying areas, in which in normative situations water is allowed to flow over flood barriers, through active and dynamic control of retention areas through (adapted) weirs and/or inlet works.
	2. Reduction discharge capacity, upstream of Ommen	By increasing the roughness of the river bed and or reducing the profile, the water levels can be increased, so that regional flood defences will overflow earlier.
	3. Flooding regional flood defences	Reducing the height of regional defences to the standard, so that retention areas are optimally used.
D	1. Increasing storage ground level	Increasing the storage capacity of the water supplying sub-catchment areas.
	2. Accelerate and delay discharges	Delay the discharge from upstream areas and accelerating the discharge from downstream areas.
E	Measures in Germany	Measures such as solutions C and D can also be realised in Germany. The effectiveness of measures in Germany is considered in a separate research.

Phase 3: Alternative analysis

Because the POV Vecht is an ongoing case during this study, a clear iteration is visible in the analysis of alternatives. First of all, the five solutions and their alternatives were modelled and the effectiveness of the measures on the water level was determined. The effectiveness was expressed on the basis of two indicators: 1) The water level reduction (cm) and 2) The savings compared to dike reinforcement (€) [D106]. During the calculations it appeared that systemic measures were effective in reducing the water level, but that none of the alternatives met the desired reduction of 20 cm [P110]. By combining alternatives, the effectiveness and robustness of the alternatives should increase. A total of four combinations were made and are modelled in more detail [D106, D120]:

- Combination 1: Floodproof dike near Dalfsen and using low-lying areas along the Vecht basin in the Netherlands
- Combination 2: River widening and using low-lying areas of the Vechtdal in the Netherlands
- Combination 3: Holding water upstream of Ommen – Measures in the river basin and using low-lying areas along the Vecht by increasing the roughness
- Combination 4: Floodproof dike near Dalfsen

The floodproof dike near Dalfsen (A) was calculated twice: as an individual measure and in combination with the use of low-lying areas in the Vecht basin. From the composition of the combinations it can be derived that reduction of wind waves (B2), active control and use of retention (C1) and measures in Germany (E) were not included in the detailed analysis. The alternative reduction of wind waves (B2) was not calculated, but no explanation was given for this. There is also no clear explanation for not including the active control of retention areas (C1). However, the administrative consultation on the 6th of December 2018 showed that the active use of retention areas is an undesirable variant of retention due to policy reasons [O7]. The solutions in Germany (E) were calculated, but it became clear during the process that lowering dikes in Germany was not an option [D115]. In addition, a cooperation process with Germany would have a different scope than the research conducted for the POV Vecht [D125]. For these reasons, the measures in Germany were not included in the combinations of measures. The acceleration and delaying of discharges from sub-basins (D2) were modelled during the rough analysis, but it was concluded that this alternative was not promising and therefore it was not included in the detailed analysis [D106].

During the alternative analysis it became clear that the number of dikes of the Overijsselse Vecht that needed to be reinforced could be less than expected. As a result of knowledge development and new hydraulic models, it was possible that the expected (cost-)effectiveness of the alternatives with respect to a dike reinforcement would be reduced. This could mean that the cost savings that systemic measures can offer to dike reinforcement would be lower [D124]. However, this uncertainty was not been taken into account during the analysis of the alternatives.

Phase 4: Weighting benefits and costs

The combinations of alternatives were not worked out sufficiently during the third phase in order to be able to score these on criteria. For this reason, the weighting of benefits and costs did not take place. For the alternatives of the POV Vecht project, a framework of assessment was already established, whereby the feasibility of the systemic measures could be assessed using the following criteria [D125]:

- Technical feasibility – Concerns the contribution of the systemic measure to reducing the water level and for what price
- Future-proof water system - Concerns the contribution of a systemic measure to a climate-proof and water-robust water system.
- Adaptability in the environment - Concerns the bottlenecks and opportunities for an alternative in an area
- Organizational feasibility - Concerns the assurance of the realisation and maintenance of a system measure.
- Financial feasibility - Concerns the financing of the systemic measure.

Because the actual scoring of the alternatives did not take place, this phase was not further analysed In this research.

5.3. How interactions influenced the formation of facts

During the POV Vecht project, interactions took place with the track of will formation, the track of image formation and within the track of fact formation. A timeline with all interaction moments is shown in Figure 16. During the project the expert interactions focused initially on the underlying modelling tools. The arrow indicates the first expert interaction where possible solutions were discussed with experts.

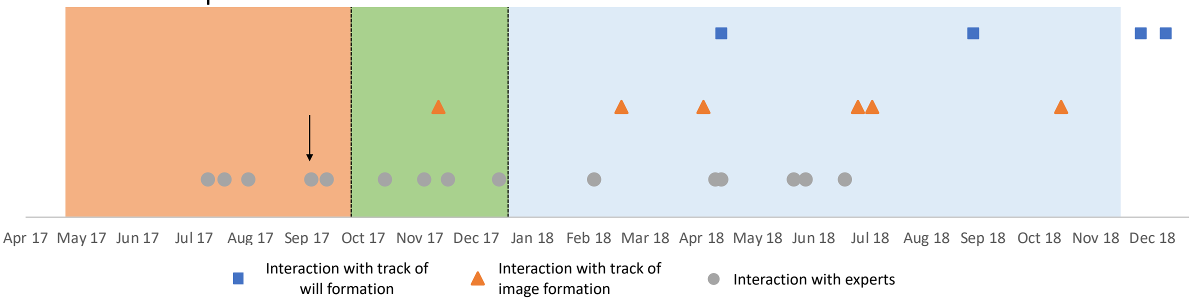

Figure 16: POV Vecht – Overview of the interaction moments with the track of will formation, the track of image formation, and experts linked to the phases Solution space generation (orange), alternative selection (green) and alternative analysis (blue). The arrow indicates the first expert meeting where possible solutions for systemic measures are discussed.

Interaction with the track of will formation

For the interactions with the track of will formation two types of interactions can be distinguished. Table 12 shows the two types of interaction, the purpose and a short description.

Table 12: Interactions with the track of will formation

Type of interaction	Purpose	Description
Administrative meetings	Informing and opinion-forming	Meetings with members of the Executive Board of regional water authorities WDODelta and Vechtstromen and representatives of the Province of Overijssel [D112, D122, D123].
Administrative consultations	Reviewing administrative support	During the administrative consultation members of the Executive Board of regional water authorities WDODelta and Vechtstromen, representatives of the Province of Overijssel and Aldermen of the municipalities of Zwolle, Dalfsen, Ommen and Hardenberg were invited to give their thoughts and opinions on the results and their ideas to include the results in a subsequent project [D121, O7]

Figure 17 shows the interactions with the track of will formation that took place during the three phases: Phase 1 - Solution space generation, Phase 2 - Alternative selection and Phase 3: Alternative analysis.

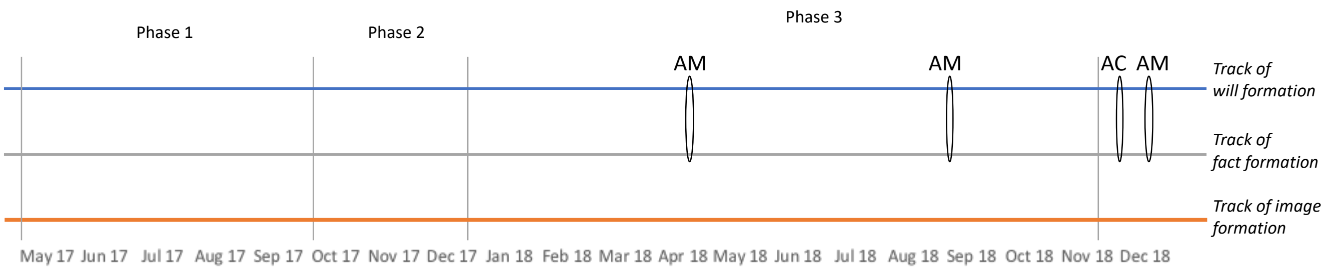

Figure 17: Interactions with track of will formation

The first two administrative meetings took place in the third phase alternative analysis. During the first administrative meeting on the 19th of April 2018, the combinations of the alternatives were not made yet. The five solutions were calculated on a rough scale and the results were presented to the administrators of regional water authority Vechtstromen, WDODelta and the province of Overijssel [P113]. During the second administrative meeting on the 5th of September 2018, the combinations of alternatives were already made and modelled. During the meeting the most important results were presented [P114]. The purpose of these administrative consultations is mainly informing and opinion-forming, there were no decisions taken [D112, D122]. A number of participants from the workshop sessions and expert consultations were also present at the administrative consultations [O106]. In the administrative meeting and the administrative consultations that took place in December 2018, the continuation of the results of the POV Vecht projects and the possibility to further explore the systemic measures in a subsequent project was discussed. At that time, the alternative analysis was already completed [D121, D123, O107].

