Does collaboration enhance learning?

The challenge of learning from
collaborative water management research

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Preface

This thesis forms the end result of a little more than four years of research. At the beginning of the research I was swimming, and almost drowning, in the large pool of knowledge about public participation, adaptive management, expert knowledge use and participatory modeling. The planned deliverables for the NeWater project helped me to focus on participatory tools and adaptive transboundary river basin management regimes. Since I was not completely happy with this focus, however, I decided in the second year of the research to assess whether collaboration in research enhanced mutual learning by the involved stakeholders.

In parallel, my first case study concerning future flood management in the Lower Rhine basin had started. In the case, I collaborated with researchers from the ACER project and policymakers from the German-Dutch Working Group on Flood Management. One of the highlights was to travel together with Gert Becker through Germany and The Netherlands, in order to interview a broad range of flood management stakeholders. Another highlight was my two-month internship at Seecon in Osnabrück, during which I learned about facilitating participatory processes and co-formulated a plan for the collaborative scenario study in the case.

At the beginning of the third year of my research, I became involved in my second case study, concerning groundwater management in and around Delft. This case study was conveniently close by and very interesting, since there was an urgent issue at stake. My involvement in both cases ended in the second half of 2008. From that time on I spent most of my time analyzing the results and writing my thesis. Even though my writing skills improved over the years, the writing still required huge amounts of time, energy and perseverance. Therefore, I am very happy to present you this thesis, many parts of which have been published in conference proceedings and scientific journals.

In line with the topic of this thesis, I would like to reflect on what I learned during the last years. For what it is worth (see Chapter 4), I have the perception that I learned a lot. I learned by reading literature from fields in which I was inexperienced, such as social sciences. Moreover, I learned from collaborating with many researchers, policymakers and societal stakeholders from several countries. I learned how to perform qualitative research, how to write scientific publications and how the "research" world and the "policy" world function. Furthermore, I found out that collaboration between researchers from different

disciplines can be a real struggle. Finally, some "double loop" learning occurred: my research aim changed from "developing better tools for collaboration" to "evaluating collaborative learning".

Summary

Does collaboration enhance learning? The challenge of learning from collaborative water management research

In recent decades, several developments took place that emphasized the need for collaboration between policymakers, researchers and societal stakeholders in natural resources management. First, limitations to the expert knowledge of researchers were revealed. Second, society developed a stronger voice. And third, the need to take both technical and social aspects into account increased.

One of the claimed benefits of collaboration is that it enhances learning about the issue at stake among the collaborating stakeholders. This hypothesis is one of the key assumptions on which several popular management concepts, such as adaptive management, are based. Empirical evidence for this hypothesis is, however, not convincing because the number of empirical studies of collaborative learning is small and because the methods that are applied to assess collaborative learning in most studies do not provide comprehensive and detailed insights.

In this thesis, we address three questions:

1) To what extent do current river basin management regimes support adaptive management?
2) How can collaboration and learning be assessed?
3) To what extent and how does collaboration influence learning?

We addressed these questions by literature study and two case studies. The cases are collaborative research processes concerning future flood management in the Lower Rhine basin and groundwater management in and around the city of Delft.

First, we analyzed the support of current river basin management regimes to adaptive management. Adaptive management emphasizes the limitations of our knowledge and sees policies as hypotheses that have to be tested and continuously revised. Collaboration and learning are central elements in adaptive management. Although literature recognizes the importance of management regimes as enabling or limiting adaptive management, it lacks a comprehensive overview of regime features that support adaptive management.

Therefore, we developed such an overview in the form of a conceptual framework that describes the actor networks, policy processes, information management and legal and financial aspects that would support adaptive management. Subsequently, we applied the framework to the Rhine, Orange and other river basins. The application revealed that the management regime in the Rhine basin supports adaptive management relatively well. It may be more difficult to collaborate and learn in other river basins.

Second, we combined insights from literature and our own reasoning to develop a conceptual framework of the relation between collaboration and learning in natural resources management. We focused on collaborative research processes and on cognitive learning. We define cognitive learning as the process of change of individual perspectives, as well as the resulting changes in individual perspectives. Perspectives are more or less consistent and enduring cognitive representations of a specific issue and the position of the individual related to this issue, as seen by this individual. They incorporate technical knowledge, values and interests concerning the issue at stake. According to the developed conceptual model, collaborative processes may enhance cognitive learning by increasing the participants' exposure to the perspectives of other participants. However, selective and interpretative processes of individual "framing" determine which elements from others' perspectives stakeholders internalize in their own perspective and how. We identified specific factors that influence individual exposure to others' perspectives and individual framing. These factors are related to the collaborative process, research process, policy process and other processes.

Third, we developed a methodology to assess cognitive learning and the factors that may influence cognitive learning related to the collaborative process and other processes. Most evaluations of learning that we found in literature were based on participants' perceptions of their own learning and process observations only. To get a more complete view, we also assessed stakeholder perspectives before and after the collaborative research processes in the cases using Q methodology. In addition, we used common statistical analysis to assess 1) overall change in perspectives, 2) the influence of the presented research results on perspectives and 3) the development of consensus between stakeholders over time. To explain the learning that occurred, we observed the collaborative process, analyzed the interaction and the content of the discussions during workshops, conducted participants' workshop evaluations, analyzed individual perspectives and interviewed participants. Finally, we explored the relation between collaboration and cognitive learning by analyzing differences in the degree of learning between the two cases, between participants and non-participants in each case and between individual participants in each case.

The first case was a collaborative scenario study concerning future flood management in the Lower Rhine basin in Germany and The Netherlands. Three scenario workshops were organized, in which policymakers, researchers and

societal stakeholders developed a set of scenarios, strategies and criteria for success. The workshop results were input for a model study concerning the effects of expected changes and strategies on peak discharges of the Rhine. We assessed learning in a group of participants and a control group. About 60% of the respondents in both groups changed their overall perspective significantly over time and about 50% of the respondents in both groups learned from the research results. Furthermore, consensus among the participants increased slightly and consensus in the control group decreased. Overall, the results suggest that the collaborative process did not significantly enhance learning. This can be explained by the limited intensity of collaboration, the limited novelty of the research results and the large influence of other studies and the media.

The second case was a collaborative research process concerning 1) the effects of reducing a large groundwater abstraction in the city of Delft and 2) measures to prevent these effects. In the process, researchers, policymakers from local and regional governments and NGOs collaborated in steering group meetings and three workshops. In parallel, a model study was performed in order to assess the effects of reducing the abstraction on groundwater levels, water quality and ground level movement, and to assess the costs and benefits of alternative management strategies. This information was urgently needed to support decision-making. The results of the repeated Q sorting demonstrated that the overall perspectives of 11 of the 12 participants changed significantly, that 7 participants learned from the research results and that consensus increased only between the 3 steering group members. Overall, the results suggest that only intensive collaboration, such as occurred during the steering groups meetings, substantially increases mutual learning. In addition, learning appeared to be strongly influenced by individual interests, strategic considerations, the perceived fairness of the collaborative process and individual perceptions of the research.

Cross-case comparison suggests that only intensive collaboration enhances learning from research results and the development of consensus. Such intensive collaboration includes 1) attending many meetings, 2) discussing perspectives intensively and 3) participating actively in the research. Yet, intensive collaboration may not be a necessary and sufficient condition for learning. The case studies suggest that learning is also influenced by the participants' willingness and ability to collaborate and learn. Furthermore, the cases suggest that learning is influenced by many factors that are unrelated to the collaborative process. These factors include strategic considerations, individual knowledge, values and interests, the relevance, quality and presentation of the research, and the influence of the media and other studies. The relative influence of each factor on learning was different in the analyzed cases, and will probably be different in other cases.

From applying the research methodology in the cases, we learned that repeated Q sorting is a useful method for assessing cognitive learning, in particular in combination with interviews. Furthermore, we learned that the methods we applied for assessing the factors that may influence learning suited their purpose. The large number of influential factors and their strong interdependence, however, made it difficult to determine the influence of separate factors on cognitive learning. Therefore we recommend performing more case studies in which the number of potential influences on learning is limited. For example, one could assess the perspectives of participants directly before and directly after a collaborative event. Alternatively, more insight in the relative influence of a broader range of factors could be obtained by more in-depth analysis of a small number of individuals, their activities and their learning over longer periods of time.

Finally, we formulated recommendations for researchers, policymakers, and societal stakeholders who intend to organize or participate in collaborative research processes. Based on literature, we formulated seven lessons for collaboration:

1) Know each other;
2) Formulate research together;
3) Produce knowledge iteratively;
4) Present results in an attractive and clear way;
5) Reflect on knowledge critically;
6) Use appropriate tools and methods;
7) Use intermediaries in case of large differences.

Following these lessons may improve both the collaborative process and its results. It may enhance cognitive learning, but may also support other goals of collaboration, such as developing skills or good relations. Yet, the case study findings suggest that these lessons can only be put to practice through intensive collaboration. This requires a great investment of time, money and creativity. Therefore, we recommend to collaborate only when all stakeholders are sufficiently motivated and prepared to invest the resources that are required to make the collaborative process successful.

Tom Raadgever
Delft, April 2009

Samenvatting

Bevordert samenwerking leren? Hoe te leren van participatief onderzoek binnen het waterbeheer

In de afgelopen decennia hebben er verschillende ontwikkelingen plaatsgevonden die de noodzaak hebben onderstreept tot samenwerking tussen beleidsmakers, onderzoekers en andere belanghebbenden in het beheer van de leefomgeving. Allereerst werden beperkingen in de expertise van onderzoekers aangetoond. Ten tweede kreeg de maatschappij een veel sterkere stem. En ten derde nam de noodzaak om rekening te houden met technische en sociale aspecten toe.

Een van de veronderstelde voordelen van samenwerking zou zijn dat het onderling leren met betrekking tot de bediscussieerde vraagstukken versterkt. Deze hypothese vervult een sleutelrol in de onderbouwing van verschillende populaire beheerconcepten, zoals adaptief beheer (adaptive management). Het empirische bewijs voor de hypothese is echter niet overtuigend. Het aantal praktijkstudies naar leren door samenwerking is beperkt en veel van de gebruikte analysemethoden kunnen geen compleet en gedetailleerd inzicht verschaffen in de relatie tussen samenwerking en leren. Daarom richten we ons in dit proefschrift op de volgende vragen:

1) In hoeverre ondersteunen de huidige institutionele regimes adaptief stroomgebiedbeheer?
2) Hoe kunnen samenwerking en leren in kaart worden gebracht?
3) In hoeverre en hoe wordt leren beïnvloed door samenwerking?

Om deze vragen te kunnen beantwoorden hebben we een literatuurstudie en twee casestudies uitgevoerd. De cases zijn participatieve onderzoeksprocessen: 1) naar het toekomstige hoogwaterbeheer in het Rijnstroomgebied in Duitsland en Nederland en 2) naar het grondwaterbeheer in en om de stad Delft.

Eerst hebben we onderzocht in hoeverre de huidige institutionele regimes adaptief stroomgebiedbeheer ondersteunen. Volgens het concept "adaptief beheer" is de kennis over complexe beheervraagstukken beperkt. Als gevolg daarvan moet beleid worden gezien als een serie van hypotheses die continu getest en verbeterd moeten worden. Samenwerking en leren van (en met) elkaar staan centraal in adaptief beheer. In de literatuur wordt het belang onderkend

van institutionele regimes als versterkende of beperkende factoren voor adaptief beheer. De literatuur biedt echter geen compleet overzicht van institutionele factoren die adaptief beheer bevorderen. Om dit gat te dichten hebben we een conceptueel model ontwikkeld dat de actor-netwerken, de beleidsprocessen, het informatiebeheer en de juridische en financiële aspecten beschrijft waarvan wij aannemen dat ze adaptief beheer bevorderen. Vervolgens hebben we dit conceptuele model toegepast in de stroomgebieden van onder andere de Rijn en de Oranjerivier. De toepassing wees uit dat adaptief beheer, inclusief samenwerking en leren, beter wordt ondersteund door het regime in het Rijnstroomgebied dan door de regimes in andere stroomgebieden.

Ten tweede hebben we op basis van de literatuur en gezond verstand een conceptueel model ontwikkeld van de relatie tussen samenwerken en leren. We hebben ons specifiek gericht op samenwerking in onderzoek en cognitief leren. Cognitief leren omvat zowel het proces van verandering van individuele perspectieven als de resulterende veranderingen. Perspectieven zijn min of meer consistente en duurzame cognitieve representaties van een specifiek vraagstuk en de positie van een individu ten opzichte van dit vraagstuk, zoals gezien door dit individu. Ze bevatten technische kennis, waarden en belangen met betrekking tot het vraagstuk. Volgens het ontwikkelde conceptuele model worden deelnemers in samenwerkingsprocessen geconfronteerd met de perspectieven van andere deelnemers. Selectieve en interpretatieve "framing" processen bepalen vervolgens welke elementen daarvan een deelnemer daadwerkelijk internaliseert, en hoe. Het conceptuele model benoemt een set van specifieke factoren die van invloed kunnen zijn op individuele blootstelling aan - en framing van - andermans perspectieven. Deze factoren zijn gerelateerd aan het samenwerkingsproces, onderzoeksproces, beleidsproces en andere processen.

Ten derde hebben we een methode ontwikkeld om cognitief leren, samenwerkingsprocessen en ander factoren die cognitief leren kunnen beïnvloeden in kaart te brengen. De meeste evaluaties van leren in de literatuur zijn alleen gebaseerd op procesobservaties of de percepties van de betrokken actoren van hun eigen leerproces. Om een meer compleet beeld te krijgen, hebben wij daarnaast met behulp van "Q methodologie" in beide cases de perspectieven van de betrokken actoren gemeten, zowel voor als na het samenwerkingsproces. Vervolgens hebben we met behulp van gebruikelijke statistische analysemethoden de veranderingen in individuele perspectieven, de invloed van de gepresenteerde technische onderzoeksresultaten, en de ontwikkeling van consensus geanalyseerd. Om de gemeten veranderingen te kunnen verklaren, hebben we de samenwerkingsprocessen, interactiepatronen, inhoud van de discussies, deelnemerevaluaties van workshops, individuele perspectieven en interviews geanalyseerd. Ten slotte hebben we de relatie tussen samenwerking en leren verkend door de mate van verandering van perspectieven te vergelijken tussen de cases, tussen deelnemers en niet-deelnemers in elke case en tussen individuele deelnemers in elke case.

De eerste case was een participatieve scenariostudie met betrekking tot het toekomstige hoogwaterbeheer in het Rijnstroomgebied in Duitsland en Nederland. Tijdens drie workshops hebben beleidsmakers, onderzoekers en andere belanghebbenden een set van scenario's, beheerstrategieën en succescriteria ontwikkeld. De workshopresultaten dienden als input voor een modelstudie naar de effecten van verwachte veranderingen en mogelijke beheerstrategieën op piekafvoeren van de Rijn. We hebben onderzocht in hoeverre de workshopdeelnemers en een controlegroep van niet-deelnemers hebben geleerd. Circa 60% van de respondenten in beide groepen hebben hun perspectief met betrekking tot het toekomstig hoogwaterbeheer significant veranderd, en circa 50% van de respondenten in beide groepen hebben geleerd van de onderzoeksresultaten. Daarnaast is de consensus tussen de deelnemers licht toegenomen, terwijl de consensus in de controlegroep is afgenomen. Deze resultaten suggereren dat het samenwerkingsproces het leerproces niet significant heeft bevorderd. Mogelijke verklaringen hiervoor zijn de beperkte intensiteit van de samenwerking, de beperkte toegevoegde waarde van de onderzoeksresultaten en de sterke invloed van andere studies en van de media.

De tweede case was een participatief onderzoeksproces met betrekking tot 1) de effecten van de reductie van een grootschalige grondwaterwinning in de stad Delft en 2) maatregelen om negatieve effecten voorkomen. In het proces hebben onderzoekers, beleidsmakers van lokale en regionale overheden en andere belanghebbenden samengewerkt tijdens stuurgroepbijeenkomsten en drie workshops. Parallel aan het proces werd een modelstudie uitgevoerd om 1) de effecten van het reduceren van de winning op grondwaterstanden, waterkwaliteit en bodembeweging en 2) de kosten en baten van verschillende beheerstrategieën in kaart te brengen. Deze informatie was nodig om de besluitvorming te ondersteunen. De casestudie toont aan dat de perspectieven van elf van de twaalf deelnemers significant zijn veranderd, dat zeven deelnemers hebben geleerd van de onderzoeksresultaten en dat alleen de consensus tussen de drie leden van de stuurgroep significant is toegenomen. De resultaten suggereren dat alleen intensieve samenwerking, zoals heeft plaatsgevonden tijdens de stuurgroepbijeenkomsten, onderling leren substantieel bevordert. Daarnaast lijkt het leerproces van de deelnemers sterk beïnvloed door individuele belangen, strategische overwegingen en individuele percepties van het onderzoek en van de gelijkwaardigheid van ieders inbreng in het proces.

Analyse van beide casestudies suggereert dat leren van onderzoek en de ontwikkeling van consensus alleen door intensieve samenwerking worden bevorderd. Intensieve samenwerking wordt gekenmerkt door 1) het bijwonen van veel bijeenkomsten, 2) het intensief bediscussiëren van perspectieven en 3) het actief participeren in het onderzoek. Intensieve samenwerking is echter niet per definitie een noodzakelijke en voldoende voorwaarde voor leren. De casestudies suggereren dat leren ook wordt beïnvloed door de motivatie en het vermogen van de deelnemers om samen te werken en te leren. Daarnaast suggereren de resultaten dat leren wordt beïnvloed door verscheidene factoren

die niet gerelateerd zijn aan het samenwerkingsproces. Deze factoren omvatten strategische overwegingen, individuele kennis, waarden en belangen, de relevantie, kwaliteit en presentatie van het onderzoek en de invloed van media en andere studies. De relatieve invloed van elke factor verschilde per case en zal naar verwachting nog weer anders zijn in andere situaties.

Door het toepassen van de onderzoeksmethode in de casestudies hebben we geleerd dat het herhaald meten van perspectieven met behulp van Q methodologie een nuttige methode is om cognitief leren in kaart te brengen, vooral als de methode wordt aangevuld met interviews. Daarnaast hebben ook de methodes voor het analyseren van de factoren die cognitief leren beïnvloeden hun nut bewezen. Het grote aantal invloedsfactoren en de sterke samenhang tussen de factoren maken het echter moeilijk om de relatieve invloed van afzonderlijke factoren vast te stellen. Daarom bevelen we aan om meer casestudies te doen waarin het aantal factoren dat leren zou kunnen beïnvloeden beperkt wordt. Men kan bijvoorbeeld de perspectieven van deelnemers direct voor en direct na een bijeenkomst bepalen. Meer inzicht in de relatieve invloed van verschillende factoren zou daarnaast kunnen worden verkregen door een meer gedetailleerde analyse van een klein aantal individuen, hun activiteiten en hun leerproces gedurende langere periodes.

Ten slotte hebben we aanbevelingen geformuleerd voor onderzoekers, beleidsmakers en andere belanghebbenden die overwegen om een participatief onderzoeksproces te organiseren of eraan deel te nemen Op basis van de literatuur hebben we zeven lessen voor samenwerking geformuleerd:

1) Ken elkaar;
2) Formuleer het onderzoek gezamenlijk;
3) Produceer kennis iteratief;
4) Presenteer het onderzoek op een aantrekkelijke en begrijpelijke manier;
5) Reflecteer (kritisch) op kennis;
6) Gebruik passende methoden;
7) Schakel bij grote verschillen intermediairs in.

Het opvolgen van deze lessen kan cognitief leren bevorderen. Daarnaast kan het helpen om andere mogelijke doelen van samenwerking te bereiken, zoals het ontwikkelen van nieuwe vaardigheden en goede relaties. De casestudies wijzen echter uit dat het in de praktijk brengen van de lessen een intensieve samenwerking en een grote investering van tijd, geld en creativiteit vereist. Daarom raden we aan om alleen samen te werken als alle partijen voldoende gemotiveerd zijn en bereid zijn om alle middelen die nodig zijn voor een succesvol proces te investeren.

Tom Raadgever
Delft, April 2009

Contents

Chapter 1

Introduction

In recent decades, several interrelated developments took place that emphasized the need for collaboration between policymakers, researchers and societal stakeholders in natural resources management: 1) limitations to the expertise of researchers were revealed, 2) society developed a stronger voice, and 3) the need to take both technical and social aspects into account in decision-making increased. One of the claimed benefits of collaboration is that it enhances learning about the issue at stake between the collaborating stakeholders. This hypothesis is one of the key assumptions on which several popular management concepts, such as adaptive management, are based (Section 1.1). Empirical evidence for this hypothesis, however, is not convincing because the number of empirical studies of collaborative learning is limited and because the methods that are applied to assess collaborative learning do not provide comprehensive and detailed insights. In order to increase insight in the relation between collaboration and learning, we formulated three research questions: 1) To what extent do current river basin management regimes support adaptive management?, 2) How can collaboration and cognitive learning be assessed?, and 3) To what extent and how do collaboration and other factors influence cognitive learning? (Section 1.2). The first question was addressed by literature study and interviews. The second and third question were answered by literature study and two in-depth case studies. The literature study supported the development of a conceptual framework of the relation between collaboration and learning and the development of a case study methodology. The case studies were performed to test and refine the conceptual framework. The cases studied are collaborative research processes concerning future flood management in the Lower Rhine basin and groundwater management in and around the city of Delft (Section 1.3). We end this chapter by describing the structure of this thesis (Section 1.4).

1.1. Background

Early in the 20th century, water management policy was the exclusive domain of policymakers and technical experts. Since the 1980s, however, various interrelated developments took place that stressed the need to consider the knowledge, values and interests of policymakers, researchers and societal stakeholders in policymaking (Dewulf et al. 2005; Gibbons et al. 1994; Steyaert and Jiggins 2007; Wesselink 2007). First, limitations to expert knowledge, such as inherent uncertainties and assumptions, were revealed. Second, the social dimension of water management became more important in research and awareness increased of the need to take the interrelations between technical and social aspects of water management fully into account (Pahl-Wostl 2004). Third, society developed a much stronger voice than in the past and proved to be able to effectively oppose management plans that did not match their values and interests.

Integrated water resources management (IWRM) and adaptive water management are concepts that have been developed to cope with complexity and change (Pahl-Wostl 2004). The concepts call for considering the knowledge, values, and interests of a broad range of stakeholders. IWRM emphasizes the need to consider all aspects and functions of the water system, and to develop sustainable solutions (e.g. Global Water Partnership - Technical Advisory Committee 2000; Margerum 1999; Mitchell 1990; Mitchell 2005). Adaptive management emphasizes the limitations of our knowledge and sees policies as hypotheses that have to be tested empirically through their implementation, and have to be continuously revised (e.g. Folke et al. 2005; Holling 1978; Pahl-Wostl 2007). Furthermore, IWRM, adaptive management and many other modern concepts for natural resources management stress the need for public participation in decision-making (e.g., Mostert 2005b), public participation in research (e.g., Douglas 2005), science-policy collaboration (e.g., Maasen and Weingart 2005) and mutual learning (Mostert 2007).

A central hypothesis in the literature is that stakeholder collaboration enhances mutual learning (e.g., Boonstra 2004; Busenberg 1999; Gray 1989; Hisschemöller 2005; Muro and Jeffrey 2008; Stringer et al. 2006). Learning, however, means different things in different disciplines (Dillenbourg et al. 1996), such as psychology (Fischer 2002) and policy sciences (Bennett and Howlett 1992), and with different adjectives (van de Kerkhof 2004), such as "social learning" (Bandura 1977; Muro and Jeffrey 2008) and "organizational learning" (Argyris and Schön 1978; Boonstra 2004). Learning by individuals can be broadly defined as a process in which individuals relate to the social and physical environment, e.g. through thinking, feeling, perceiving and behaving (Kolb 1984), and adapt to it, e.g., by developing new perspectives, skills and/or actions (Craps 2003).

In this thesis, we focus specifically on cognitive learning by participants in collaborative processes. By cognitive learning we mean the process in which individual "perspectives" or "mental models" (Doyle and Ford 1998; Kolkman et al. 2005) change, as well as the resulting changes in perspectives. We define a perspective as a more or less consistent and enduring cognitive representation of a specific issue and the position of the individual related to this issue, as seen by the individual. It includes the individual's knowledge, values and interests concerning the issue at stake. When individuals exchange their perspectives and reflect on each others' perspectives in a collaborative process, their perspectives may change.

The joint results of a collaborative process may reflect the individual cognitive learning that took place. The substantive quality of the process results, e.g., policies, may be improved when they reflect the variety of the perspectives of the participants. Second, consensus among the participants may increase through reflection on, and discussion of, their perspectives. This may increase support for the implementation of the process results.

1.2. Topic of research

Problem statement
While many claim that collaboration enhances cognitive learning, others claim that the relation between collaboration and learning is not so evident. Critics have questioned for various reasons whether intensive collaboration is an effective and efficient way to support learning in specific situations. First, they consider that collaboration and learning may not be feasible without an enabling institutional set-up (Folke et al. 2005; Gunderson 1999; Johnson 1999; Walters 1997). Second, there are many differences between researchers, policymakers and societal stakeholders, which may cause misunderstanding (e.g., Borowski and Hare 2006; Caplan 1979; Weiss 1977) and limit mutual learning. Third, collaboration may have negative consequences, such as explicit conflict about sensitive issues. And fourth, the efficiency of collaboration is often questioned, as the transaction cost of collaboration may exceed the benefits of collaboration (Dombrowsky 2007).

In order to judge the validity of the different claims that are made about the relation between collaboration and learning, we sought empirical evidence of collaborative learning, and the factors that may limit it. We found such evidence in a limited, but growing number of case studies in natural resources management practice (e.g., Daniels and Walker 1996; Leach et al. 2002; Saarikoski 2000; Steyaert and Jiggins 2007). The findings of these case studies indicate that collaboration enhances cognitive learning, but not in every situation. The findings, however, are based on the participants' perceptions of their own learning, obtained through interviews or questionnaires, or on

observation and analysis of the collaborative process, e.g., the discussion content.

Instead, we think that a structured, repeated measurement of perspectives (e.g., Niemeyer 2004; Pelletier et al. 1999) is needed to assess cognitive learning. Because processes of cognitive change are mostly diffuse, indirect and intuitive, individuals are only partly aware of their own perspective and how it changes over time (Beratan 2007; Weiss 1977). Therefore, participants' perceptions of learning may be incomplete, may lack sufficient detail, and may be biased (cf. Innes and Booher 1999). Furthermore, process observations can capture only fragments of perspectives and changes therein.

Aims

The main aims of this research were to 1) collect existing theoretical and empirical insights about whether and how collaboration between researchers, policymakers and societal stakeholders enhances mutual learning, and 2) add to the existing knowledge base by assessing cognitive learning, and the factors that influence it, in water management practice. A secondary aim of the research was to develop and apply a methodology to assess in a detailed and structured way cognitive learning, collaborative processes and other factors that influence learning.

Focus and scope

We focused our analysis on collaboration between researchers, policymakers and societal stakeholders in collaborative research processes. Such collaboration can be useful for policymakers and societal stakeholders who are confronted with technical knowledge gaps and can use research results to make well-informed and legitimate decisions. Such collaboration can also be useful for researchers who want to increase their influence on policymaking or who have to do policy-relevant research in order to obtain research funding (Martin 2003; Neilson 2001).

A collaborative research process can enhance learning by policymakers and societal stakeholders by enhancing mutual trust (e.g., Wynne 1996) and by facilitating the production and exchange of policy-relevant and understandable research results. We assessed changes in overall perspectives on the issue at stake, focusing on assessing and explaining cognitive learning from the presented technical research results. We did not assess cognitive learning by the involved technical researchers in detail. We did, however, assess to what extent they took the perspectives and preferences of the other stakeholders into account, e.g., in their modeling, and how this influenced cognitive learning.

We performed our research in two cases. The first case concerned future flood management in the Lower Rhine basin in Germany and The Netherlands. The second case concerned groundwater management in and around the city of Delft, in the western part of the Netherlands. Thus, both cases concerned water

management issues. Even so, the findings may also be useful for other policy domains in which policymakers, researchers and societal stakeholders intend to enhance mutual learning by collaboration. This may be the case in all fields of natural resources management that have been confronted with the developments sketched at the beginning of this introduction. Similarly, the conceptual framework and the case study methodology are in our opinion relevant for the whole domain of natural resources management (and maybe even beyond).

Furthermore, both case study areas were located in the Rhine basin. Although many of the insights are also relevant for other basins, the institutional setting in other basins may not be as supportive to collaboration and learning. This point is elaborated in Chapter 2 and in the conclusions of this thesis.

Finally, we did not only study whether collaboration enhances learning, but also how specific factors related to the collaborative process, the research process, the policy process and other processes influence learning. These factors may influence to which knowledge an individual is exposed and how the individual selects and interprets this knowledge (see Section 3.3).

Research questions
In order to gain insight in the relation between collaboration and cognitive learning, we addressed the following questions:

1. To what extent do current river basin management regimes support adaptive management?

2. How can collaboration and cognitive learning be assessed?

    a. How can cognitive learning be assessed?
    b. How can collaborative processes be assessed?
    c. How can other factors that may influence cognitive learning be assessed?
    d. How can cognitive learning be related to collaborative processes?

3. To what extent and how does collaboration influence cognitive learning?

    a. To what extent does cognitive learning occur in water management practice?
    b. To what extent and how does collaboration influence cognitive learning?
    c. To what extent and how do other factors influence cognitive learning?