Interaction with the track of image formation

For the interactions with the track of will formation two types of interactions can be distinguished. Table 13 shows the two types of interaction, the purpose and a short description.

Table 13: Interactions with the track of image formation

Type of interaction	Purpose	Description
Workshop sessions - WS	Informing, creating public support	During the project, four workshop sessions are organized in which stakeholders are invited. Participants from the four workshop sessions are from the province of Overijssel, WDODelta, Regional water authority Vechtstromen, municipalities (Zwolle, Dalfsen, Ommen, Hardenberg, Zwartewaterland), 'LTO Noord', 'Natuur en Milieu Overijssel' and 'Staatsbosbeheer'. A large part of the participants in the workshop sessions are part of existing networks (including the Room for the River Vecht project).
Plenary sessions in Germany - PS	Informing, exchange information	The results of the POV Vecht are presented and an exchange about climate scenarios and climate adaptation strategies took place [D115]

Figure 18 shows the interactions with the track of will formation that took place during the three phases: Phase 1 - Solution space generation, Phase 2 - Alternative selection and Phase 3: Alternative analysis. The first workshop session was organized during the second phase alternative selection on the 14th of November 2017. At that moment, the five types of solutions were already generated, but not all alternatives were generated yet. The goal of this first workshop session was to invite participants to brainstorm about the possible system measures and to create public support [D126]. During the four workshop sessions, interim results were presented, and the progress of the project was discussed. During the sessions, participants were invited to participate actively and to give their opinion about the feasibility of the measures [D125, O101, O104, O105]. During the POV Vecht project, contact was also maintained with Germany. The German regional authorities were involved in two plenary sessions that took place in February and July 2018. These consultations took place during the phase alternative analysis. The purpose of these sessions was to keep the German authorities informed about the development of the POV Vecht project. The results of the POV Vecht were presented and an exchange about climate scenarios and climate adaptation strategies took place [D115].

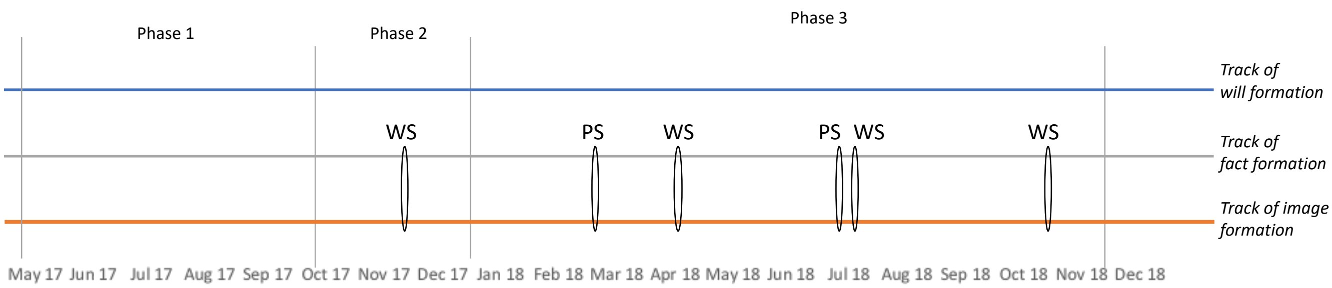

Figure 18: Interaction with the track of image formation

Interaction within the track of fact formation

The focus of the POV Vecht project was to investigate whether measures in the water system are hydrologically effective and explore whether it is possible to reduce the number of dikes that need to be reinforce. Therefore, many experts both from the three initiators (WDODelta, Vechtstromen, Province of Overijssel) as well as extern experts were involved in the project. In total four types of interactions with experts can be distinguished. Table 14 shows the four types of interaction, the purpose and a short description.

Table 14: Interactions within the track of fact formation

Type of interaction	Purpose	Description
Expert meetings - EM	Soundboard, asking other experts for advice	Experts meetings of the three initiators of the project: regional water authority Vechtstromen, WDODelta and the Province of Overijssel. During some of the expert sessions extern experts (Rijkswaterstaat, KNMI, HKV, Twynstra Gudde, KPR, Hydrologic) are involved to give their input and advice.
Measure sessions – MS	Generating solutions and alternatives	Expert sessions focussed on the generation of solutions and alternatives. Involved experts were from the Province of Overijssel, regional water authorities Vechtstromen and WDODelta
Area Sessions - AS	Exchanging knowledge, meeting German water managers	Sessions with experts (e.g. hydrologists) of the river basin. Meetings with experts and water managers from municipality of Hardenberg and hydrologists and water managers from Germany (NLWKN).
Review- and soundboard sessions - RS	Reviewing results, soundboard	Experts from the Province of Overijssel, the Regional water authority Vechtstromen, WDODelta, HKV, Hydrologic, Rijkswaterstaat, the Flood Protection Program, the University of Twente, Twynstra Gudde and regional water authortity De Dommel

Figure 19 shows the interactions with experts that took place during the project. The first three meetings with experts were 'area sessions' in which experts met hydrologists and water managers from the municipality of Hardenberg and from Germany. The first expert interactions with regard to the generation of solutions took place at the end of the first phase solution space generation at the 6th of September 2017. Experts that were invited to the expert meetings are experts of the three initiators: Regional water authority Vechtstromen, WDODelta and the Province of Overijssel.

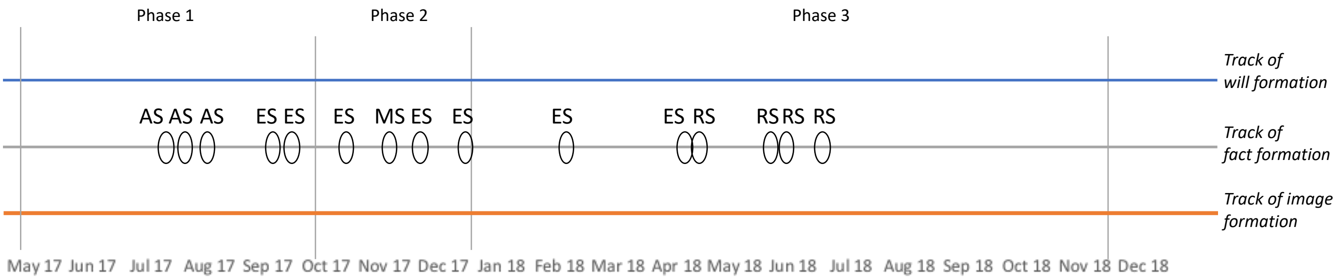

Figure 19: Interaction with experts

During some meetings experts from external organisations were invited (e.g. Rijkswaterstaat, KNMI, KPR, HKV, Twynstra Gudde) [D105, D107, D116]. The expert meetings were used as a soundboard and offered the possibility to ask other experts for advice. The purpose of the expert meetings was to create substantive support and to prevent discussion of results at a later stage [D105]. Expert meetings took place during all three phases of the decision-making process. The expert meetings mainly concern the underlying modelling tools that were used to model the alternatives [P103-108]. The first expert meeting where possible solutions were discussed was the expert meeting on the 6th of September 2017 [P103]. The solutions were discussed on the 7th of November 2017 in a measure session with experts from the Province of Overijssel, Regional water authority Vechtstromen and WDODelta [D104]. During the phase alternative analysis, the results and the method were discussed with other experts through review and soundboard sessions. For these review sessions, experts were invited from, among others, the Province of Overijssel, the Regional water authority Vechtstromen, WDODelta, HKV, Hydrologic, Rijkswaterstaat, the Flood Protection Program, the University of Twente, Twynstra Gudde and regional water authority De Dommel [D111, D113, D114, P109, O102]. German experts were also involved in the project during the project. In three expert sessions in Germany, experts from WDODelta, Regional water authority Vechtstromen, Niedersächsischen Landesbetriebs für

Wasserwirtschaft, Küsten- und Naturschutz (NLWKN), Bezirksregierung Münster and Samtgemeinde Emlichheim met. These expert sessions in Germany took place during the first phase solution space generation. During these sessions knowledge was exchanged about the (sub-) river basin(s) and the expected climate change. In addition, the solutions that would be researched in the POV Vecht project were discussed. During these discussions it was concluded that it was not possible to lower the height of the dikes in Germany to solve water problems in the Netherlands [D115].

5.4. Process-tracing POV Vecht

In Figure 20 an overview of het process of POV Project is shown. The reason to investigate the systemic measures was that the majority of the dikes along the Overijsselse Vecht did not meet the safety standards (2017). This could make systemic measures a cost-effective alternative to dike reinforcement. During the project, five major events that can be distinguished:

1. Generation of the five solutions: Floodproof dike (A), Measures in the major bed (B), Retention (C), Measures in the river basin (D) and measures in Germany (E).
2. The generation of the alternatives. For each solution, except for the floodproof dike, two or three alternatives are generated. The following alternatives are generated: Inlet near Dalfsen (A), River widening measures (B1), Reduction of local wind waves (B2), Active control of retention areas (C1), Reduction of discharge capacity (C2), Flooding of regional defences (C3), Increasing storage on ground level (D1), Accelerate and delay discharges (D2) and measures in Germany (E). The measures in Germany divided into three alternatives: increasing roughness (E1), Lowering inflow heights (E2) and Increasing storage on ground level (E3).
3. Analysis of the alternatives on a rough scale.
4. Detailed analysis of the alternatives. After the alternatives are modelled on a rough scale, combinations of alternatives are made in order to increase the effectivity. These combined alternatives are analysed in more detail.
5. After the analysis of the alternatives, the decision is made to include systemic measures in subsequent projects of the dike reinforcement along the Overijsselse Vecht.

Based on the analysis of the formation of facts and the interaction moments that took place during the project the drivers for these five events are reconstructed. In Figure 20 the process of fact formation in the POV Vecht project is shown. The generation of the five solutions (1) was based on the input of experts from the three initiating parties: regional water authorities Vechtstromen and WDODelta and the Province of Overijssel. Also, policy advisors of the Province of Overijssel were included in the process [D104, D105]. These parties were also included in the generation of the alternatives (2). The generated alternatives were presented in a workshop session to the involved stakeholders: Municipalities in the catchment area (Officials of the municipalities of Dalfsen, Zwarte Waterland, Zwolle, Dinkelland), Farming association ('LTO Noord'), Nature and environmental organisations ('Staatsbosbeheer', 'Natuur en Milieu Overijssel', 'Groen Platform Vecht'). During this workshop sessions the stakeholders were invited to give their thoughts and ideas about the alternatives. Extern experts of Twynstra Gudde (TG) and the University of Twente (UT) were involved during the workshop sessions. In the generation of alternatives some extern experts were indirectly involved (The Royal Netherlands Meteorological Institute (KNMI), Rijkswaterstaat (RWS), HKV and KPR) [D116]. These experts gave advice on the approach and method for the analysis of the solutions and alternatives. The analysis and the modelling of the alternatives was performed by engineering agency HydroLogic. First all alternatives were modelled on a rough scale (3). The results of the rough analysis are presented to stakeholders during the workshop [D117, O101] and to the executive boards of regional water authorities Vechtstromen, WDODelta and the province of Overijssel during an administrative consultation [D112, P115]. Based on the results of the rough analysis of HydroLogic and the input from stakeholders and the administrative consultation four combinations of alternatives are made. These are then calculated in more detail (4). During the meetings with the German experts and partners it became clear that there was little support for taking measures in Germany. Therefore, these alternatives were not included in the more detailed analysis. Based on the modelling results of HydroLogic and input from the administrative consultation with Alderman of the municipalities of Zwolle, Dalfsen, Ommen and Hardenberg [D121, O7] the decision was made by the deputies of the Province of Overijssel, the executive boards of the regional water authorities Vechtstromen and WDODelta to include the results of the POV Vecht project in the subsequent dike reinforcement projects along the Overijsselse Vecht [D123].

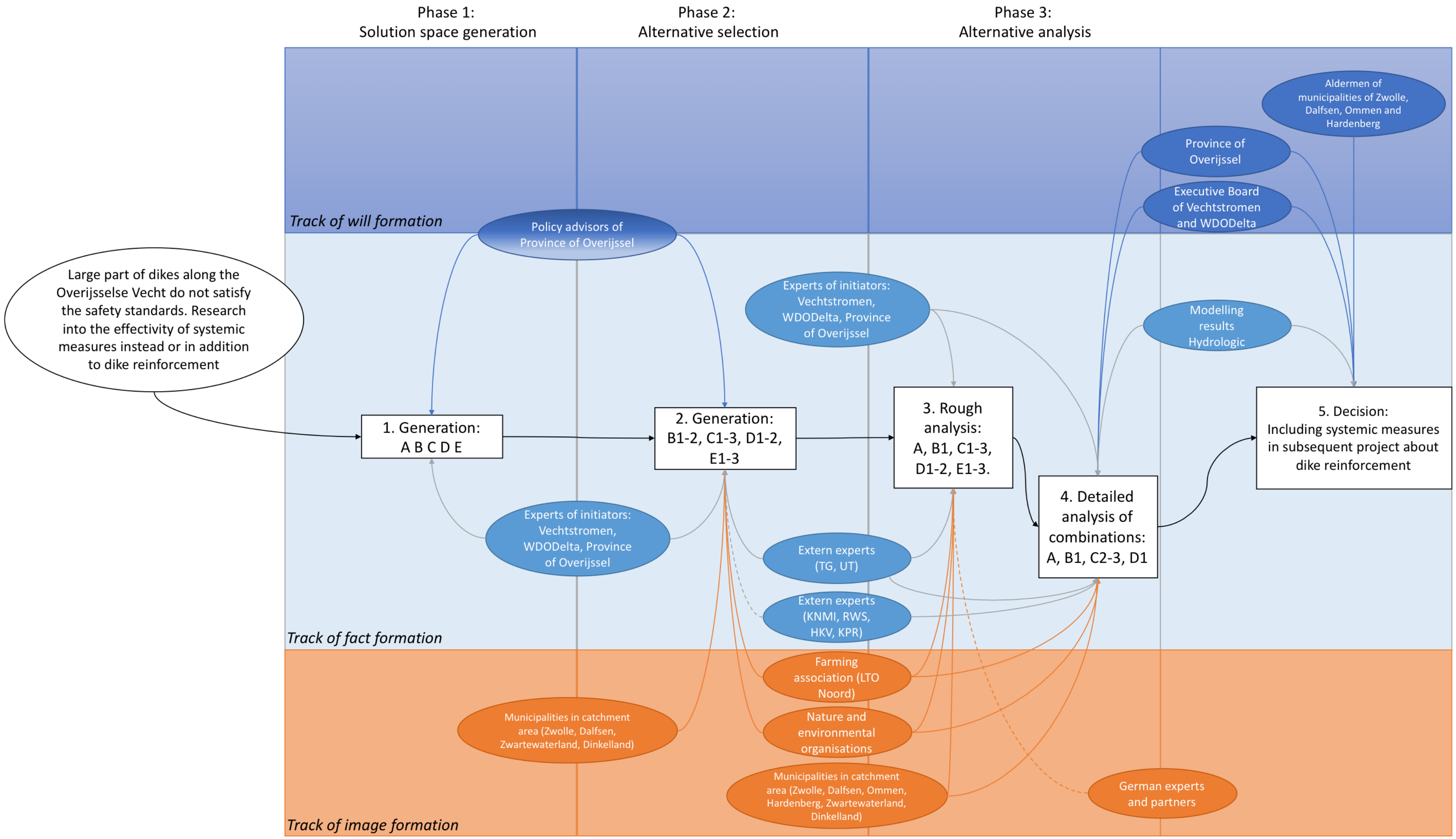

Figure 20: Process analysis of POV Vecht project

5.5. Synthesis results of the POV Vecht project

This synthesis contains a summary of the results of the project Stadsdijken Zwolle. The four case study questions that were used to analyse the cases will be answered here.

1. How were the solutions and alternatives generated?

Five solutions were generated for the POV Vecht project. For each solution, except for the floodproof dike (A), two or three alternatives were generated. There are no new solutions or alternatives generated during the project. During the project no solutions were officially rejected. Nevertheless, some alternatives were not analysed or were not analysed in more detail. There is not always a clear explanation why it was decided to exclude certain alternatives. The five solutions were generated within the team of POV Vecht. A first set-up for possible solutions was described in the planned approach of the project. On the basis of this initial setup, various possible solutions were generated and discussed with experts. Finally, the various solutions were merged into five solutions. These five solutions were presented to stakeholders during the first workshop session in order to get feedback and to create public support. In the third phase 'alternative analysis', it became clear that the decision-making process is not a linear process. A clear iteration was visible during the modelling of the alternatives. First, the alternatives were calculated on a rough scale to determine the effectiveness of the individual alternatives. Later on, these results were used to make combinations of the alternatives. These combinations were then calculated in more detail.

2. What reasons were given for rejecting solutions and alternatives?

Because officially no alternatives were rejected, there is little argumentation why solutions or alternatives were not analysed or were not analysed in more detail. At the end of the project, the weighting of benefits and costs of the alternatives did not take place, so the actual decision for most favourable alternative was not taken and was postponed. Despite that it was stated that no alternatives are rejected, six of thirteen alternatives did not end up in the combinations and were not analysed in more detail. Three of these alternatives are the measures in Germany (E1-E3). The measures in Germany were not included because they did not fit the scope of the project. For the alternatives reduction local wind waves (B2) and active control of retention areas (C1), no clear substantiation can be found why they were not calculated. However, during an administrative meeting it was stated that it is not desirable to actively regulate retention due to policy reasons.