The first research question was intended to provide the context for the rest of the research. We addressed the question in order to be able to compare the support for collaborative learning in the Rhine basin, in which the cases were situated, with the support for collaborative learning in other basins. The second research question is a methodological question that reflects the secondary aim of the research. We addressed the question in order to develop an appropriate

methodology for assessing cognitive learning and for relating it to collaboration and other factors that may influence learning. Finally, the third research question directly reflects the main aims of the research. We addressed this question in order to improve current insight in the relation between collaboration and learning in water management practice.

1.3. Research methodology

The research consisted of literature study and detailed analysis of two cases. In order to address the first research question, we studied literature about transboundary river basin management, adaptive management, and the institutional regimes in seven transboundary river basins. We identified institutional conditions that may support adaptive management, and assessed how well these conditions are fulfilled in seven basins around the world.

In order to address the second research question, we performed a literature study, in which we explored existing methods for assessing collaboration and learning. Based on the literature, we decided to assess cognitive learning by measuring changes in individual perspectives over time with a repeated Q sorting questionnaire. Furthermore, we decided to assess the collaborative process and other factors that may influence learning using process observations, participants' workshop evaluations and interviews. The practical strengths and weaknesses of the methods were tested in the cases.

Finally, in order to address the third research question, we performed different research activities: 1) literature study, 2) analysis of single cases, 3) cross-case analysis and 4) confronting insights from the literature with case study findings. First, we explored factors that may influence cognitive learning in collaborative research processes in literature about the science-policy interface, public participation, collaborative knowledge construction, learning and framing. Second, we assessed the relation between collaboration and learning in two collaborative research processes in the Rhine basin. Third, we compared the cases and confronted propositions from the literature about the factors that influence learning with the case study findings.

1.4. Structure of the thesis

In Chapter 2 of this thesis we address the first research question. We specify what institutional features are expected to support adaptive management, and assess whether these features exist in the Rhine basin and other river basins. Since collaboration and learning are central in adaptive management, many of the features that support adaptive management, support collaborative learning as well. The findings of the chapter help to evaluate the relevance of empirical insights obtained in the Rhine basin for other basins.

After the assessment of institutional regimes, we focus on the issue of cognitive learning in collaborative research processes. In Chapter 3 we analyze literature about collaboration and learning, and summarize lessons from literature about how to collaborate in research. Moreover, we develop a conceptual framework of the factors that may influence cognitive learning related to the collaborative process, research process, policy process and other processes. The framework gives a preliminary answer to the third research question. Subsequently, in Chapter 4, we analyze literature about the assessment of collaboration and learning, and develop our own research methodology. This way, we address the second research question.

In the remaining chapters we improve our answer to the third research question. In Chapter 5 and 6, we test the developed conceptual framework by applying the developed methodology in the case studies. Chapter 5 concerns the case of future flood management in the lower Rhine basin and Chapter 6 concerns the case of groundwater management in Delft. Finally, we synthesize the research findings in Chapter 7, which consists of four parts. In the first part of the chapter we compare and synthesize the findings from both case studies. In the second part of the chapter we discuss the strengths and weaknesses of the applied methodology. The chapter ends with the main conclusions and the main recommendations of this research.

Chapter 2

Assessing management regimes in transboundary river basins: do they support adaptive management? [1]

River basin management is faced with complex problems that are characterized by uncertainty and change. In transboundary river basins, historical, legal, and cultural differences add to the complexity. The literature on adaptive management gives several suggestions for handling this complexity. It recognizes the importance of management regimes as enabling or limiting adaptive management, but there is no comprehensive overview of regime features that support adaptive management. In this chapter, we present such an overview, focused on transboundary river basin management (Section 2.1). We inventoried the features that have been claimed to be central to effective transboundary river basin management (Section 2.2) and refined them using adaptive management literature (Section 2.3). We collated these features into a framework describing actor networks, policy processes, information management, and legal and financial aspects. Subsequently, we applied this framework to the Orange and Rhine basins. The results of the analysis suggest that the regime in the Rhine basin supports adaptive management relatively well. The support of the regime in the Orange basin to adaptive management appears more limited, but a lot of progress has been made in recent years (Section 2.4). We conclude that the framework provides a consistent and comprehensive perspective on transboundary river basin management regimes, and can be used for assessing their capacity to support adaptive management (Section 2.5).

2.1. Introduction

In the past, river basin management was often the exclusive realm of hydraulic engineers, who managed the river for a single purpose only, such as navigation or hydropower. Nowadays, river basin management is often multi-purpose and basin-wide, and involves many more actors (cf. Ridder et al. 2005). Moreover, river basin management has to deal with increasing rates of human-induced change and increasing concerns about the causes and consequences of these changes (Pahl-Wostl 2004; Toffler 1980). In transboundary river basins, differences in legal frameworks, historical and cultural backgrounds, and technical capabilities add to the complexity (Timmerman and Langaas 2005).

Adaptive management has been proposed as a way of dealing with uncertainty and change (Holling 1978). It aims at developing robust and flexible management strategies that perform well under different possible futures and can be modified if necessary. It acknowledges that current knowledge will never be sufficient for future management (Pagan and Crase 2004). Therefore, policies are treated as hypotheses and their implementation as experiments to test them (Gunderson 1999; Walters and Holling 1990). Adaptive management requires a process of active learning by all stakeholders, and continuous improvement of management strategies by learning from the outcomes of implemented policies (Geldof 1995; Pahl-Wostl 2004; Pahl-Wostl 2007). The learning process is not a matter of random trial and error, but a structured, cyclical process, involving 1) integrated assessment of current problems and possible solutions as perceived by different stakeholders, 2) setting goals, 3) formulation of policies that are hypothesized to contribute to reaching the goals, 4) implementation, to test the hypotheses, through 5) systematic monitoring and evaluation of policy outcomes, including surprises (Figure 2.1). In practice, these are not distinct stages, as the system pulses through alternating spurts of learning and implementing.
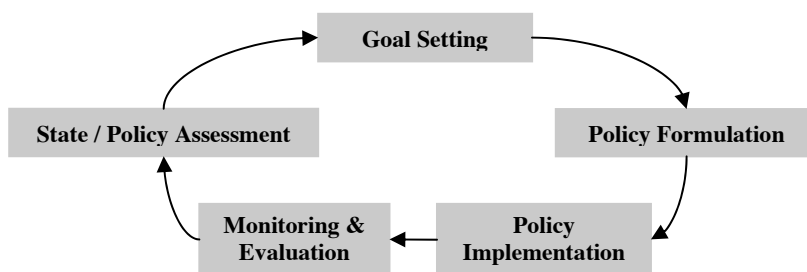
Figure 2.1. The adaptive management cycle (Pahl-Wostl 2007)

By involving all relevant stakeholders in the assessment and goal-setting stages, an overview of relevant technical knowledge, values, and interests can be obtained. Such an overview allows for designing "experiments" that minimize

the risk of degradation of the ecosystem, in particular irreversible change, and failure of ecosystem services. Furthermore, joint policy formulation, implementation and evaluation may improve learning and increase support for policy changes. One strategy to avoid unnecessary risks is to use simulation models to develop system knowledge and inform the debate (Lee 1999).

Despite its popularity, adaptive management is not without its problems. First, the meaning of adaptive management is not fixed. Within the literature, two interpretations of adaptive management can be distinguished: "scientific adaptive management," which focuses on experimentation as a means to learn more about the social ecosystem, and "adaptive co-management," which emphasizes the importance of stakeholder involvement (cf. McLain and Lee 1996; Olsson et al. 2004). Secondly, although the number of examples of adaptive management is increasing (e.g., Gilmour et al. 1999; McLain and Lee 1996; Tompkins and Adger 2004), these examples often remain limited to small scales and to modeling instead of experimentation (Lee 1999; Walters 1997). One explanation given for this in the adaptive management literature is that current institutional settings are often too constraining and inflexible to allow continuous improvement (e.g., Folke et al. 2005; Gunderson 1999; Johnson 1999; Walters 1997). Yet, this literature does not provide us with a comprehensive overview of institutional factors that support adaptive management (cf. McLain and Lee 1996).

This chapter sets out to provide such an overview in the form of a framework for assessing the adaptive capacity of transboundary river basin management regimes. First, it identifies the features of transboundary management regimes that are mentioned in water management literature as central to effective management. Second, it complements and refines these features using adaptive management literature and elaborating on it. These features are subsequently collated into a framework for assessing the adaptive capacity of transboundary river basin management regimes. Finally, the paper applies the framework to two selected regimes - the management regimes of the Orange Basin in Southern Africa and the Rhine Basin in Western Europe - in order to test whether it can be used for describing and assessing actual regimes. The chapter concludes with a discussion of the framework and recommendations for further research.

2.2. Key features of transboundary management regimes

There are presently some 260 transboundary river basins around the world, covering 45% of the land surface of the earth (Wolf et al. 1999). Unilateral action in these basins is often ineffective, inefficient, or simply impossible, e.g., a dam on a boundary stretch of a river. Moreover, it can harm the other basin countries (UN ESCAP 2003). For this reason, transboundary cooperation is necessary.

Transboundary cooperation is shaped by, and contributes to, the development of transboundary management regimes. According to Krasner (1983), a transboundary regime consists of "implicit or explicit principles, norms, rules, and decision making procedures around which actors' expectations converge in a given area of international relations." Consequently, river basin management regimes are defined as the principles, norms, rules, and decision-making procedures around which actors' expectations in (transboundary) river basin management converge.

In this chapter, we focus on five central regime elements: actor networks, water law, water policy, information management, and financing systems (see Figure 2.2). Key elements are the - relatively stable but not unchanging - actor networks. The actor networks make the laws and policies, which in turn influence their activities (cf. structuration theory: Giddens 1984). Management regimes can be distinguished from operational management: the technical measures and the regulatory, financial, and communicative instruments that directly intervene in the physical river basin system, or directly address the users of the river and the river basin. Moreover, management regimes can be distinguished from the general institutional and political context and from regimes in other policy fields (see Figure 2.2). This section summarizes the main features of transboundary river basin management regimes that are mentioned in literature as being central to effective management.

Actor Networks
Transboundary cooperation can be institutionalized by the establishment of international river basin commissions (Dieperink 1998)). Ideally, they should support an interdisciplinary and intersectoral approach (Wolf 1998). International river basin authorities with decision-making and enforcement powers can be practical for performing specific operational tasks, like restoration of water quality or operation and management of infrastructure (Mostert et al. 1999). Non-governmental organizations (NGOs) and donors can play a valuable role in transboundary river basin management as well. Although this may take more time initially, involvement of NGOs and the general public can support cooperation and enlarge the acceptance of proposed measures (Huisman et al. 2000).

Legal Framework
Transboundary river basin management can be analyzed in terms of the development and implementation of international "agreements," such as treaties, protocols, gentlemen's agreements, tact understandings, etc., including binding laws and non-binding policies (Bernauer 2002; Mostert 2005a). To conform to international law, agreements should reflect the relevant principles of equitable and reasonable utilization, the obligation not to cause significant harm, and the duty to notify and exchange information (Mostert et al. 1999). Another important aspect is how the legal framework deals with information exchange and communication across different legal and institutional frameworks, cultures,

and languages (Gooch et al. 2006). Finally, the likelihood and intensity of dispute decreases when treaties, as well as water management bodies, have the capacity to absorb rapid physical or institutional change (Wolf et al. 2003).
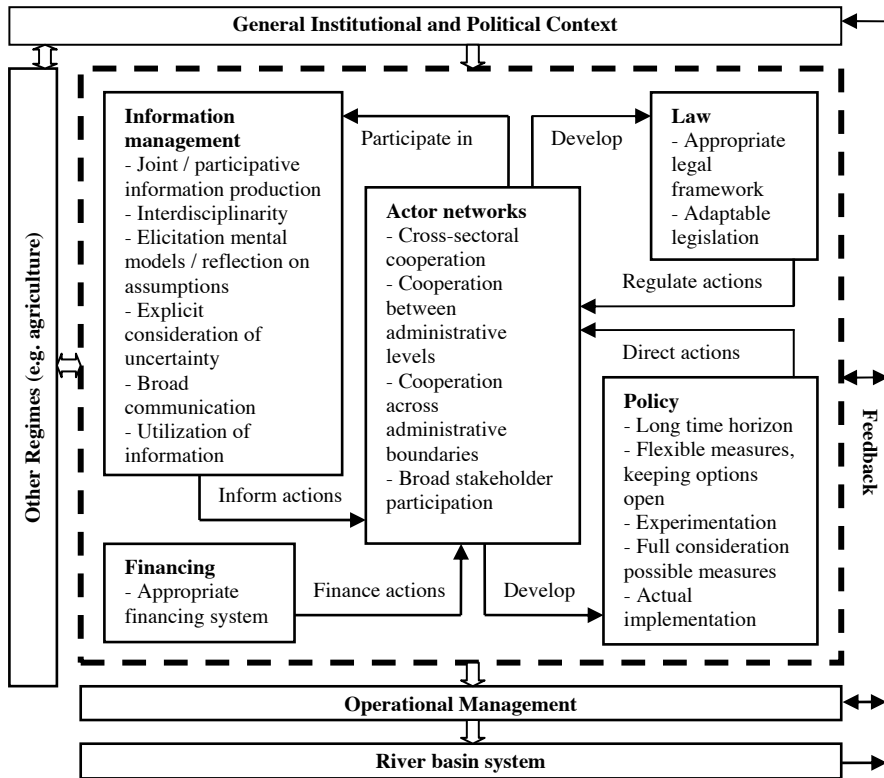
Figure 2.2. River basin management regime and criteria for an adaptive regime

Policy
Policy refers to the goals of government, or other organizations, and the strategies to reach these goals. Policies can be recorded in formal documents or followed in practice. To promote effective implementation, policies should be tailored toward the specific interests and resources of the involved parties (Marty 2001). In addition, policies should be updated periodically to provide an opportunity to adapt objectives and measures to changing conditions and the opinions of society (Huisman et al. 2000; Marty 2001).

Information Management
Information management is the iterative process of determining information needs, and producing, exchanging, and using information. Cooperation in information management, e.g., joint monitoring, is often an effective way to start developing trust between riparian countries. Free access to information is an essential precondition for this (Mostert et al. 1999; van der Zaag and Savenije

2000). National governments and transboundary commissions should exchange information and actively disseminate information to the public (Nilsson 2003). This can result in the development of an improved technical capacity, more mutual understanding, a shared vocabulary and shared insights (Mostert et al. 1999; van der Zaag and Savenije 2000). To broaden the knowledge base and prevent selective information use, institutional mechanisms should be put in place to ensure that all available information is used. These mechanisms include requirements for public participation and offering possibilities for counter expertise (Timmerman 2004).