3. How did uncertainties play a role in this process?

Uncertainties were not explicitly used as an argument for not calculating a solution or alternative (in more detail). However, uncertainties seem to influence the decision process implicitly. An example is the floodproof dike (A). There seemed to be a preference for this measure, since this alternative was calculated twice in more detail, namely in combination with the use of low-lying areas in the Vecht basin in the Netherlands and as an individual measure. Possible explanation could be that floodproof dike (A) is the only measure that can be completely realized in the district of WDODelta.

4. Which interactions with track of will formation and the track of image formation took place?

The first interaction with the track of will formation took place in the third phase 'alternative analysis'. During the first administrative meeting, the five types of solutions were discussed. During the first iteration phase, the alternatives were calculated individually. During the second administrative meeting, the combinations of alternatives were already made and analysed, and the results were presented to the general board of the regional water authorities Vechtstromen and WDODelta. The purpose of the administrative meetings is mainly informative and opinion-forming. The boards of the three initiating parties are kept informed of the progress and results, and the administrative support for possible solutions is examined. There are no decisions taken during the administrative meetings or consultations.

Interactions with the track of image formation starts during the second phase ‘alternative generation’. Stakeholders were involved in the project for the first time during the second phase alternative generation. The five solutions were discussed with the stakeholders and stakeholders were asked to think along and gave their opinions about possible alternatives. A total of four workshop sessions were organized where officials from municipalities, representatives of the regional water authorities and the province of Overijssel and various environmental organizations were asked about the feasibility of the alternatives and how they could be realised. The stakeholders in the river basin in the Netherlands were asked to actively participate in the decision-making process. Stakeholders in the German part of the catchment area were mainly kept informed of the research and the results.

In order to analyse how the facts are formed also the interactions within the track of fact formation were analysed. The first interaction with experts took place during the first phase solution space generation. The first expert consultations focussed mainly on the modelling tools and were aimed at creating a shared support base and to prevent discussion later on in the project. Extern experts were mainly involved in the approach and method for modelling the alternatives. In total, sixteen expert interactions took place during the project. Experts were involved in the generation of alternatives, were used a sounding board and for discussing and reviewing the modelling results. For the reviews of the results also extern experts were involved. Experts from the three initiators: regional water authorities Vechtstromen and WDODelta, and the Province of Overijssel were involved in most of the expert interactions.

6. Cross-case analysis

After the results were collected for both projects, a cross-case analysis was carried out which focussed on the similarities and differences between the results of two projects. The comparison is based on four research questions that were used to guide the analysis of the projects:

1. How were the solutions and alternatives generated?
2. What reasons were given for rejecting solutions and alternatives?
3. How did uncertainties play a role in this process?
4. Which interactions with track of will formation, track of image formation and within the track of fact formation took place?

1. How were the solutions and alternatives generated?

A comparison of the results of the generation of solutions and alternatives between the two projects is shown in Table 15. For both projects no new solutions were generated during the project. In addition, both projects did not use stakeholders to generate possible solutions. As far as the generation of alternatives was concerned, no alternatives were generated for the solutions at the Stadsdijken Zwolle project. In the POV Vecht project, two or three alternatives were generated for four out of five solutions. The generation of alternatives had also received input from stakeholders. During the first workshop session, experts and stakeholders from various parties discussed possible alternatives. With regard to the duration of the phases, both projects lasted about twenty months. For the Stadsdijken Zwolle project there were four phases of the decision-making process completed, and for the POV Vecht project there were three phases completed. The biggest difference here was the duration of the first two phases: solution space generation and alternative selection. The first two phases were completed in approximately two months in the Stadsdijken Zwolle project, while in the POV Vecht project the first two phases last approximately nine months. In the POV Vecht project, considerably more time was spent on the modelling tools at the start of the project and the creation of a shared expert support for the modelling tools to prevent discussions in the future.

Table 15: Comparison of results - Generation of solutions and alternatives

Generation of solutions and alternatives	***Stadsdijken Zwolle***	***POV Vecht***
Generation of solutions	*- Solutions were generated by experts from WDODelta, the province of Overijssel, Rijkswaterstaat and the municipality of Zwolle* *- Solutions were generated during one session* *- No new solutions were added during the project*	*- Solutions were generated by experts of the initiating parties and are later on discussed with extern experts* *- Solutions were generated during several months in which they were discussed with experts* *- No new solutions were added during the project*
Generation of alternatives	*- Few alternatives generated for the solutions* *- Stakeholders were not involved in generating solutions or alternatives*	*- Several alternatives were generated for four out of five solutions* *- Stakeholders were asked to give their input for the alternatives in order to get public support*
Duration of phases in the project	*- The first three phases were completed in just under nine months, with the first two phases going through in less than two months* *- The fourth phase lasted a little more than nine months*	*- The first three phases together lasted for about twenty months* *- The first two phases were completed in about nine months* *- The fourth phase and therefore the assessment of the alternatives did not take place*

2. What reasons were given for rejecting solutions and alternatives?

A comparison of the results of the rejection of solutions and alternatives between the two projects is shown in Table 16. The main difference between the rejection of the solutions and alternatives between the two projects is that in the Stadsdijken Zwolle project the majority the solutions were rejected early in the process, while no solutions were rejected at the POV Vecht project. As far as the rejection of alternatives was concerned, there were several arguments at the Stadsdijken Zwolle project to explain why it was decided to reject a solution or alternative. Most solutions were rejected after a qualitative analysis on the basis of an estimated effectiveness and/or costs. Contrary to this, in the POV Vecht project it was stated that no solutions or alternatives were rejected. However, in the POV Vecht project a number of alternatives was not modelled or was not modelled in more detail, without any substantiation for this. Implicit decisions may therefore had been taken and/or these interim decisions were not documented. The biggest difference between the two projects is the assessment of the solutions and alternatives. At the Stadsdijken Zwolle project, the assessment of alternatives mainly took place by expert of WDODelta, while the POV Vecht project organized several review sessions in which experts from extern organizations gave their thoughts and advice. Besides this, a final decision was taken at the Stadsdijken Zwolle project, while at the POV Vecht project the project stopped after the phase alternative analysis. What is noticed in the results is that almost the same alternative was generated and analysed in both projects. The alternative retention in dike ring 9 (E1) from the Stadsdijken Zwolle project concerns the same principle and area as the alternative floodproof dike (A) from the POV Vecht project. In both projects it was decided to calculate the effects of this alternative, whereby the conclusion from the Stadsdijken Zwolle project was that the alternative is not promising and was therefore rejected, whereas it was concluded in the POV Vecht project that this alternative is effective and promising. In the POV Vecht project it was decided to model this alternative twice in more detail.

Table 16: Comparison of results – Rejection of solutions and alternatives

Rejection of solutions and alternatives	***Stadsdijken Zwolle***	***POV Vecht***
Rejection of solutions	*- A large part of the solutions (6/9) was rejected early in the process, before the solutions were quantitatively analysed - Clear arguments/criteria why an alternative or variant was rejected*	*- There are no solutions rejected - Despite the fact that measures in Germany are regarded as not promising at the start of the project, they are still being modelled*
Rejection of alternatives and variants	*- There were few/no alternatives developed for the solutions. However, there were several variants of the Storm surge barrier (A) generated*	*- There is no actual decision to reject alternatives, however, some of the alternatives (6/13) are not analysed at all or are not analysed in more detail.*
Used argumentation	*- Most solutions were rejected based on estimated costs and effectiveness.*	*- There is little explanation why an alternative is not calculated or why it is not calculated in more detail*
Assessment of solutions and alternatives	*- The assessment of the solutions and alternatives took place within WDODelta - Final assessment and final decision were made - Variants of the Storm surge barrier were assessed on three criteria: impact on environment, technical feasibility and costs*	*- Assessing the solutions and alternatives was done within the team and with the help of external experts - Final assessment of alternatives did not take place, criteria for the final assessment had already been drawn up: technical feasibility, future-proof water system, adaptability in the environment, organizational feasibility, financial feasibility*

3. How did uncertainties play a role in this process?

One of the assumptions of this research, based on the study by Warmink et al. (2017), is that uncertainties play a role in the decision-making process when systemic measures are researched as an alternative to dike reinforcement. The results of both projects show that uncertainties are not explicitly used as an argument for rejecting the solutions or alternatives. However, implicitly uncertainties do seem to play an important role during the interim decisions that are made during the project. In the Stadsdijken Zwolle project it can be seen that all solutions that have high costs are the first alternatives to be rejected. This could be because the Flood Protection Programme only reimburses alternatives solutions to dike reinforcement if the costs of this alternative are lower. Also, solutions that need to be implemented outside the management area or need to be implemented on a large scale are the first ones to be rejected. In the Stadsdijken Zwolle project the two alternatives where most of the time is put into the Storm surge barrier (A) and the retention in Dike Ring 9 (E1). Both are alternatives can be realised within the management area of WDODelta. Also, in the POV Project, uncertainties seem to play a role implicitly. For example, in the POV Vecht project, the floodproof dike (A) was included twice in the more detailed analysis. First in combination with of using low-lying areas in the Vecht Basis and as an individual measure. The Floodproof dike (A) is also the only alternative which can be completely realized within the management area of WDODelta. What also emerges in the POV Vecht project is that a number of uncertainties were not taken into account or ignored. For example, at POV Vecht it is possible that number of dikes along the Overijsselse Vecht that need to be reinforced will be considerably lower than assumed at first, due to the development of modelling tools. This would result in a decrease of the cost-effectiveness of the systemic measures studied in comparison to dike reinforcement. This uncertainty was not included in the project.

4. Which interactions with track of will formation, track of image formation and within the track of fact formation took place?

The interactions with the track of will formation and the track of image formation and within the track of fact formation are discussed below.

Interaction with track of will formation

A comparison of the results of interaction with the track of the will formation between the two projects is shown Table 17. In both projects the first interaction with the track of will formation took place in the third phase analysis of alternatives. At that moment, all solutions and alternatives were known, and a number of alternatives were already rejected. The interactions with the track of will formation differ from each other because the interactions were much more focused on the final decision at the Stadsdijken Zwolle project. The trade-off between a dike reinforcement and the Storm surge barrier (A) is discussed with the administrators of WDODelta. The interactions with the track of will formation at the POV Vecht project, are much more informative in nature. There are no decisions taken yet. The boards of regional water authorities Vechtstromen, WDODelta and the province of Overijssel were kept informed of the process and the results and it was assessed whether there was administrative support for certain solutions or alternatives.

Table 17: Comparison of results - Interaction with the track of will formation

Administrative interaction	***Stadsdijken Zwolle***	***POV Vecht***
First involved	*- During the third phase: alternative analysis, but related to systemic measures after the fourth phase: weighting benefits and costs*	*- During the third phase: alternative analysis*
Goal	*- Focused on decision making* *- Interactions with management are mainly focused on the trade-off between the Storm surge barrier and a dike reinforcement*	*- Mainly consulting and informing* *- Keeping the board informed of the process and sharing results.* *- Assessing the administrative support for possible solutions*
Type of interaction	*- Administrative Support Group (ASG), Executive Board (EB) and General Board (GB)*	*- Only Executive Board (EB)*
Number of interactions	*- In total, six interactions with the ASG, EB and GB took place.*	*- During the project two interactions with EB took place*

Interaction with track of image formation

A comparison the interactions with the track of image formation between the two projects is shown in Table 18. In both projects, stakeholders were only involved after all solution have been generated. In the POV Vecht project, stakeholders were involved in the decision-making process earlier than stakeholders in the Stadsdijken Zwolle project. The POV Vecht projects invited stakeholders to give input for alternatives and asked stakeholders to think about the public support and implementation of these alternatives. In the Stadsdijken Zwolle project, considerably more interactions with stakeholders were organized than with the POV Vecht project. At the Stadsdijken Zwolle project there were a total of twenty stakeholder interactions during the project, of which twelve related to the systemic measures. The majority (seven out of twelve) of these interactions was with the Official Support Group (OSG). The interactions with the OSG were mainly focused on the final decision and the trade-off between the Storm surge barrier (A) and a dike reinforcement. During these interactions, there was also worked towards administrative decision-making. The Storm surge barrier (A) was being discussed during two interactions with stakeholders. The other solutions that were generated for the Stadsdijken Zwolle project were not discussed with stakeholders. In comparison, in the POV Vecht project there were six interactions with stakeholders organized. During two of these interactions, the German partners were involved in the project and were informed about the results. In four workshop sessions, stakeholders were actively involved in the decision-making process, informed about the results and it was discussed whether and how alternatives can be realised.

Table 18: Comparison of results - Interaction with stakeholders

Interaction with stakeholders	*Stadsdijken Zwolle*	*POV Vecht*
First involved	*- During the third phase: alternative analysis*	*- During the second phase: alternative selection*
Type of interaction	*- Most interactions with Official Support Group (OSG)* *- During one session, companies/associations located in the plan area were asked to think about the Storm surge barrier (A)* *- Two additional contact moments are organised with companies and residents after communicating the final decision in favour of dike reinforcement*	*- In two sessions in Germany, German partners were informed about the project and the results* *- In four workshop sessions, civil servants from municipalities, representatives from regional water authorities and the Province of Overijssel and various environmental organizations were asked to think about the alternatives and how these could be realised*
Goal	*- The official support group (OSG) is working towards administrative decision-making* *- In design workshops the public support for the Storm surge barrier (A) among stakeholders was assessed* *- In the extra contact moments, the final decision was explained to stakeholders*	*- Stakeholders in the river basin were asked to actively think along. The public support for the systemic measures was assessed* *- German stakeholders were kept informed about the developments of the research and the results*
Number of interactions	*- A total of twenty interactions with stakeholders, of which twelve relate to the systemic measures. Seven out of twelve interactions were with the OSG* *- In two interactions, stakeholders had the opportunity to give input to the Storm surge barrier*	*- A total of six interactions: two sessions with German stakeholders and four workshop sessions with stakeholders from the river basin, including officials from municipalities, environmental and agricultural organizations*

Interactions within the track of fact formation

A comparison of the results of the interactions within the track of fact formation between the two projects is shown in Table 19. In both projects, experts were involved during the first phase ‘solution space generation’. In the Stadsdijken Zwolle project, experts were involved to generate solutions and to qualitatively assess them. In the POV Vecht project, the experts played a greater role and were used to generate alternatives, as a sounding board, to create a joint basis for the results and to review modelling results. In the Stadsdijken Zwolle project, there were considerably fewer interactions with experts than within the POV Vecht project, namely seven (three of which relate to the systemic measures) versus sixteen in the POV Vecht project. In the POV Vecht project, more external advisors were asked to give their thoughts and opinions, not only experts from the Province of Overijssel, Rijkswaterstaat and the municipality of Zwolle were invited to expert meetings, but also several external advisers from, among others, engineering and consultancy firms.

Table 19: Comparison of results - Interaction with experts

Expert interaction	***Stadsdijken Zwolle***	***POV Vecht***
First involved	*- During the first phase: solution space generation.*	*- During the first phase: solution space generation.*
Goal	*- Experts are involved for generating solutions and qualitatively assessing solutions*	*- Experts are involved for the generation of alternatives, as a sounding board, for creating joint basis for the results and for reviewing the modelling results*
Number of interactions	*- Seven expert meetings take place, of which three consultations relate to systemic measures.*	*- A total of sixteen expert meetings take place - The modelling tools are extensively discussed with experts*
Involved parties	*- For the expert meetings regarding the systemic measures: WDODelta, Province of Overijssel, Rijkswaterstaat and Municipality of Zwolle - In the last expert consultation also two external advisers involved*	*- During the project experts from the three initiators are involved: Province of Overijssel, Regional water authority Vechtstromen and WDODelta - In the case of expert interactions, several external advisors are involved - German experts are also involved in the project*

7. Discussion

The aim of this study was to provide insights into the steps that lead to decisions about systemic measures in regional-high water projects by analysing and comparing for two projects how facts are formed and how authorities, stakeholders and uncertainties play a role in the formation of these facts. In this chapter the conceptual model, the results and the limitations will be discussed.

7.1. Reflection on conceptual model

The conceptual model that was established at the beginning of this study is based on two models: 1) The cycle for problem-solving described by Kolkman et al (2005) in which a decision-making process is considered as a process that is made of interim considerations and decisions, and 2) The track model Van Buuren (2007), in which a decision-making process is conceptualized in three tracks: the track of image formation, the track of will formation and the track of fact formation (Van Buuren, 2007).

The cycle for problem-solving is driven by the frames of the actors. A frame determines what someone considers important and contains someone's knowledge, assumptions, interests, values and beliefs. Frames are often implicit, meaning that they are not deliberately brought to the attention or discussed. Frames are driven by an underlying mental model. The mental model determines which data a person derives from the "real world" and what knowledge is derived from it. The mental model of an actor also determines which information is considered important (Kolkman et al., 2005). This research focused on the decisions driven by the frames of actors. The results show that uncertainties are not explicitly used as an argument for rejecting alternatives, but implicitly the uncertainties seem to play an important role in the steps that lead to decisions about systemic measures. This is a limitation of this research, because there was no explicit evidence found that uncertainties were the reason for rejecting solutions and alternatives. A possible explanation for this could lie with the underlying mental models. Further research is recommended to take a closer look at how mental models play a role in the decision-making process about systemic measures.