Financing
Without a good financing system, transboundary river basin management is not viable in the long run. The costs of transboundary river basin management include the costs of producing a diverse set of public goods (e.g., flood protection) and market goods (e.g., hydropower), as well as the costs of the management process itself (e.g., travel costs). In so-called developing countries, international donors and banks often bear the management costs of negotiating an international treaty, but they may also finance river basin commissions and research projects for a longer time, and give loans for specific projects. The effectiveness of donor and bank involvement can be improved greatly when they coordinate their activities better (Mostert 2005a; Mostert et al. 1999; Wolf 1998). However, too much dependence on donors and banks makes management vulnerable. Financial as well as ecological sustainability can be improved by recognizing water as an economic good and recovering the costs as much as possible from the users (Global Water Partnership 2003). Water pricing can reduce excessive water use, but at the same time, access to clean water and sanitation should be offered to all people at an affordable price (International Conference on Water and the Environment 1992). The provision of public goods and the management costs can be financed from national taxes, such as general taxes or a tax per hectare. Governments should have a financing strategy to match income with costs (Global Water Partnership 2003).

Cooperation Process
In addition to regime features, literature on transboundary river basin management also contains many lessons for the international cooperation process. Probably the most important requirement for successful international cooperation is mutual trust, which can only be developed in small steps (Huisman et al. 2000; Mostert et al. 1999). Political cooperation can more easily be established when technical cooperation is already in place. To convince upstream parties of the need for cooperation, downstream parties often have to be alert and creative (Dieperink 1998; van der Zaag and Savenije 2000). It is also important to identify and solve conflicts before they escalate (Wolf 1998). Water management disputes can often only be solved through active dialog among the disciplines that are relevant for the issue at stake, and by involving policy sectors other than water, as this can open up new opportunities for win-win situations, e.g., through issue linking (Huisman et al. 2000; Mostert et al.

1999; van der Zaag and Savenije 2000). Other mechanisms that can be used for overcoming conflicting interests include financial compensation and accepting less favorable agreements in the expectation that other countries will do the same ("diffuse reciprocity", LeMarquand 1977; Mostert et al. 1999).

2.3. Adaptive river basin management regimes

The literature on transboundary river basin management does not provide a satisfactory overview of institutional features that support adaptive management. Many articles are based on one or a few cases only, different theoretical approaches are used, e.g., institutional economics, politics, geography, and engineering, and, most importantly, the issue of uncertainty and change is addressed to a limited extent only. However, using the adaptive management literature, it is possible to complement and refine the insights gained, and develop a complete framework for assessing the extent to which transboundary river basin management regimes support adaptive management. The framework consists of a number of criteria for the different regime elements, and indicators for each criterion (See Appendix A). Although some of the criteria and indicators have been derived directly from the literature, others had to be developed by the authors themselves. The framework focuses on the international level, but it can also be applied at the national and sub-national levels, where many crucial decisions for transboundary management are made.

Actor Networks
A central requirement of adaptive management is active learning by all relevant stakeholders (Folke et al. 2005; Pahl-Wostl and Hare 2004). Transboundary water management often centers around national governments, taken as unitary actors, but in addition, cooperation is needed between different government sectors and government levels, between government authorities, NGOs, and individual citizens, and between all these and the experts. All these actors have different resources that are necessary for transboundary river basin management, such as information, expertise, funds, and legal competencies. To improve the legitimacy and efficacy of management, the views of all relevant stakeholders should be taken into account. This requires, first, that authorities, experts, and stakeholders realize that they depend on each other for reaching their own goals. Next, they need to start interacting, share their problem perceptions and develop different potential solutions. This requires development of mutual trust, recognition of diversity and critical self-reflection. Finally, the stakeholders need to make joint decisions and make arrangements for implementation (Gray 1989; Ridder et al. 2005).

Legal Framework
The adaptive management literature does not contain many specifics concerning the legal framework. Reasoning from the logic of adaptive management, however, we hypothesize that water law should be complete and clear, enabling

all stakeholders to express their concerns and provide input into management, and providing all legal tools for regulating the use of the environment, while still allowing sufficient freedom to experiment with new approaches. Developing such a framework is a difficult balancing act requiring a lot of skill and creativity. A complete legal framework should include arrangements for public participation, information management, financing and planning, as well as many provisions concerning operational management, such as permitting (cf. Global Water Partnership 2003). It should also contain provisions to regularly review and, if necessary, adapt policies. The framework itself should be adaptable as well. The legislative process should not be too time consuming and complex. Individual water rights should not be permanent, but subject to review, in order to adapt to changing circumstances and new insights.

Policy
As mentioned in the introduction, adaptive management acknowledges the uncertainty inherent in policy making, and therefore, advocates developing robust and flexible policies. This requires that the full range of possible measures is considered, and that these measures are assessed in different scenarios, such as "weak" or "strong" climate change and "weak" or "strong" economic growth (e.g., Carpenter and Gunderson 2001; van der Heijden 1996). Moreover, policies should keep as many options open as possible and be flexible to change when new evidence comes up (e.g., Carpenter and Gunderson 2001). The reason for this is, first, it may be impossible to identify measures that perform well under all scenarios. Second, it is impossible to anticipate all eventualities: future developments may lie outside the scope of the scenarios considered. And third, even in the current situation, our knowledge of ecological and social systems is insufficient for predicting the effects of measures with complete certainty. For this reason, small-scale policy experiments could be conducted (cf. Gunderson et al. 1995). Generally, a long time horizon should be applied, and last but not least, policies should be implemented. This usually requires that the stakeholders responsible for, or influencing, the implementation of policies already participate in policy development (see the paragraph on Actor Networks, above).

Information Management
As learning by all relevant stakeholders is central to adaptive management, information management should actively involve all important governmental and non-governmental stakeholders. Stakeholders should have the opportunity to express their information needs, direct information production, and exchange and discuss data and viewpoints to develop a shared knowledge base and mutual understanding of the system to be managed and the problems that occur (cf. Timmerman and Langaas 2005). The shared knowledge base should integrate technical, political, and process knowledge in order to facilitate informed decision making and avoid unnecessary risks. Moreover, the shared knowledge base should reflect the perceptions of all stakeholders in order to promote the legitimacy and quality of the knowledge. This requires that stakeholder

perceptions, or "mental models," including those of the experts, are first elicited and then discussed. Experts should not impose their, often mono-disciplinary, view on the issues at stake, but reflect critically on their own assumptions and be open to the expertise of other disciplines and the local population. Experts should also communicate uncertainties, and not assume that other stakeholders cannot cope with uncertainty (Wynne 1996). Transparency about information and its limitations decreases the risk of misinterpretations and strategic information use purely to legitimize policy, and maximizes the chances of real learning (cf. Weiss 1977). As implementation of policies often occurs at the local level, and the effects are often felt at this level, there is a need for effective information transfer between the transboundary and the local level.

Financing
The challenges for the financing system of transboundary river basin management are to ensure sufficient funding, prevent perverse price incentives, and maximize learning opportunities. Moreover, the total costs should remain acceptable. Although participatory approaches, experimentation and monitoring of the outcome cost money, in the long run they may prevent costly delays and the construction of unnecessary, expensive infrastructure (cf. Beierle 1998; Carnes et al. 1998; Charnley and Engelbert 2005; Chess and Purcell 1999). Financing systems are most robust when they can rely on multiple sources. As stated before, cost recovery, e.g., by means of water pricing, adds to the robustness of the financing system by adding private funds and may reduce water use and pollution. In addition, cost recovery may limit the construction of infrastructure. Infrastructure is often inflexible, as it cannot easily be adapted to changes, e.g., in water demand. Ideally, decision making, financing, and benefiting should be in one hand. This promotes the integral assessment of measures and the implementation of measures that have been agreed upon, and minimizes the chance of overuse because others have to pay the bill - literally or metaphorically (cf. Huitema et al. 2009). That being said, a perfect match usually is not possible and river basin management should not become too complex. Finally, authorities should be able to take loans and depreciate their assets. This makes it easier to make long-term investments that would otherwise have to be financed in one year and ensures that assets can be replaced in time.

2.4. Assessment of the Orange and Rhine regimes

The framework described in the previous section has been applied to seven transboundary river basin management regimes in Europe, Africa, and Asia in order to test whether it can be used for describing actual regimes and assessing their adaptive capacity (Raadgever and Mostert 2005; see Figure 2.3). For each basin, one or more researchers with experience in that basin first performed a literature study to describe the regime according to a common format (see the individual case study reports: Becker 2005; Kranz, Interwies and Vidaurre 2005; Kranz, Interwies and Vorwerk 2005; Raadgever 2005a; Raadgever 2005b;

Timmerman 2005; Timmerman and Doze 2005). In the Rhine and Orange basins, additional interviews were conducted to capture less formalized knowledge. Secondly, the researchers scored "their" regimes for each criterion for adaptive regimes (see Appendix A), using a three-point scale: 1) low, 2) average, or 3) high. Then, the scores for the different basins were compared and discussed to check whether all researchers had applied the criteria in the same way. This resulted in some small adjustments to the scores.
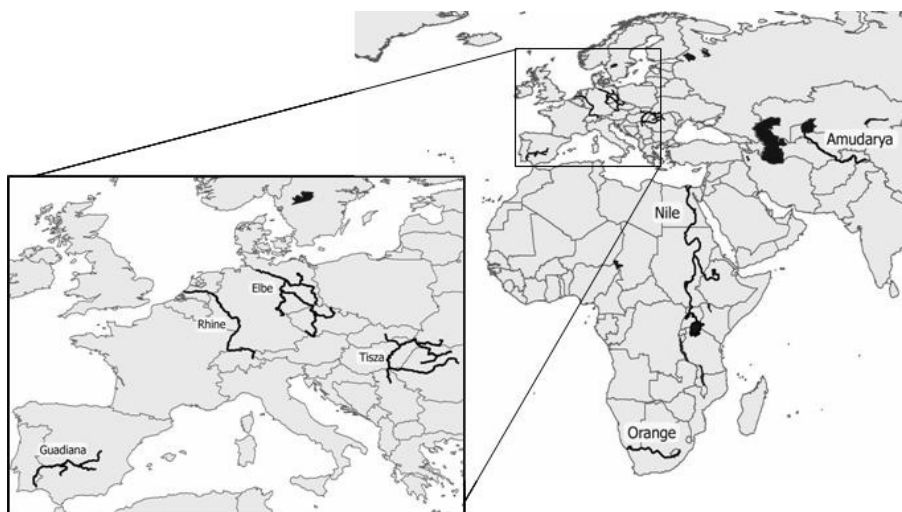
Figure 2.3. Map of the seven studied river basins

In this section, we present the results for two of the seven basins: the Orange and Rhine (Table 2.1, Figures 2.4 and 2.5). These basins have been selected because of the high availability of information. Even so, information on some of the criteria was limited. For example, it appeared difficult to draw general conclusions about the reflection on assumptions (criterion 14) for an entire transboundary river basin regime. The assessment of the two regimes revealed large differences between the two basins. The Rhine regime scores higher on the criteria for an adaptive regime than the Orange regime. A summary of the results can be found in Table 2.2 and more details can be found in the basin reports (Kranz, Interwies and Vidaurre 2005; Raadgever 2005b).

Assessment of the Regime in the Orange Basin
The Orange basin regime scores average on most criteria, with a lot of progress in recent years (Kranz, Interwies and Vidaurre 2005). Transboundary cooperation is still in an emerging state, as the Orange-Senqu River Basin Commission (ORASECOM) was only established in 2000. The development of transboundary institutions has been driven by donors, who have been involved in financing the establishment of the ORASECOM, financing participatory processes and financing concrete research projects in the basin. Donor funding may not be the ideal financial source for adaptive management (see below), but

it did contribute to the development of cooperation and more complete law. Integration of the water sector with other sectors is still low. Although government structures are traditionally top down, there is increasing awareness that local levels should be more intensively involved in international planning processes. Improving public participation has been identified as a major task of the ORASECOM and serious efforts have been undertaken to fulfill this task, e.g., the development of a roadmap for public participation. In addition, provisions for stakeholder participation have been established in new water laws and policies - most prominently in South Africa - but implementation is still limited. This may be explained by the lack of adequate means for communication with relevant stakeholder groups, particularly in rural areas.

Table 2.1. Overview of main characteristics of the Orange and Rhine river basins

Basin	Physical characteristics	Countries	Main river/water users	Main issues
Orange	Basin area: 948 x 10^3 km^2 [†] River length: 2,200 km Average discharge at mouth: 95 m^3/s [‡]	South Africa Namibia Botswana Lesotho	- Irrigation / agriculture - Environmental demands - Power generation - Industry - Domestic use	- Water availability / allocation - (Inter-basin) water transfers - Droughts
Rhine	Basin area: 198 x 10^3 km^2 [§] River length: 1,300 km Average discharge at mouth: 2,200 m^3/s	Germany Netherlands Switzerland France Austria Luxembourg Belgium Liechtenstein Italy	- Navigation - Irrigation / agriculture - Industry - Power generation - Domestic use - Waste water disposal - Recreation	- Pollution / water quality - Floods - Ecological restoration

[†] Based on (Wolf et al. 1999).
[‡] Based on a graph of the discharge at a downstream location (South African Department of Environmental Affairs and Tourism 1999).
[§] Based on (Coördineringscomité Rijn 2005).

International law in the basin consists primarily of the Southern African Development Community Protocol on Shared Watercourses, the legal framework around the ORASECOM, and several bilateral agreements. These do not yet constitute a comprehensive legal framework, but they are adaptive to some extent. The legal framework clearly refers to integrated water resources management (IWRM) as the guiding principle for water management. National water laws are explicitly linked to international agreements. They have undergone several adjustments and updates over recent years, and some have included provisions for a periodical update.

Policy development in the Orange basin scores average, but policy implementation scores low. Water management in the basin has traditionally concentrated on large-scale infrastructure, such as dams and water transfer pipelines, tailored toward meeting short-term water demands of individual countries. Recently, there has been a lot of discussion on the long-term adverse effects of large-scale infrastructure, and alternatives such as demand management, stricter regulation and benefit sharing among riparian states have been advocated. Implementation of transboundary policies is very slow, but many stakeholders expect a lot from the multilateral planning under the auspices of the ORASECOM within the coming years.

Table 2.2. Qualitative scores of basins on criteria for adaptive management

	Criterion	Orange	Rhine
A. Actors networks (Average 1-4)		$0^{\dagger}$	0 / +
1	Cross- sectoral cooperation	-	0
2	Cooperation between administrative levels	0	0
3	Cooperation across administrative boundaries	0	+
4	Broad stakeholder participation	0	+
B. Legal framework (Average 5-6)		- / 0	0 / +
5	Appropriate legal framework	-	+
6	Adaptable legislation	0	0
C. Policy (Average 7- 11)		0	+
7	Long time horizon	0	+
8	Flexible measures, keeping options open	0	+
9	Experimentation	0	0
10	Full consideration of possible measures	0	+
11	Actual implementation of policies	-	+
D. Information management (Average 12-17)		- / 0	0 / +
12	Joint/ participative information production	0	+
13	Interdisciplinarity	n/a‡	0
14	Critical reflection on assumptions	n/a‡	n/a‡
15	Explicit consideration of uncertainty	0	0
16	Broad communication	-	+
17	Utilization of information	-	0
E. Financing (18)		-	+
18	Appropriate financing system	-	+

[†] The scores have the following meanings: - = low, 0 = average and + = high.
[‡] We could not find sufficient information to assign a score to this criterion.