According to Van Buuren (2007), the tracks of fact formation, will formation and image formation come together through interactions. The rounds model of Teisman (1992) is focussed on interactions between involved parties and the results of those interactions. Koppenjan and Klijn (2004) describe the decision-making processes on the basis of interactions between the various actors. One of the findings of this study is that during decision-making processes the three tracks of the track model of Van Buuren (2007) are interacting with each other, but that is not just through direct interactions. One of the findings of this research is that interim decisions can be based on expectations of other actors. This does not correspond to the theory about the arenas described by Teisman (1992) and Koppenjan and Klijn (2004) which states that a decision-making process takes place in different arenas where most actors are only part of one arena, some actors are part of multiple arenas and some actors are not represented in any arena. From this study it seems that actors that are not present in an arena can still have an influence in the decision-making process that takes place, because decisions can be made based on the expectation of this actor. For further research, it is interesting to investigate whether these expectations are correct and where these expectations are based on.

The scope of this research was on the four steps leading to a decision: solution space generation, alternative selection, alternative analysis and weighting of benefits and costs. The results show that the step before these four steps, namely ‘problem definition’, also affects the decision-making process. The problem definition sets the boundaries of the solution space, which can be broad, or narrow and focus on a stakeholders’ preferences. Also, the decision criteria and weighting factors that are used to determine the most favourable solution are based on the definition of the problem (Kolkman et al., 2005). For further research it is recommended to research how the stakeholders’ boundaries of the problem definition influence the decision-making process.

7.2. Reflection on results

For this research two projects of WDODelta have been analysed. In the two projects, systemic measures were researched as an alternative to dike reinforcement. At the beginning of this research, the two studied projects seemed very similar: both projects are part of the 'Flood protection programme' and in both projects systemic measures are researched as an alternative to dike reinforcement. Nevertheless, there appears to be a difference between the results of the two projects. A possible explanation for this is the reason why the systemic measures were researched. In the Stadsdijken Zwolle project originally only alternatives for dike reinforcement were examined, but after it became apparent that more dikes did not meet the safety requirements also alternatives for systemic measures were investigated. Therefor the examination of the systemic measures was performed parallel to the examination of the alternatives for dike reinforcement. While in the POV Vecht project the whole project was focussed on the research of systemic measures. The reason and context for researching systemic measures is therefore different in the Stadsdijken Zwolle project as for the POV Vecht project. Another explanation for the difference in the results, is that the POV Vecht project is a type of pilot study. The underlying idea of a pilot study is that it is possible on a small scale and outside existing frameworks to develop and test innovative ideas. In addition, it is possible with pilot studies to gain support for innovations and to demonstrate its effectiveness (Van Popering-Verkerk & Van Buuren, 2017). Because there is more space and time in the POV Vecht project to explore alternatives, this could be another reason why there is a difference between the results of the two projects.

One of the expectations that were set at the start of this research, based on the study by Warmink et al. (2017), is that uncertainties play a role in the decision-making process when systemic measures are researched as an alternative to dike reinforcement. The results of both projects show that uncertainties are not explicitly used as an argument for rejecting the solutions or alternatives. However, implicitly uncertainties seem to play an important role in the interim decisions that are being made. In both projects there seems to be a preference for measures that can be realised within the district of WDODelta and have relatively low costs. For example, in the Stadsdijken Zwolle project, the solutions that are rejected first are solutions that need to be implemented outside the district of WDODelta, on a large scale or have high costs. The two alternatives where most time is put into are the storm surge barrier (A) and the retention in dike ring 9 (E1). Both alternatives can be realised within the district of WDODelta. Also, in the POV Vecht project, the floodproof dike (A) was included twice in the more detailed analysis. This is also the only alternative which can be completely realised within the district of WDODelta. According to Warmink et al. (2017) uncertainties are unavoidable in policymaking, but often uncertainties receive too little attention. From observations during the interactions with actors in the POV Vecht project it was noticed that uncertainties receive little attention. Only uncertainties in the model outcomes are communicated. A similar conclusion was drawn by Bergsma (2016). She concluded that in decision-making by administrators of regional water authorities in the Netherlands little attention is paid to the uncertainty in the research itself, used bandwidths and de value judgements that underlie the research (Bergsma, 2016, p. 38).

The interim decisions that are taken during a decision-making process seem to have a major influence on the outcome of a decision-making process. Competent decision-making should show all decisions and underlying assumptions, values and preferences. This allows better and open discussion about the most favourable alternative (Kolkman et al., 2005). However, some of the interim decisions are not well documented or communicated. This is one of the limitations of this research, since it was not always possible to determine which actor provided which arguments for rejecting certain solutions and alternatives.

8. Conclusions and recommendations

The aim of this research was to provide insights into the steps that lead to decisions about systemic measures in regional-high water projects by analysing and comparing for two projects how facts are formed and how authorities, stakeholders and uncertainties play a role in the formation of these facts. In order to do this, the following research questions were answered:

1. Which theoretical framework is appropriate for analysing the decision-making process in regional high-water projects?

Based on the literature study three assumptions are made about decision-making processes in the field of water engineering and management: 1) A decision-making process is built up of small considerations and decisions. It seems that the decision for the most favourable solution is taken at the end of a decision-making process, however prior to every major decision many small decisions are made by various bodies or management organisations that are responsible for parts of a project (Kolkman et al., 2005; Loucks et al., 2017). 2) Knowledge that is used for decision-making is spread over various actors in a decision-making process (Koppenjan & Klijn, 2004). This knowledge can be conceptualised into three tracks: the track of image formation, the track of will formation and the track of fact formation. These three tracks contain respectively the images, perceptions and interpretations of actors; the ambitions, sources and means of power of actors; and all facts and research. The tracks are interconnected and interdependent, but also develop independently of each other with their own dynamics (Van Buuren, 2007). 3) Uncertainties are inherent to water management and decision-making processes. Policy makers consider uncertainties as a complicating factor and are unwilling to accept and embrace uncertainties in their decision-making processes (Warmink et al., 2017). These assumptions were implemented in the conceptual model that was used for this research. This model builds upon two existing models: the problem-solving cycle described by Kolkman et al. (2005) which is focussed on a water engineering context and the track model described by Van Buuren (2007) which is focussed on a public administration context. The conceptual model that was used for this research is shown in Figure 21.

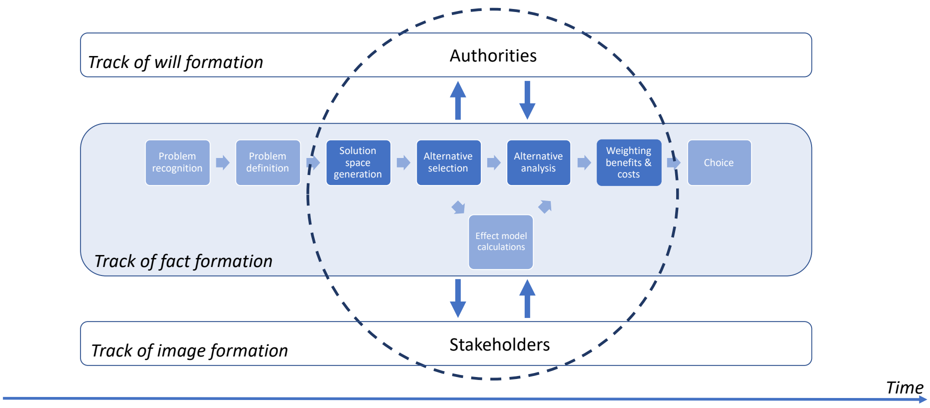

Figure 21: Conceptual model used to analyse the projects

2. How are facts formed about systemic measures in regional high-water projects?

For this research a case study is performed at regional water authority WDODelta in which two projects were researched in which systemic measures were examined as an alternative for dike reinforcement: the Stadsdijken Zwolle project and the POV Vecht project. In the Stadsdijken Zwolle project systemic measures are researched as an alternative to dike reinforcement. After it became clear that the number of dikes that did not meet the safety requirements (2017) had increased, systemic measures could be a cost-effective alternative. In the POV Vecht project it is investigated if systemic measures are effective in lowering the water levels and can add social value, after it was found that the majority of the dikes along the Overijsselse Vecht did not meet the safety requirements (2017).

For the formation of facts, it is examined what solutions and alternatives of systemic measures were generated and analysed, when solutions and alternatives were rejected and what reasons were used for rejecting the solutions alternatives. The results show that in both projects a similar method was used for the formation of facts. First, all solutions were generated at the beginning of the project. During both projects no new solutions were generated. Second, for some solutions alternatives were generated, which are options of how a solution could be realised. Then the promising alternatives were analysed quantitively. Both projects used extern engineering firms to analyse and model the effects of the alternatives. Based on these modelling outcomes, decisions were made to analyse solutions or alternatives in more detail or to choose the most favourable solution(s) or alternative(s).

In the Stadsdijken Zwolle project in total nine solutions for systemic measures were generated. After the generation of the solutions, almost no alternatives were generated. Most solutions were rejected because of the first estimation of the feasibility based on the expert judgement about the effect on reducing water levels and costs. It was expected that the effects of the solutions were too low, or the costs were too high (compared to a dike reinforcement). From the three promising solutions, two solutions were analysed in more detail by extern engineering firms. Based on these results it was decided that only one solution was feasible. In the POV Vecht project in total five solutions were generated. For the majority of the solutions, two or three alternatives were generated. Since the goal of the POV Vecht project was to research the effectivity of systemic measures it was stated that no solutions will be rejected during the project. The alternatives were then analysed in more detail by an extern engineering firm. Despite the fact that officially no alternatives would be rejected, out of the thirteen alternatives that were planned to analyse, only seven out of thirteen were eventually analysed in more detail.

3. How do authorities, stakeholders and uncertainties influence the formation of facts?

The authorities and stakeholders were not involved in the generation of solutions for both projects. During the generation of the solutions no interactions with stakeholders or authorities took place. In both project the authorities were involved after the alternatives were quantitively analysed. Interactions with the authorities were mainly focussed on summarizing the process, assessing the administrative support and preparing for the final decision. During the formation of facts, authorities were kept informed about the main results of the project. Interactions with stakeholders mainly took place in order to get input on alternatives and to research the public support for certain systemic measures. In both projects, stakeholders were not involved in the generation of solutions. In the POV Vecht project, stakeholders were involved earlier in the decision-making process than in the Stadsdijken Zwolle project. In the POV Vecht project, stakeholders were asked to actively participate in the decision-making process, by giving input on the generation of alternatives and giving their thoughts and ideas about the feasibility of the alternatives. In the Stadsdijken Zwolle project only one of the solutions was discussed with stakeholders. During interactions with stakeholders the public support for this solution was assessed. Indirect, authorities and stakeholders were involved in the project earlier, through experts, policy advisors and civil servants who were involved earlier in the earlier phases of the decision-making process. These experts were involved for generating solutions and qualitatively assessing the solutions.

Despite the fact that stakeholders and authorities are not always directly involved in the project, some of the interim decisions were based on expectations of these parties. This is also one of the interesting results of this study. In the literature the influences of stakeholders and authorities are usually represented by direct interactions between parties (Koppenjan & Klijn, 2004; Teisman, 1992). However, from the observations during the POV Vecht project and the arguments for rejecting certain solutions and alternatives in the Stadsdijken Zwolle project, it can be seen that sometimes interim decisions are based on expectations. This means that stakeholders or authorities can influence the decision-making process without being present.

One of the assumptions of this research was that uncertainties play a role in the decision-making process when systemic measures are researched as an alternative to dike reinforcement (Warmink et al., 2017). The results of both projects show that uncertainties are not explicitly used as an argument for rejecting the solutions or alternatives. However, implicitly uncertainties seem to play an important role in the interim decisions that were made. In both projects there seems to be a preference for systemic measures that can be realised within the district of WDODelta, on a small scale and have relatively low costs.

4. Which recommendations can be made, based on the comparison of the results of the two projects, about the formation of facts of systemic measures and the influence of authorities, stakeholders and uncertainties?

Based on the results of the case study and literature some recommendations can be made to about the formation of facts and the influence of authorities, stakeholders and uncertainties.

Firstly, this research showed that the interim decisions that are made in a decision-making process have a major influence on the final decision. However, some of these interim decisions were poorly documented. It is important to better document the interim decisions that are being made. Good quality decision-making should show all decisions and underlying assumptions, values and preferences. This will allow a better and open discussion about the most favourable alternative (Kolkman et al., 2005). Secondly, it is important to involve authorities and stakeholders more and earlier in the project, despite the fact that this can complicate decision-making processes. This research showed that authorities and stakeholders were involved in the project after all solutions were generated. In order to have competent decision-making, decisions should be made based on good-quality research and are supported by all actors, because the decisions fit in with their ambitions and problem perception (Van Buuren, 2007). When the ambitions and perceptions of actors are not adequately identified, this could lead to decision-making outcomes that do not fit the expectations or needs of actors involved. Lastly, with respect to the uncertainties that are inherent to water management it is important that regional water-managers start to involve uncertainties in their decision-making processes (Ascough et al., 2008). This research showed that uncertainties played a role implicitly in the decision-making process, but that this was not documented. Coping with uncertainties is unavoidable to water management, so water managers and policy makers should become better at using strategies to deal with uncertainties (Warmink et al., 2017). It is also important that these uncertainties are shared more with stakeholders. In the POV Vecht project only uncertainties in model outcome were presented to stakeholders and authorities. For the communication of uncertainties it is challenge to not only quantify the uncertainties, but also communicate it effectively in a way that it does not confuse the decision-making process (Loucks et al., 2017).

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Appendices

Appendix A – Overview of definitions of uncertainty

Author	Definition
Ascough et al. (2008)	"Incomplete information about a particular subject" (p. 387)
Brugnach et al. (2008)	"Uncertainty refers to the situation in which there is not a unique and complete understanding of the system to be managed." (p. 4)
Kok et al. (2017)	"Uncertainty exists when more outcomes are conceivable than can actually occur." (p.30)
Koppenjan and Klijn (2004)	"Uncertainty arises when parties are confronted with societal problems and do not know what the effects of their efforts to resolve them will be." (p. 6)
Refsgaard et al. (2007)	"A person is uncertain if s/he lacks confidence about the specific outcomes of an event. Reasons for this lack of confidence might include a judgement of the information as incomplete, blurred, inaccurate, unreliable, inconclusive, or potentially false." (p. 1546)
Sigel et al. (2010)	"A person is uncertain if he lacks confidence about his knowledge relating to a specific question." (p. 504)
Van den Hoek et al. (2014)	"Uncertainty refers to the situation in which there is not a unique and complete understanding of the system to be managed" (p. 374)
Walker et al. (2003)	"Any deviation from the unachievable ideal of completely deterministic knowledge of the relevant system" (p. 8)
Winch (2010)	"The lack of all the information required to take a decision at a given time" (p. 7)