The Orange basin scores average with respect to shared production of information between the riparian countries, but low with respect to information exchange and utilization. Several research institutes and universities are involved in data collection on various issues of water management. The need to develop, exchange and integrate data has been clearly identified, as a key task of the ORASECOM. However, an integrated data and information system has not been established yet. The dissemination of information by the ORASECOM to stakeholder groups is limited.

The Orange basin scores low with respect to the financing system. Financial contributions of international donors have been quite instrumental in the development of large infrastructural works, which increased the availability of resources, but also increased dependence on third parties. Currently, donor efforts seem to be concentrating more and more on institutional capacity building, which is expected to support adaptive management by contributing to cooperation, law and policy. In addition, the member states have been more and more involved in the financing of the ORASECOM and have recently split the costs of the permanent secretariat among the four of them.

Figure 2.4. Map of the Orange basin[2]

Assessment of the Regime in the Rhine Basin
In the Rhine basin, long-lasting institutional stability has created opportunities to develop trust and cooperation, and thus this region is closest to meeting the criteria (Raadgever 2005b). In the International Commission for the Protection of the Rhine (ICPR, or IKSR in German), the riparian countries have cooperated

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[2] South African Department of Water Affairs and Forestry, retrieved 22 August 2007 from http://www.dwaf.gov.za/orange/images/rm017m6.gif

for many decades. The ICPR consists of a plenary commission, comprising national representatives, permanent multidisciplinary working groups, and a secretariat, supporting the plenary commission and the working groups. Adjustment of water policies with agricultural and spatial planning policies takes place, to some extent, at the national and sub-national levels. Lower-level governments are often involved in the implementation of (inter)national policy. Non-governmental organizations, citizens and the scientific community are involved in many different ways in water management, and a high degree of organization and cooperation between various actors has been established. Formal procedures for participation in decision making and access to information are well-established in all basin states.

The legal agreements developed in the framework of the ICPR focus on institutional issues, as well as chloride and chemical pollution (cf. Dieperink 1998). Several, non-legally binding, policy documents, such as the Rhine Action Plan of 1987, contain additional provisions concerning water quality, ecology, and flooding. An influential legal document is the EU Water Framework Directive (2000/60/EC), which includes many requirements for river water quality, ecology and the water management process. The international law and policy are elaborated in comprehensive systems of national and lower-level law. In most Rhine countries, adaptation of water law, regulations and policy are possible, and in some cases, periodic review is obligatory.

The ICPR policies contain a wide range of small- and large-scale, structural and non-structural measures and usually have a long time horizon. The planning horizon of the ICPR flood policy (IKSR 1998), for instance, is the year 2020. The national governments usually adjust their national policies to ICPR policies, and implement the agreed measures. Nevertheless, implementation may take a long time. For example, the ambitious goals of the Rhine Action Plan on Floods were not fully realized as planned (IKSR 2001). The implementation of ICPR plans is evaluated on a regular basis, but there are no legal sanctions in case of non-compliance.

The ICPR member states exchange data, cooperate in research and exchange interests and points of view. National governmental actors participate in the production of information and in the ICPR working groups. NGOs participate in the working groups as observers. Uncertainties are usually assessed. Legal obligations to make information accessible have been established at several levels, and the ICPR disseminates a lot of information via its website. The ICPR policies reflect the information that is produced by its working groups, but it can take a long time before information on emerging issues enters national and transboundary policy debates.
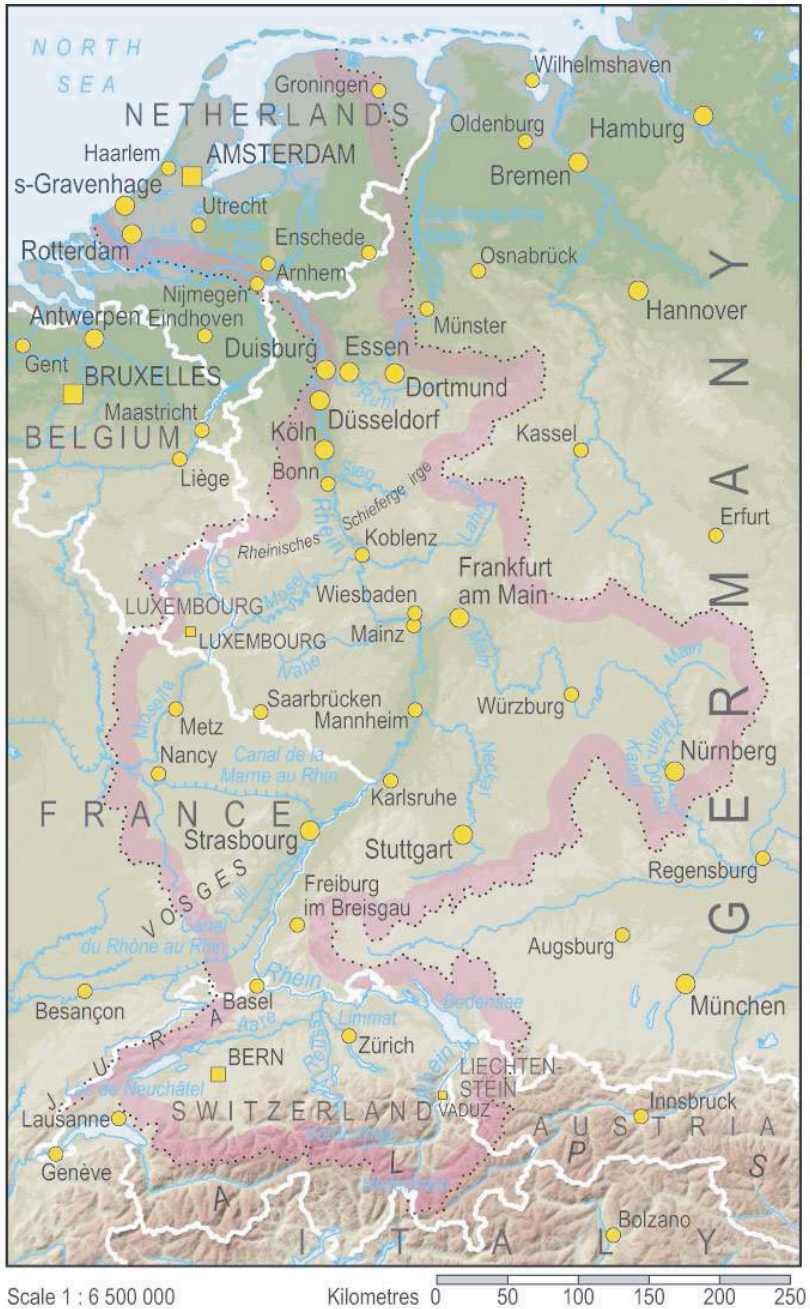
Figure 2.5. Map of the Rhine basin[3]

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[3] UNEP/DEWA/GRID-Europe, Retrieved 22 August 2007 from
http://www.grid.unep.ch/product/publication/freshwater_europe/images/map4.jpg

The work of the ICPR, as well as the implementation of its policies, is financed out of public resources of the riparian countries. As they also make all the important decisions in the ICPR, decision making and financing are in one hand and there is no reliance on third parties. At the national level, collective water management issues, such as flood management, are financed mainly from public resources, whereas the costs of water supply and wastewater treatment are to a large extent recovered from the users.

2.5. Discussion and conclusions

We set out to develop and test a framework for assessing the adaptive capacity of transboundary river basin management regimes. This framework hypothesizes what the actor networks, laws, policies, information management and financing systems in a transboundary river basin should look like in order to support adaptive water management. As mentioned in the introduction, adaptive management could be useful for dealing with complex problems, uncertainty and change. However, adaptive management may not be necessary in every situation (van Eeten and Roe 2002). Adaptive management involves high costs, including the high transaction costs of the necessary cooperation and integration (Dombrowsky 2007), and the costs and time needed for gathering the necessary technical information (Lee 1999). These high costs may not be justified when dealing with well-structured issues (cf. Johnson 1999), which are characterized by agreement about the goals to be achieved and sufficient technical knowledge. However, many water management issues are not well structured, especially in a transboundary context, and for these issues, adaptive management provides a useful conceptual model for dealing with complexity.

Our framework reflects one specific interpretation of adaptive management that values stakeholder participation and scientific experimentation equally, and combines them in one approach. In our view, the participatory and scientific aspects of adaptive management cannot be strictly separated, because even scientific knowledge is not value free, but influenced by the people involved in producing it (cf. Douglas 2005). The hypotheses in the framework have not yet been tested in any strict sense. We have assessed the "independent variables," regime characteristics, but not the "dependent variables," operational water management. This would require the development of criteria and indicators for adaptive operational management. However, adaptive management as incorporated in the framework, as well as many other interpretations of the concept, leaves room for very different types of operational management. It does not provide complete answers to normative questions about who should adapt, for whom or for what, or how much it may cost. Adaptive management may result in solutions that benefit all interests involved, e.g., nature protection as well as economy, but often difficult choices remain. In theory, the concept offers little help in making these choices. In practice, however, people using or advocating adaptive management have their own preferences and may make

their own, implicit and even subconscious, choices. Our own ideal is for adaptive management to promote an open discussion of both the results and the means of river basin management, and to help stakeholders make their own choices.

Although the framework has not been fully tested, it has been applied to the Rhine and Orange basins in order to test its potential for describing and assessing actual management regimes. This has resulted in a comprehensive description of the two regimes. Moreover, their (hypothetical) support for adaptive management has been assessed and regime elements that require further development have been identified. The assessment of the regimes has been performed by researchers familiar with the respective areas and has been checked by other researchers, but it remains to some extent subjective. To reduce this subjectivity, more objectively measurable indicators, e.g., scaled and/or quantitative indicators, for the different criteria should be developed.

The assessment results indicate that the criteria for adaptive regimes have only been partially met in the case study basins. An interesting topic for further research is whether adaptive regimes are feasible. The situation in the Rhine suggests that many elements of an adaptive river basin regime can be developed. The situation in the Orange basin suggests that not all elements of an adaptive management regime can develop when the general institutional and political context is not ready for it. However, the institutional and political context is not static, nor are the management regimes themselves. Regime development in general is a never-ending, long-term process. The development of international agreements usually takes 10 or more years, and sometimes even 100 years (Mostert 2005a). Regime developments could be analyzed using collaboration theory (Gray 1989), focusing on the role of individuals (e.g., Majone 1989; Saleth and Dinar 2004) or on group processes (e.g., Ostrom 1990). Better insight into the order and time scale of regime development is needed to support the transition toward adaptive management regimes and to identify leverage points. For this purpose, detailed case studies of regime development over time and more theoretical work on regime development should be undertaken, each informing the other (Conca et al. 2006). The influence of contextual factors that could block or enable the functioning and formation of adaptive regimes, such as the distribution of power, costs, and benefits over the upstream and downstream countries, also needs additional attention.

Chapter 3

Collaborative research and learning [4]

"Tell me and I'll forget; show me and I may remember; involve me and I'll understand."
(Chinese proverb)

In this chapter we develop a conceptual framework of the relation between collaboration and learning in natural resources management. First, we reflect on the role of theory in our research. We combined multiple theories, and our own reasoning, in order to inform the empirical research in the case studies. In turn, we used (preliminary) case study findings to improve the conceptual framework (Section 3.1). Key concepts that form the basis for the framework are stakeholders, collaboration, knowledge and perspectives, learning, and framing (Section 3.2). According to the literature collaborative processes may enhance cognitive learning by increasing the participants' exposure the perspectives of other participants, including research results. However, selective and interpretative processes of individual framing determine which explicit knowledge stakeholders internalize in their own perspective and how. For example, individual interests or individual perceptions of the quality of knowledge may influence learning. Specific factors that influence individual exposure to others' perspectives and individual framing can be related to collaborative processes, research processes, policy processes and other processes (Section 3.3).

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[4] This chapter is based on the following publications:

Raadgever, G. T., and Mostert, E. (2007). The role of expert knowledge in collaborative water management. *International Conference on Integrated and Adaptive Water Management,* Basel.

Raadgever, G.T. (2008). Does collaboration enhance learning? The case of future flood management in the Rhine basin. Submitted to: *Ecology and Society.*

3.1. The role of theory in this research

Before analyzing the literature about collaboration and learning, we shortly discuss the role of theory in this research. In our opinion, a theory is not "the truth", but a complex network of hypotheses that provides plausible insights in reality, and thus has an instrumental value. Theories can never fully describe reality in all its complexity and there are always several possible theories that can explain observations of reality.

Which theories are developed and tested in a certain field of research depends partly on rational choices and partly on more subjective factors (Kuhn 1970). Theories always serve subjective purposes. For example, researchers may study topics that they consider interesting, or that are of interests to their financers. Selecting a theory that supports a specific purpose is usually influenced by more rational factors, and how well a theory reaches its purpose can be validated. For example, hydrologists who want to understand the relation between precipitation and river discharges can select different conceptual models and can test their validity against empirical data.

Instead of elaborating our position in science philosophy here, we want to emphasize the instrumental value of theory. Theories and associated research methods can have an important function in structuring observations and interpreting reality. Just like reasoning and empirical research can inform theory, theory can inform reasoning and empirical research. We believe that an important role researchers have, is to constantly challenge existing theories and develop new theories, by confronting the theories with new findings. Furthermore, by describing reality, theory can inform action, e.g., in water management practice.

In this research, we first used existing theories, in combination with our own reasoning, in order to formulate a conceptual framework of hypotheses about the relation between collaboration and learning. Then, we tested the hypotheses against the empirical findings from our case studies. Finally, we refined the conceptual framework based on the empirical findings. We performed multiple iterations of these steps and performed multiple steps in parallel. The products of the confrontation of theory, reasoning and empirical findings in this research may inform action in natural resource management practice, at this moment or after further research.

In order to gain knowledge about collaboration and learning, we explored literature from different disciplines in the social sciences, such as institutional science, organizational science and psychology. In this literature, we did not find one overarching theory that addresses in sufficient detail the full range of questions that we considered relevant. Rather, different theories provided useful insights about different aspects of collaboration and learning. Therefore we selected relevant concepts, such as "cognitive learning" and "framing", and

relevant methods, such as "Q methodology" and "interaction analysis", as the basis for this research. Our personal preferences played a role in this selection. For example, our fear to miss relevant data is reflected in the fact that we recorded as much data as possible and our preference for quantification is reflected in the assessment of changes in perspectives.

Adopting elements from different theories instead of choosing one overarching theory had advantages and disadvantages. An important advantage was that we could obtain insights about collaborative learning from different theoretical perspectives, decreasing the risk of missing important aspects. In addition, we could apply multiple methods to answer the same question (cf. "methodological triangulation" in Yin 1994), increasing the reliability of our findings. A disadvantage of using concepts and methods from different theoretical backgrounds was that the consistency of the research was not automatically guaranteed. It took quite some effort to integrate different theoretical and methodological elements in a sufficiently consistent research approach.