Appendix B – Overview used sources Stadsdijken Zwolle

a. Documents

Code	Naam document	Datum document
D1	170404 Afwegingsnotitie VKA Zwartewatekering v1.0	4-apr.-17
D2	Bijlage 1 Systeemoplossingen Zwolle beargumentatie haalbaarheid 1.0.docx	11-nov.-15
D3	Offerteuitvraag technische haalbaarheid systeemmaatregelen HWBP-Project stadsdijken Zwolle	22-jan.-16
D4	PR3265_Concept_Rapport_Tech. haabaarheid maatr_v3.pdf	1-apr.-16
D5	PR3265_Rapport_Tech. haabaarheid maatr. Zwolle_eindoplevering	1-jun.-16
D6	20151116 Notitie stappenplan systeemmatregel.docx	16-nov.-15
D7	Memo vergroten faalkans Ramspolkering.docx	27-nov.-15
D8	ZL584-1-17-005.755-rapd-Milieueffectrapportage.pdf	20-apr.-17
D9	Bijlage 1 Verkenningenrapport HWBP Stadsdijken	22-aug.-17
D10	Narratief Werkplaatssessie ZWK concept (002).docx	12-feb.-17
D11	Bijlage 2 Gebiedsproces.pdf	11-aug.-17
D12	170213 Overzicht sessies, overleggen en communicatie - Verkenningsfase Stadsdijken Zwolle.docx	13-feb.-17
D13	290915 Verslag Expertsessie HWBP Stadsdijken Zwolle.pdf	?
D14	151124 Verslag expertsessie I_TB.docx	24-nov.-15
D15	151210 Verslag sessie meekoppelkansen en mogelijke alternatieven_conc.docx	10-dec.-15
D16	160114 Verslag sessie kansrijke alternatieven.docx	16-jan.-16
D17	Verslag ABG 9 februari 2016_concept.docx	9-feb.-16
D18	Notulen ABG 12 december 2016_concept.docx	12-dec.-16
D19	Notulen ABG 9 januari 2017_definitief.docx	9-jan.-16
D20	Verslag ABG 26 januari 2017_definitief.docx	26-jan.-17
D21	Verslag ABG 9 februari 2017_definitief.docx	22-feb.-17
D22	170220 Verslag ABG 20 februari 2017_def.docx	20-feb.-17
D23	170315 Verslag ABG 15 maart 2017_def.docx	15-mrt.-17
D24	170411 Verslag ABG 3 april 2017_versie 1.0.docx	11-apr.-17
D25	170424 Verslag ABG 24 april 2017_versie 1.0.docx	24-apr.-17
D26	170606 Verslag ABG 6 juni 2017 versie 1.0.docx	6-jun.-17
D27	Verslag BBG HWBP Stadsdijken Zwolle 26 feb_conc_na wijziging provincie.docx	26-feb.-16
D28	Bijlage 3 Notitie kansrijke alternatieven Stadsdijken Zwolle.pdf	10-feb.-16
D29	170519 Agenda BBG Stadsdijken Zwolle.pdf	19-mei-17
D30	HWBP ZW Verslag BBG HWBP Stadsdijken Zwolle 170519_definitief versie 1.0.docx	21-mei-17
D31	HWBP ZW Verslag BBG HWBP Stadsdijken Zwolle 170721_v1.0 def.docx	21-jul.-17
D32	170410 DB voorstel concept VKA HWBP Stadsdijken 1 0 ter vaststelling DB .docx	10-apr.-17
D33	151019 Oplossingen Zwolle.docx	19-okt.-15
D34	concept_besluitenlijst_db_18_april_2017 (1).docx	2-mei-17
D35	besluitenlijst_db_29_augustus_2017_definitief.pdf	12-sep.-17
D36	Concept%20besluitenlijst%20AB%20d.d.%2026%20september%202017%2019%201017MvR.pdf	31-okt.-17
D37	170829 DB voorstel defintief VKA HWBP Stadsdijken vs 1.0.docx	29-aug.-17
D38	Besluit%20Voorkeursalternatief%20(VKA)%20HWBP%20Stadsdijken%20Zwolle.pdf	29-aug.-17
D39	21062016 ENW adviesvraag WDOD Systeemmaatregel Zwarte Water v1.0.docx	21-jun.-16
D40	Opzet Ontwerpatelier 1 Deeltrajecten.docx	?
D41	160315 Verslag Ontwerpatelier 1 Kwaliteiten en Kansen DT1en2.docx	15-mrt.-15
D42	160315 Verslag Ontwerpatelier 1 Kwaliteiten en Kansen DT3.docx	15-mrt.-15

D43	160322 Verslag Ontwerpatelier 1 Kwaliteiten en Kansen DT4en5.docx	20-apr.-16
D44	160420 Verslag Ontwerpatelier 2 van Kansrijke Alternatieven naar Ruimtelijk Ontwerp DT1, 2 en 3.docx	20-apr.-16
D45	160420 Verslag Ontwerpatelier 2 van Kansrijke Alternatieven naar Ruimtelijk Ontwerp DT4 en 5.docx	20-apr.-16
D46	160713 Verslag ontwerpatelier 3 - def 160727.docx	27-jul.-16
D47	161027 Verslag ontwerpatelier DT 4 en 5 HWBP Zwolle_concept.pdf	27-okt.-16
D48	161128 Verslag brainstormatelier ZWK_concept.docx	28-nov.-16
D49	170220 Verslag ontwerpatelier dijkversterking Scaniaterrein_def.docx	20-feb.-17
D50	170228 Verslag ontwerpatelier deeltraject 4_concept.docx	28-feb.-17
D51	170316 Opzet terugkombijeenkomst.docx	16-mrt.-17
D52	170508 Vragen tijdens terugkoppelbijeenkomst 8 mei 2017.docx	08-mei-17
D53	D53 - ZL584-1-17-005.755-rapd-Milieueffectrapportage.pdf	20-apr.-17

Appendix C – Overview used sources POV Vecht

a. Documents

Code	Naam	Datum Document
D101	Uitvraag POV Vecht_onderzoek effectiviteit systeemmaatregelen DEF.docx	20-dec.-17
D102	P967 - POV Vecht Concept Eindrapport C04 20180803	1-jul.-18
D103	POV-Vecht opzet projectcontract versie 0 99 (002) (002).pdf	26-apr.-17
D104	Bespreekverslag Maatregelensessie 7 nov 2017 -v02.docx	7-nov.-17
D105	opzet en aantekeningen Bijeenkomst 6 september.docx	?
D106	P967 - Hydrologic POV Vecht Eindrapport D01 20181123.pdf	23-nov.-18
D107	Aantekeningen Expertsessies Barry.docx	?
D108	Aantekeningen barry Expertsessie 18-12.docx	19-dec.-17
D109	GRADE expertsessie aantekeningen 8-2-18.docx	8-feb.-18
D110	20180208 bespreekverslag Expertsessie 6 bruikbaarheid GRADE.pdf	8-feb.-18
D111	20170328 bespreekverslag collegiale reviewsessie startdoc 28 maart 2017 POV SHO Vecht def.pdf	28-mrt.-17
D112	verslag bestuurlijk overleg POV Vecht opm berry.docx	?
D113	bespreekverslag review Vechtstromen tussentijdse resultaten 29 mei 2018 01.docx	29-mei-18
D114	Bespreekverslag Eindreview 26 juni 01.pdf	28-jun.-18
D115	2.1 samengevoegde notulen Duitsland sessies v02.pdf	?
D116	20171016 Bespreekverslag Expertsessie 3 Review NvU POV 16 okt 17 versie_1.0.pdf	17-okt.-17
D117	20180409 Verslag tweede werkplaats POV.pdf	13-apr.-18
D118	20180711 Verslag derde werkplaats POV.pdf	11-jul.-18
D119	2.2 P967 Maatregelen Duitsland 20180411 C02_effect maatregleen DUI.pdf	13-apr.-18
D120	2.10 Beslisnotitie Maatregelenpakketten detailberekeningen POV Vecht_versie 4 DEF.pdf	15-mei-18
D121	181206 Verslag Bestuurlijke consultatie.docx	6-dec.-18
D122	verslag Hoogwaterperspectief Vecht 5 september.docx	?
D123	EDOP-#5207946-v1-CONCEPT_VERSLAG_Bestuurlijk_Overleg__POV_Vecht_20_dec_2018_(002).docx	20-dec.-18
D124	Bestuursvoorstel - 2018-12-11 Bestuursvoorstel PFO en DB Besluitvorming afronding POV Systeemmaatreg.DOCX	11-dec.-18
D125	Rapport Governance POV Vecht v2.docx	6-dec.-18
D126	Verslag Brainstormsessie groep Barry.pdf	14-nov.-17
D127	2. Bijlage 2 Beschikking pov Vecht 1.pdf	13-jul.-17
D128	9.3.2 20181223 Tijdlijn en mijlpalen POV Vecht technisch spoor DEF.docx	23-dec.-18
D129	D129 - Handreiking Stroomgebiedsbenadering HWBP_v0.5 tekstueel AL.docx	5-feb.-19

b. Presentations

Code	Naam	Datum presentatie
P101	P967 Globale verkenning maatregelen POV Vecht C02.pptx	?
P102	P967 Selectie maatregelen POV Vecht C01.pptx	?
P103	20170906 Expertsessie 1 Uitgangspunten Opgave keringen.pptx	06-sep.-17
P104	20170914 Expertsessie 2 Hydrologie en Hydraulica.pptx	14-sep.-17
P105	20171016 Expertsessie 3 vaststellen uitgangspunten.pptx	16-okt.-17
P106	Expertsessie PlausibiliteitModelinstrumentariumVecht_20_11_2017.pptx	20-nov.-17
P107	20171218_Expertsessie 5 GRADE reproductie werklijn.pptx	28-dec.-18
P108	20180419 Reviewsessie I Bevindingen en aanpak GRADE klooster.pptx	19-apr.-18
P109	20180605 Reviewsessie II Klooster.pdf	05-jun.-18
P110	P967 POV Vecht Werksessie 9 april 2018 D01.pptx	09-apr.-18
P111	Startoverleg Hydrologic_12-2-18.pptx	12-feb.-18
P112	20171129 Groslijst MAaatregelen_POV v02.pptx	29-nov.-17
P113	20180419 Bestuurlijk Overleg tussentijdse resultaten modelstudie.pptx	19-apr.-18
P114	20180905 Bestuurlijk Overleg eindresultaten onderzoek.pptx	05-sep.-18
P115	20180419 Bestuurlijk Overleg tussentijdse resultaten modelstudie.pptx	19-apr.-18

c. *Observations*

Code	Naam	Datum
O101	Werkplaatssessie 2	09-apr-18
O102	Expertsessie	05-jun-18
O103	Expertsessie	26-jun-18
O104	Werkplaatssessie 3	11-jul-18
O105	Werkplaatssessie 4	23-okt-18
O106	Bestuurlijk overleg 5 september	05-sep-18
O107	Bestuurlijke consultatie 6 december 2018	06-dec-18