3.2. Key concepts

Before discussing the relation between collaboration and learning, we define what this research is about. We define who we are talking about, how they can collaborate, what types of knowledge they may have, and how this knowledge can change over time.

Policymakers, researchers and societal stakeholders
A stakeholder can be any person, group or organisation with an interest in a policy issue, either because he is affected by the problem or possible solutions or because he can influence possible solutions, e.g., by knowledge, power or financing (cf. Freeman 1984; Mostert 2005b). In this thesis, we distinguish between policymakers, researchers and societal stakeholders.

We define policymakers as stakeholders who work as government officials with a responsibility for, task in, or influence on water management. Policymakers are confronted with water management problems and are concerned with the development of management solutions. In this research we focus on assessing collaboration and learning by government officials who are involved in developing policies. In a broader sense, however, policymakers can also be politicians, who decide on policies, or water managers, who implement policies.

We define researchers as stakeholders that work at universities or research institutes and perform research. In this research we focus on assessing collaboration by technical researchers, who produce expert knowledge about the physical system, e.g., about hydrology or hydraulic constructions. Such expert knowledge may also be produced by consultants and technical experts working for the government (cf. Gibbons et al. 1994). Consultants and governmental

experts, however, have slightly different roles and different relations to policymakers (Stone et al. 2001).

Finally, we define societal stakeholders as the citizens, NGOs and businesses with an interest in a policy issue, either because they are affected by the issue or because they may influence the issue. In this research, we focus on assessing collaboration and learning by organized stakeholders, not individual citizens.

Before explaining how these stakeholders can be involved in collaborative research processes, we would like to emphasize some differences between researchers and policymakers (a more detailed discussion can be found in Raadgever and Mostert 2007). Among the fundamental differences are different goals, different intended results and different mechanisms for quality control (see Table 3.1). If these differences are not understood and managed well, this may lead to problems in the communication and limited use of research results in policymaking (Borowski and Hare 2006; Caplan 1979).

Table 3.1. Fundamental differences between the research community and the policy community

	Research	Policy
Goals	Knowledge	Action, policy
Results	Publications	Action, policy
Quality control	Peer review	Political and societal support
Knowledge	Fragmented, abstract	Integrated, concrete
Time frame	Long term	Short-term

Collaborative research processes
In this thesis we define collaboration as an interactive process in which two or more persons work together to achieve common goals. With an "interactive process" we mean that there is two-way communication that allows for mutual feedback. Specific roles that need to be fulfilled in each collaborative process are the roles of initiator, designer and facilitator of the collaborative process, financer and decision-maker. Each role has its specific rights and duties and can be fulfilled by different stakeholders. By participating in collaborative research processes, researchers can contribute to policymaking activities, policymakers can contribute to research activities, and societal stakeholders can contribute to both policymaking and research activities.

First, we address the policymaking activities in which researchers and societal stakeholders can collaborate. In this thesis we focus on the stages of the management cycle in which goals are set and policies are formulated (see Figure 2.1). The activities in these stages include the assessment of problems, formulation of goals, generation of management strategies, definition of evaluation criteria, evaluation of strategies and selection of alternative strategies (cf. Kallis et al. 2004). The activities do not necessarily happen in this order and often multiple iterations are required before the final policy can be formulated. Researchers are typically involved in the assessment of problems, generation of

management strategies and evaluation of alternative management strategies (Monnikhof 2006). In contrast, societal stakeholders are typically involved in the assessment of problems, formulation of goals and definition of criteria for evaluating strategies. In addition, the knowledge of societal stakeholders can be a valuable contribution in other policymaking activities.

Second, we address the research activities in which policymakers and societal stakeholders can collaborate. Research typically consists of the following steps: research set-up, model or tool development, selection of inputs and desired outputs, production and analysis of outputs, and dissemination of the results. Like policymaking, research is often a non-linear process in which activities overlap and multiple iterations of the research steps are required. Policymakers typically contribute most to the research set-up, selection of inputs and outputs, and dissemination of results. However, sometimes policymakers also contribute to model development and simulation, e.g., by placing their own models at the researcher's disposal or by supporting model calibration with local knowledge. Societal stakeholders typically contribute to the same activities as policymakers.

Besides descriptive information about collaborative research processes, we also obtained a lot of prescriptive information. From literature about science-policy collaboration, interviews, informal conversations and feedback on a conference paper (Raadgever and Mostert 2007), we derived seven lessons for collaborative research (see Textbox 3.1).

Knowledge and perspectives
Before introducing the concept of learning, we have to introduce the concept of knowledge. The nature of knowledge has been a topic of discussion for ages. For the discussion in this chapter, it is necessary to make a distinction between two perspectives on knowledge: positivism and constructivism. Positivism assumes that there is an objective external reality and that it is possible to obtain objective knowledge about this reality. Constructivism, however, rejects these assumptions. Some constructivists assume that there is no objective, external reality, as reality itself is a social construction. Others assume that an objective reality does exist, but that all knowledge about it is subjectively constructed. The subjectivity is caused by the selective and interpretive character of obtaining and exchanging knowledge, by individuals functioning in a social context (cf. Beratan 2007; Hisschemöller 2005; Monnikhof 2006). We adopt the latter view.

Knowledge can be analyzed in terms of individual "perspectives" or "mental models" (Doyle and Ford 1998; Kolkman et al. 2005). A perspective is a more or less consistent and enduring cognitive representation of a specific issue and the position of the individual related to this issue, as seen by the individual. Because most cognitive processes happen on an intuitive level (Beratan 2007), individuals are usually only partly aware of their perspective. Below we describe the structure and building blocks of perspectives in more detail.

Textbox 3.1. Seven lessons for collaborative research

1. Know each other. Differences between the collaborating stakeholders can limit mutual understanding and trust. By taking the time to learn to know each other, mutual understanding and trust may be developed (Neilson 2001). In addition, researchers and policymakers may have to change their state of mind. Researchers have to take a more supportive role, try to integrate knowledge from different disciplines, and accept that research findings are only one of the sources that may influence policymaking, which may have to be integrated with, or may have to compete with, the knowledge of other stakeholders (Gibbons et al. 1994; Heinrichs 2005). In turn, policymakers have to be willing to contribute to research and to be transparent about how they use different types of knowledge, values and interests (cf. Fearon 2003; Lavis et al. 2003; Monnikhof 2006; Olsson and Andersson 2007; van Buuren and Edelenbos 2005).

2. Formulate research together. In order to produce appropriate knowledge, policymakers, researchers and other stakeholders should exchange their perspectives, identify relevant knowledge gaps and jointly formulate (and execute) the research that is needed (Busenberg 1999; Hoppe and Huijs 2003; Olsson and Andersson 2007; Raad voor het Milieu- en Natuuronderzoek 2000; van Buuren and Edelenbos 2005). Researchers should provide an overview of the existing expert knowledge and its limitations (Olsson and Andersson 2007), suggest alternative research approaches and focus on pragmatic aspects (Monnikhof 2006). Then, researchers, policymakers and societal stakeholders should jointly formulate a) who should study which questions, b) for which purposes, c) according to which methods, d) with what expected results and e) presented in what way (Busenberg 1999; Halfman 2007; Hoppe and Huijs 2003; Olsson and Andersson 2007; Raad voor het Milieu- en Natuuronderzoek 2000; van Buuren and Edelenbos 2005). It is important that research supports the generation and evaluation of a broad range of management alternatives against jointly formulated criteria (Monnikhof 2006; Olsson and Andersson 2007).

3. Produce knowledge iteratively. In an ongoing dialogue, researchers can present (intermediate) results and get feedback, and policymakers and societal stakeholders can learn and indicate changes in their knowledge needs (cf. Lavis et al. 2003; Olsson and Andersson 2007). The content and timing of research products needs to be adjusted to the stages in the policy process (Halfman 2007), e.g., by first doing a quick scan of a broad range of management alternatives, and then evaluating a limited number of alternatives in detail. Furthermore, researchers should be flexible to adapt to changes in knowledge needs (Monnikhof 2006), or even anticipate shifts in problem definitions (Hoppe and Huijs 2003). In turn, policymakers should remain open to change under credible arguments as well (Monnikhof 2006). In addition, policy experiments could be executed. The effects should be monitored and considered in ongoing analysis and management (cf. adaptive management in Holling 1978).

4. Present results in an attractive and clear way. Because learning is a selective and subjective process, knowledge is more likely to be used when it is carefully tailor-made for the intended users (Lavis et al. 2003). Appealing metaphors, management summaries and visualization in pictures, graphs, maps and tables are more likely to be used by a broad public than lengthy reports (Dahinden et al. 2000; Neilson 2001; Stone et al. 2001). In addition, researchers should always explain why their knowledge is relevant for policymaking. Furthermore, they should make important assumptions and uncertainties explicit (Alkan Olsson and Andersson 2007).

5. Reflect on knowledge critically. By critical reflection on the methods, assumptions and uncertainties in the knowledge production, knowledge users can develop a sense of the reliability of the knowledge and of required improvements (Lavis et al. 2003; Olsson and Andersson 2007). The use of knowledge can be improved when users consider in advance how they will act upon the knowledge, including uncertainties and qualitative information (Hoppe and Huijs 2003; Monnikhof 2006; Raad voor het Milieu- en Natuuronderzoek 2000). The knowledge of policymakers and societal stakeholders may also be a valuable contribution in developing the research results. Therefore, new standards of quality control and other 'watchdogs', such as the media and politics, may be needed (Gibbons et al. 1994; Jasanoff 1990; Martin 2003; Raad voor het Milieu- en Natuuronderzoek 2000).

6. Use appropriate tools and methods. Computer models can be used to develop expert knowledge. Because models are laden with assumptions, one should use multiple models that are grounded in multiple disciplines (Hoppe and Huijs 2003). When stakeholders have different areas of interest, tools should be applied at different spatial scales (Olsson and Andersson 2007). In order to facilitate learning of different stakeholders, simple, interactive and transparent communication tools that foster explicit discussion of perspectives and integrate the discussed perspectives should be used (cf. Borowski and Hare 2006; Olsson and Andersson 2007; Ubbels and Verhallen 2000; van Boxtel et al. 2000).

7. Use intermediaries in case of large differences. When policymakers, researchers and societal stakeholders do not sufficiently understand or trust each other, they can collaborate using intermediaries, who form a bridge between the different communities (cf. 'knowledge brokers' in Jasanoff 1990; or 'policy entrepeneurs' in Stone et al. 2001). Intermediaries can play an important role in the interpretation, synthesis, and communication of knowledge (cf. Jasanoff 1990), and in organizing and facilitating collaborative processes. This may remove pressure from researchers, increase the credibility of the knowledge (Lavis et al. 2003), and speed up the process. In very complex cases, it may be useful to involve intermediaries, such as an independent expert committee, to check the validity of the contributed knowledge (Hoppe and Huijs 2003).

Perspectives can be described as argumentative structures (cf. Fischer 1995; Hoppe and Peterse 1998, see Figure 3.1). Following Toulmin (1958), an argument can be analyzed in terms of a) a claim, b) data supporting the claim, c) warrants linking the claim to the data, d) backings supporting the warrant, e) qualifiers indicating the certainty with which the claim can be made, and f) conditions of exception, for which the claim is not true. In a perspective concerning a specific policy issue, the claim consists of the set of policy instruments that is considered appropriate to solve the perceived problems. The argumentation for such a claim consists of first order, case-specific grounds and second order, general political-ideological grounds (Fischer 1995; Hoppe and Peterse 1998). First order grounds concern the perceived problems and goals, as well as the effectiveness and efficiency of different policy instruments. Second order grounds concern general interests and values. The qualifiers and conditions of exception in an argument reveal the assumptions and uncertainties in it.
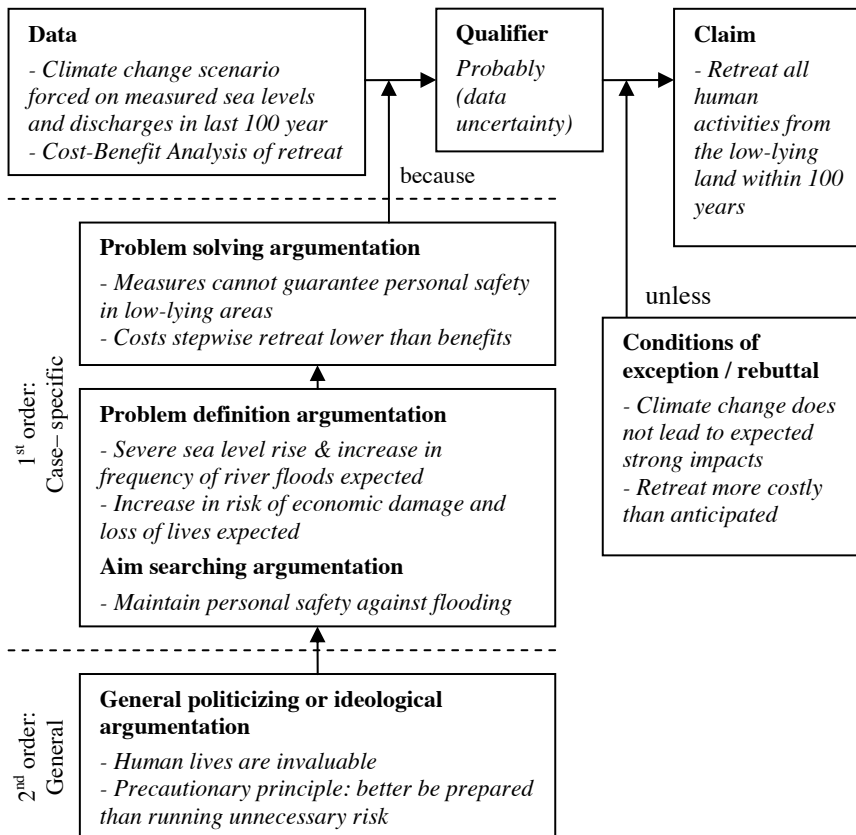
Figure 3.1. The argumentative structure of a policy perspective (Adapted from Fischer 1995; Hoppe and Peterse 1998; Toulmin 1958), including a fictive example of the elements of a possible perspective about adaptation to climate change in a river delta (cursive)

One of the building blocks of a perspective is knowledge concerning the issue at stake. We distinguish between different types of knowledge. First, we make a distinction between expert knowledge and lay knowledge. Expert knowledge 1) has a specialized and abstract character, 2) is produced using formal, scientific methods that can be characterized by the aim for inter-subjective reproducibility (Weale 2001), and 3) has a high social status. Therefore, expert knowledge is often used for legitimizing decision-making. In contrast, lay knowledge is concrete, obtained through unstructured observation and experience, and generally has a low social status. Our second distinction concerns the subject of knowledge. We distinguish between a) technical knowledge, concerning physical or economic processes, b) political knowledge, concerning power relations between social groups, and c) process knowledge, concerning process management and facilitation (Leeuwis and van den Ban 2004 in Wesselink 2007).

Other building blocks of a perspective are values and interests. Values and interests are strongly related notions that express what a stakeholder, or a group of stakeholders, considers important. Values can be seen as general political-ideological goals and interest as case-specific goals (see Figure 3.1).

The different building blocks of a perspective can be used to characterize the perspectives of policymakers, researchers and societal stakeholders. Policymakers typically have an integrated perspective on problems and solutions, including technical, political and process knowledge. Furthermore, the perspectives of policymakers are typically a mix of lay knowledge and expert knowledge. In contrast, researchers typically have a more fragmented perspective, consisting primarily of expert knowledge concerning specific technical aspects of the issue at stake. Finally, in the perspectives of societal stakeholders lay knowledge, values and interests typically have a prominent role.

This research focuses on assessing learning from technical expert knowledge, or in other words technical research results. In terms of the argumentative structure of a perspective (Figure 3.1), technical expert knowledge concerns mainly first order argumentation and underlying data. However, the selective process in which it is produced and communicated necessarily reflects the second order grounds of the researchers. For example, the choice of a researcher to study the efficiency of climate change adaptation measures using cost-benefit analysis may be influenced by the researcher's economy-oriented values, as well as by the researcher's interest in doing research for which sufficient funding is available. Consequently, the subjective nature of knowledge also applies to expert knowledge (cf. Mostert and Raadgever 2008; Raad voor het Milieu- en Natuuronderzoek 2000)

Learning

The concept of "learning" means different things in different disciplines (Dillenbourg et al. 1996). We found literature about learning in the fields of psychology (e.g., Fischer 2002; Sauquet 2004), policy sciences (e.g., Bennett and Howlett 1992; Sabatier 1988), natural resources management (Muro and Jeffrey 2008; e.g., Steyaert and Jiggins 2007), organizational management (e.g., Argyris and Schön 1978; Boonstra 2004) and computer sciences (Fischer and Mandl 2005; Weinberger and Fischer 2006). Furthermore, the concept is used with different adjectives (van de Kerkhof 2004), which are often related to the discipline from which the specific concept originates. Examples are "social learning" (Bandura 1977; e.g., Muro and Jeffrey 2008; Steyaert and Jiggins 2007), "experiential learning" (e.g., Kolb 1984), and "organizational learning" (e.g., Argyris and Schön 1978; Boonstra 2004).

A similarity between all notions of learning is that learning always involves a change and often involves an improvement (van de Kerkhof 2004). Analysis of the differences between different notions of learning reveals that learning can be distinguished by a) the subject of learning (who learns?), b) the object of learning (learns what?), c) the process of learning (learns how?), and d) the results of learning (to what effect?) (cf. van de Kerkhof 2004). The subject of learning may be an individual or a group of people. The objects of learning may be knowledge, attitudes, skills and/or actions (Craps 2003). The process of learning may include thinking, experimenting, observing, perceiving, analyzing, and interacting (Kolb 1984). And finally, the direct results of learning may be changes in knowledge, attitudes, skills, and/or actions. Indirectly, learning may be institutionalized in policies or organizational structures (cf. Bennett and Howlett 1992; Innes and Booher 1999).

Furthermore, literature distinguishes between different levels of learning. Looking at cognitive learning, three levels of learning can be distinguished, which concern changes to different elements of a perspective. Low level learning concerns problem solving argumentation, e.g., the effectiveness and efficiency of policy instruments (cf. first order learning in Argyris and Schön 1978). High level learning concerns problem definition or aim searching argumentation (cf. double loop learning in Argyris and Schön 1978). An even higher level of learning concerns ideological and political values. The probability and speed of learning are assumed to decrease with an increasing level of learning (cf. Sabatier 1998). For example, the individual perspective on the costs and benefits of a stepwise retreat from the low-lying areas in a delta (see Figure 3.1) can be expected to change fast, whereas the aim for personal safety against flooding and the value that one attaches to a human life may change only once, or never, during a lifetime.

In our research, we focus on the stakeholders involved in collaborative research processes as subjects of learning and on collaboration as the process of learning. Furthermore, we focus on individual perspectives as the objects of learning and

changes therein as the results of learning. By assessing changes in perspectives, which include problem solving argumentation, aim searching argumentation and ideological and political values, we can address different levels of learning. Finally, we focus on measuring learning from technical research results. Literature about the use of scientific knowledge in policymaking suggests that research results can be used in three different ways:

1. Instrumental knowledge use (Beyer 1997; Caplan 1979; Pelz 1978) occurs when the research results are reflected in the stakeholder's perspective on the issue at stake and/or in policy documents, and thus have a direct and concrete impact on policymaking;
2. Conceptual knowledge use (Beyer 1997; Caplan 1979; Pelz 1978; Weiss 1977) occurs when research results are not directly reflected in the stakeholder's perspective on the issue at stake and/or in policy documents, but have an indirect and abstract impact. In general, university research is most likely to be used conceptually (Amara et al. 2004; Weiss 1977);
3. Strategic, or symbolic, knowledge use occurs when research results are only used to confirm the programs or positions that one wishes to promote (Beyer 1997; Pelz 1978).

Strategic knowledge is most likely in situations in which "public policy results from conflict, bargaining and coalition formation among a potentially large number of societal groups organized to protect or advance particular interests common to their members" (Grindle and Thomas 1991, pp. 22-23). In contrast, instrumental and conceptual knowledge use are most likely in situations in which multiple knowledge users aim to create consensus (Busenberg 1999; Glicken 2000).

Frames
When multiple individuals interact, e.g., to discuss a water management issue, they exchange their perspectives. This includes externalization of the perspective of one individual, through speech, and internalization of the perspective by the other individual(s) (Nonaka et al. 1995). From a constructivist viewpoint, it is impossible to objectively and comprehensively express a perspective into explicit knowledge, e.g. spoken word, models, or reports, or to objectively and comprehensively internalize explicit knowledge into a perspective. Instead, individuals use processing rules, or frames, to express their perspective and to interpret explicit knowledge (see Figure 3.2). In order to better understand why cognitive learning in collaboration is sometimes limited, we analyze the role of individual frames in transferring knowledge.

Frames function as selective and interpretative filters or lenses (Beratan 2007; Carton 2007; Dewulf et al. 2005; Dewulf et al. 2004; Gray 2003). They determine how knowledge about a certain issue, with a certain representation, from a certain source, and in a certain context, is internalized and externalized. Because frames develop through experience, e.g., education and work,

stakeholders from different backgrounds may internalize and externalize knowledge in a different ways. Frames can also be seen as abstractions of an individual's perspectives on different topics, which are strongly related to the general values of this individual. Because of their abstract character, frames change more slowly than perspectives.
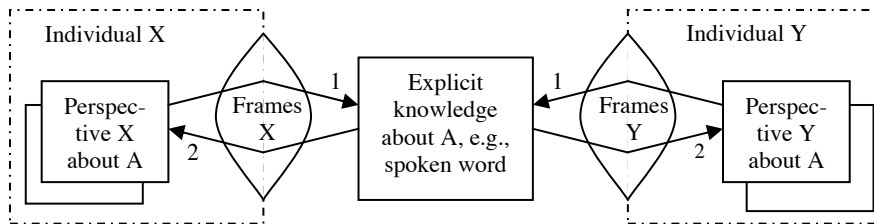
Figure 3.2. Processes of externalization (1) and internalization (2) of knowledge about issue A between two communicating individuals (X and Y)

Frames influence knowledge internalization in multiple ways. Only knowledge that the individual considers relevant and trustworthy, and that is presented in an attractive way, will be internalized (cf. Lavis et al. 2003; Olsson and Andersson 2007). Whether an individual considers explicit knowledge relevant and trustworthy may be related to the match between the explicit knowledge and the individual's perspective on the issue at stake. Explicit knowledge may be considered most relevant, when it fills a gap in the perspective, adds detail to the perspective, or concerns small alterations to the perspective (cf. instrumental knowledge use). When the knowledge, however, differs strongly from the individual's perspective, it is more likely to be internalized in a later stadium (cf. conceptual knowledge use) or not at all. Furthermore, the probability of knowledge internalization is very low when the knowledge conflicts with the values and interests of the individual (cf. strategic knowledge use; Fischer 1995; Olsson and Andersson 2007; Sabatier 1998).

3.3. The relation between collaboration and learning

Collaborative learning in literature
Besides the literature that addresses the previously described key concepts separately, we also found literature that addresses several of these concepts at the same time, by discussing collaborative or cooperative learning. It discusses, among others, whether and how collaboration can enhance learning by students and adults, organizational learning and policy-oriented learning. Most of the studied literature agrees on the proposition that collaboration can enhance learning. Therefore research on cooperative learning has moved beyond the question of whether collaboration enhances learning to focus on the conditions under which it is optimally effective (Dillenbourg et al. 1996; Slavin 1996).

There are different theoretical perspectives on how collaboration can enhance learning. The most inclusive range of theoretical perspective that we found in literature is given by Slavin (1996), who identified four (groups of) theoretical perspectives on the relation between collaboration and learning. Although Slavin focuses on learning by students (educational psychology), the perspectives he introduces appear to be applicable to other types of collaborative learning as well. First, motivational perspectives focus on the goals of the collaborating actors as the major factor that influences their learning. "From a motivationalist perspective, cooperative incentive structures create a situation in which the only way group members can attain their own personal goals is if the group is successful. Therefore, to meet their personal goals, group members must both help their groupmates to do whatever helps the group to succeed, and, perhaps even more importantly, to encourage their groupmates to exert maximum efforts" (Slavin 1996, p 44). Second, social cohesion perspectives focus on the influence of the cohesiveness of the group of learners on their learning. The idea is that collaborators help each other learn because they care about one another and want one another to succeed. In addition, Slavin identified two cognitive perspectives that identify factors related to the mental processing of information as major influences on collaborative learning. According to the developmental perspectives, learning may be enhanced by discussing the issue at stake, which includes expressing ones own perspectives and being exposed to others' perspectives. More specifically, the cognitive elaboration perspective claims that explaining information to someone else is one of the most effective means to internalize the information in ones own perspectives.

Before exploring how these theoretical perspectives can inform our research, we want to introduce three other relevant distinctions concerning the relation between collaboration and cognitive learning. First, literature distinguishes between learning from cognitive conflict and learning from non-conflict based mechanisms. According to Piaget, open discussion of cognitive conflicts, with the aim to solve these conflicts, effectively enhances learning. According to Vygotky, co-construction of knowledge, without cognitive conflict, can results in learning as well (Dillenbourg et al. 1996; Mandl and Renkl 1992). Second, literature distinguishes between learning from interaction between peers and learning from interaction between a novice and a more competent partner. Piaget emphasizes that open discussion between peers enhances learning, whereas Vygotsky emphasizes that 'novices' can learn from 'experts', who function as role models or coaches (Dillenbourg et al. 1996; Mandl and Renkl 1992). Third, literature distinguishes between changes in individual cognitions and changes in shared cognitions. In the shared cognition perspective, the social context is an integral part of cognitive activity and consequently learning due to collaboration should be assessed as a group product (Dillenbourg et al. 1996).

By treating the identified theoretical perspective as complementary (like Slavin 1996), we were able to extract specific variables that may influence learning in collaborative processes (from Dillenbourg et al. 1996; Slavin 1996):

- The group goals (e.g., individual learning by all group members);
- The individual motivation to learn, to encourage fellow group members to learn, and to help them to learn;
- Group size and heterogeneity (e.g., with respect to general intellectual development, domain expertise, or social status);
- Individual prerequisites (e.g., individual skills to understand others)
- Task features (e.g., planning and/or problem solving);
- Interaction (i.e., what happens in the collaborative process);
    o Explanation of knowledge to others;
    o Imitation, assessment and correction of others;
    o Domination by "experts".

For most of these variables, there is empirical evidence that they are relevant in specific situations (Slavin 1996). At the same time, however, probably none of the variables is relevant for learning in all circumstances (Slavin 1996). Therefore, Mandl and Renkl (1992) plea for "more local" theories of cooperative learning, which take into account, among others, the specific domain, the type of learning objective, and the psychologically and educationally relevant dimensions of the collaborative process. Similarly, Dillenbourg et al (1996) call for research that analyzes learning as the result of specific types of interaction. Such research could focus on the variables that are relevant in the specific situation and could further specify these variables where appropriate. Another relevant remark from literature is that the variables interact strongly with another. Consequently, it is almost impossible to establish causal links between separate independent variables and the dependent variable of learning (Dillenbourg et al. 1996).

In natural resource management the idea that collaboration may enhance cognitive learning is also widespread (e.g., Busenberg 1999; Muro and Jeffrey 2008; Stringer et al. 2006). Most authors seem to adopt a line of reasoning which is similar to the Piagetian perspective. Put in our own words: stakeholders that collaborate may exchange their perspectives on the issue at stake, give feedback on others' perspectives, reflect on their own perspective in relation others' perspectives and adopt elements of others' perspectives. Furthermore, by adopting elements of each others' perspectives, perspectives may converge and mutual agreement or consensus may increase (Muro and Jeffrey 2008).

Although this sounds feasible in theory, there are many reasons why the relation between collaboration and learning is less straightforward in practice. First, collaborative processes that provide sufficient space for discussion of perspectives among the participants may be too time-consuming and expensive (cf. Dombrowsky 2007), in particular when a large number of stakeholders is involved. Second, all cognitive learning is influenced by individual framing. And third, stakeholders may be confronted with other, possibly conflicting, knowledge outside the collaborative process.

Collaborative learning in this research

In this research, we analyzed individual cognitive learning about water management issues by professionals and organized stakeholders in collaborative research processes. The groups of collaborating stakeholders are heterogeneous, since they include policymakers, researchers and societal stakeholders. In the analyzed collaborative processes, we consider everybody to be an expert, since "an expert is not a special kind of person, but each person is a special kind of expert" (Mitroff 1983, p 125), in particular concerning his or her own field. For example, a farmer may be an expert in cultivating specific crops and also an expert concerning groundwater levels in the surroundings of his farm. Similar to the Piagetian perspective, we are convinced that the perspectives of all collaborating stakeholders are relevant and that their exchange may enhance learning. When focusing on learning from research results, however, we are more close to the Vygotskian perspective, because we implicitly treat the researchers as "experts", concerning the research results, and the other stakeholders as "laymen" who can learn from the "experts".

Based on the literature that was discussed earlier in this chapter, we developed a specific conceptual framework for analyzing collaborative learning in this research. We distinguish four processes that may influence cognitive learning in collaborative research processes, either by exposing individual participants to knowledge or by influencing their framing: the collaborative process, the research process, the policy process, and external influences. Below we explain in more detail how these processes can influence cognitive learning (see also Figure 3.3). Because we focus on assessing learning by policymakers and societal stakeholders, we related the possible influence of their prior technical knowledge, values and interests in the Figure to the policy process. These factors could, however, also be seen as separate factors that directly influence how an individual frames the knowledge to which he or she is exposed.

Important preconditions for collaboration and collaborative learning are that the involved stakeholders are willing and able to collaborate and learn. Stakeholders are only willing to organize a participatory process or participate in it when they can reach their goals by collaborating. Therefore, it is required that the involved stakeholders have common, or at least compatible, goals. For example, policymakers may collaborate with researchers to improve their insight in technical aspects of water management and researchers may collaborate with policymakers to influence policymaking (Stone et al. 2001). Furthermore, learning may be influenced by the motivation of the involved stakeholders to learn and to support learning by others. For example, stakeholders may want to learn from each other in order to enable better management of the issue at stake. The ability to collaborate concerns the skills of the involved stakeholders to employ activities that will result in the achievement of common goals. Limitations to the willingness and ability to collaborate and learn may be caused by insufficient resources for organizing, or participating in, a collaborative

process, insufficient mutual understanding between the collaborating stakeholders, or insufficient trust between the stakeholders, e.g., due to negative experiences. Limitations to collaboration and learning may be stronger when a large number of participants is involved and/or when the group of participants is strongly heterogeneous.

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┌─────────────────────────────┐      ┌─────────────────────────────┐
│ Collaborative process       │      │ Research process            │
│ - Willingness and ability   │      │ - Relevance of research     │
│   to collaborate and learn  │      │   results                   │
│ - Intensity of collaboration│      │ - Quality of research       │
│   / discussion              │      │   results                   │
│ - Fairness of collaboration │      │ - Attractiveness / clearness│
│   / discussion              │      │   of presentation research  │
│                             │      │   results                   │
└─────────────────────────────┘      └─────────────────────────────┘

┌──────────────────┐   ┌──────────────────────────────┐   ┌──────────────┐
│ Policy process   │   │ Individual cognitive learning│   │ Other        │
│ - Strategic      │   │  ┌────────────────────────┐  │   │ processes    │
│   considerations │   │  │  Explicit knowledge    │  │   │ E.g., media, │
│ - Individual     │   │  └────────────────────────┘  │   │ natural      │
│   values and     │   │       ╲      Frames    ╱     │   │ events       │
│   interests      │   │        ╲_____╱      │   │              │
│ - Individual     │   │  ┌────────────────────────┐  │   │              │
│   technical      │   │  │     Perspective        │  │   │              │
│   knowledge      │   │  └────────────────────────┘  │   │              │
└──────────────────┘   └──────────────────────────────┘   └──────────────┘
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Figure 3.3. Conceptual framework of the factors that influence cognitive learning in collaborative research processes

The intensity of the discussion of perspectives and the intensity of collaboration in others' activities may influence the extent of cognitive learning. The intensity of the discussion of perspectives is related to the extent to which the participants are exposed to others' perspectives, including research results, the extent to which they have to explain their own and others' perspectives, and the extent to which they critically reflect on their own and others' perspectives. The possibility for intensive discussion of perspectives is related to the number and length of interactive meetings, such as workshops, and the activities during these meetings. In our research, the intensity of participation in activities of others concerns the degree of participation of policymakers and societal stakeholders in the research process, e.g., by directing the research or providing local knowledge, and the degree of participation of the researchers in the policy process, e.g., by incorporating the problems, strategies and evaluation criteria of policymakers and societal stakeholders in the research. Finally, the fairness of the collaborative process may influence cognitive learning. When certain participants dominate the collaborative process, this leaves little room for others to participate in the discussion of perspectives or in the activities of others (cf. Habermas 1984; Renn et al. 1995). In turn, this may limit cognitive learning from the less dominant participants and by the less dominant participants.

The research process influences cognitive learning by exposing individuals to the research results and by influencing individual framing of these results. We hypothesize that stakeholders will only learn from research results that they consider to be relevant and of sufficient quality (cf. Lavis et al. 2003; Neilson 2001; Weiss 1977), and that are presented in an attractive and clear way (cf. Dahinden et al. 2000; Lavis et al. 2003). Individuals are only expected to learn from knowledge that challenges or adds to their original perspective (e.g., about new technologies; Neilson 2001). Whether these preconditions are fulfilled may be strongly influenced by the collaborative process. For example, a joint research formulation by policymakers, researchers and societal stakeholders, and an iterative, flexible research process are essential for the production of policy-relevant research results (Busenberg 1999; Lavis et al. 2003; Olsson and Andersson 2007; Wynne 1996).

The policy process typically exposes policymakers and societal stakeholders to each other's values and interests, but also influences individual framing of explicit knowledge, including research results. Individuals are most likely to learn from knowledge that is relevant for fulfilling their tasks or realizing their goals and thus can be used instrumentally by the individual. In contrast, the probability of individual learning from information that conflicts with the individual's values and interests is very low (Fischer 1995; Olsson and Andersson 2007; Sabatier 1998). Stakeholders may learn particularly little in situations of strong political conflict, in which their behavior is strongly influenced by strategic considerations. In such cases, information is most likely to be used strategically (cf. "adversarial analysis" in Busenberg 1999). In addition, the technical knowledge of an individual may influence 1) whether the individual understands the knowledge to which he or she is exposed, 2) how critical the individual is towards the knowledge, and 3) what type of knowledge presentation the individual prefers. The individual's technical knowledge, values and interests concerning the issue at stake may be influenced by the individual's background, e.g., education and work.

Finally, individual learning over longer periods of months or years cannot only be attributed to a specific combination of a collaborative process, a research process and a policy process. Stakeholders can also be confronted with information that emerges from other processes. For example, they may be exposed to new insights from other technical studies, from experiencing major natural events, or from discussions related to the issue at stake in the media. When external insights conflict with insights from the collaborative research process, e.g., the discussed research results, individuals may perceive the latter as less relevant or less trustworthy.

Chapter 4

Assessing collaboration and learning [5]

"Measure what is measurable, and make measurable what is not so."
(Galileo Galilei, quoted in Weyl 1959)

In this chapter we describe the methodology that we applied to assess cognitive learning, the collaborative process, and other processes that may influence learning. We first give an overview of different approaches for evaluating collaborative processes and their results, as we found them in literature. It appears that evaluations are often based on participants' perceptions of their own learning and process observations only (Section 4.1). To get a more complete view on cognitive learning, we also assessed stakeholder perspectives before and after the collaborative research process using Q methodology. In addition, we used common statistical analysis to assess the degree of change in overall perspectives, change in the direction of the research results and change in the consensus between stakeholders over time. To explain the learning that occurred, we observed the collaborative process, analyzed the interaction and the content of the discussions during workshops, conducted participants' workshop evaluations, analyzed individual perspectives and interviewed participants. Finally, we explored the relation between the dependent and the independent variables by comparing cognitive learning between participants and non-participants, between the participants in the two cases and between specific (groups of) individuals within the cases (Section 4.2). In the final sections of this chapter, we discuss in detail how we applied Q methodology (Section 4.3) and interaction analysis (Section 4.4).

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[5] This chapter is based on the following publications:

Raadgever, G. T., Mostert, E., and van de Giesen, N. C. (2008). Identification of stakeholder perspectives on future flood management in the Rhine basin using Q methodology. *Hydrology and Earth System Sciences,* 12(4): 1097-1109.

Raadgever, G.T. 2008. Does collaboration enhance learning? The case of future flood management in the Rhine basin. Submitted to: *Ecology and Society.*

4.1. Evaluating collaboration and cognitive learning

The literature describes various approaches for evaluating collaborative processes and their results, which use different evaluation criteria. Some evaluations concern the collaborative process itself, others concern the results of the process, and again others concern the relation between the process and the outcomes (cf. Chess and Purcell 1999; Innes 1996; Rowe and Frewer 2004; Thissen and Twaalfhoven 2001). Examples of comprehensive criteria for evaluating the collaborative process itself are "fairness", referring to equal opportunities for the participants to be involved in collaborative activities, and "competence", referring to the ability of the participants to take part in those activities (Habermas 1984; Renn et al. 1995). Examples of more specific criteria are representativeness, independence, early involvement, influence, transparency, resource accessibility, task definition, structured decision-making and cost-effectiveness (Rowe and Frewer 2000; Rowe et al. 2004) .

The results of collaborative processes may be tangible products, such as policy documents of computer models, or intangible results, such as learning, which may occur directly after the process or on the longer term (cf. Innes and Booher 1999). Criteria for evaluating the results of collaborative processes may include the substantive quality of the results, learning by the participants about the issue at stake or about how to collaborate, the level of agreement reached, the impact on decision-making and the impact on the conditions in the river basin (cf. Carnes et al. 1998; Chess and Purcell 1999; Innes and Booher 1999; Leach et al. 2002; Muro and Jeffrey 2008). In addition to the more theoretical criteria for evaluating collaborative processes and their results, some literature emphasizes the need for including participant-based criteria, which refer to specific goals of the participants (e.g., Charnley and Engelbert 2005; Santos and Chess 2003).

Related to the multitude of evaluation criteria, literature also mentions a multitude of methods for evaluating collaborative processes and their results. In the field of public participation, it is common to conduct interviews and questionnaires in order to elicit the opinion of participants about the process and its outcomes (e.g., Halvorsen 2001; Leach et al. 2002). In addition, Charnley and Engelbert (2005) measured the participants' perceptions by organizing focus groups to evaluate the participatory process. A shortcoming of these approaches is that they only assess how the process and its results are perceived by the participants. However, participants' perceptions may not reflect the process and its results comprehensively and in sufficient detail, since participants may not remember all relevant interactions and may be unaware of specific results (cf. Innes and Booher 1999). For example, processes of cognitive learning are mostly diffuse, indirect and intuitive. Therefore, participants are only partly aware of their own perspective, how it changes over time and by what factors changes are influenced (Beratan 2007; Weiss 1977). Furthermore, participants' perceptions of the process and its results may be biased. For example participants may be too positive, because they want to have the feeling that their

time was well-spent. To obtain more comprehensive, more detailed, and less-biased insights, it is required to complement participants' perceptions with structured observations of the process and its results by an external evaluator (cf. Innes and Booher 1999). For example, Rowe et al. (2004) evaluated participatory exercises by completing evaluation checklists as external process evaluators.

Literature in the field of collaborative knowledge construction offers some more formal methods for analysis of (computer-based) collaborative processes and their results by external evaluators. For example, Schrire (2006) applied a three-level analysis approach. First, she used interaction mapping to graphically depict those messages that are responses to others. Second, she conducted qualitative discourse analysis of individual contributions to evaluate the content of the discussion. And third, she used three conceptual models to evaluate the depth and quality of learning, and coded each contribution according to the categories of leaning in these models. Weinberger and Fischer (2006) introduced an even more extensive evaluation approach, which covers four dimensions of analysis. First, they analyzed the quantity and heterogeneity of individual contributions to the discussion. Second, they assessed the ratio of task-oriented contributions, and determined for each task-oriented contribution how the learner solved the task. Third, they assessed for each argument that was made whether the claim was grounded, or qualified, or both. And fourth, they identified arguments, counterarguments and integration arguments. Finally, they assessed for each contribution how it referred to contributions of other participants. Although these methods were applied to assess computer-based interaction, they can be used to assess transcripts of other interactions as well.

Thus, literature offers some useful examples of methods to evaluate collaborative processes and their results based on participants' perceptions and observation and analysis of the process by external evaluators. However, even when both approaches are combined, many intangible results cannot be revealed. For example, process observations are not well suited for assessing cognitive learning. Process observations can reveal the explicit knowledge that is discussed and that reflects fragments of the participants' perspectives, but cannot reveal whether and how individuals internalize the discussed knowledge. Furthermore, individuals may (temporarily) give in to group pressure to establish agreements that do not match their perspective (Pelletier et al. 1999). It is relevant to assess such discrepancies between individual perspectives and stated agreement, because participants that do not truly support agreements may form barriers to the implementation of these agreements.

Literature in the field of collaborative knowledge construction also includes the study of artificial situations, in which the individual ex ante and ex post performance on a carefully constructed task is measured to evaluate cognitive change due to collaboration (Fischer 2002). For example, Beers (2005) studied individual cognitive changes, in order to evaluate whether the set of rules for

collaboration that he developed resulted in an increased common ground between the collaborating individuals. Beers' evaluation approach includes individual problem solving tests before and after the collaborative activity and analysis of the interaction using interaction coding. Van Boxtel et al. (2000) used a similar methodological set-up to measure how participation in collaborative learning processes changes the way in which students use conceptual knowledge in individual tasks. The artificial, experimental setting in which both Beers and van Boxtel et al. operated, allowed them to construct tasks that could be used to assess how well an individual solved a specific problem. When assessing changes in perspectives in a practical, professional context, however, the evaluator cannot judge whether a change is an improvement or not, since different argumentations and policy claims may be valid. Other difficulties of working in a practical context are the limited control that the evaluator has over the characteristics of the collaborative process and the participation of stakeholders in evaluation activities.

We found only two studies that assessed cognitive learning in natural resources management practice by repeatedly assessing stakeholder perspectives (Niemeyer 2004; Pelletier et al. 1999). We will use the study by Pelletier et al. to illustrate the research approach in both studies. Pelletier et al. applied Q methodology (Brown 1980; Stephenson 1953) to study changes in collective viewpoints that resulted from participatory planning events concerning the local food system in New York's North Country. They measured the perspectives of in total 141 participants, several weeks before and several weeks after their engagement in the events. Each participant attended one of the six two-and-a-half day events that were organized at different locations and typically involved 30-50 individuals, who collaborated in small groups and in plenary sessions. Q methodology was used to identify collective viewpoints, or shared perspectives, among the respondents, as well as changes therein as a consequence of the planning events. Limitations of this study are that changes in individual perspectives were not analyzed and that changes in perspectives were not linked to detailed observation and analysis of the collaborative process.

4.2. Research approach

Selection of case studies
The aim of our research was to add to the empirical knowledge base about collaboration and learning, by assessing collaboration, learning and the relation between the two in practical cases. We followed a case study methodology, since this enabled us to assess individual perspectives and observe collaborative processes. It also enabled us to conduct focused questionnaires and interviews. We focused on only two cases, both in water management practice, in order to be able to perform detailed analysis. The criteria for selecting the cases were:

- a collaborative research process had to take place in which policymakers, researchers, and societal stakeholders were involved;
- the involved stakeholders needed to have different perspectives on the issue at stake, including technical knowledge gaps and disagreement about the goals to achieve;
- technical models, e.g., hydrological models, and participative methods, e.g., sub group discussion, had to be used in the process;
- the time planning of the process had to match the time planning of our research;
- the collaborative process had to take place in the proximity of Delft, allowing for frequent field visits.

In addition, we wanted to maximize variety between the cases concerning scale and topic. This resulted in the selection of a case about future flood management in the German and Dutch part of the Rhine basin (Chapter 5). The other case concerned groundwater management in and around the city of Delft, in the West of The Netherlands (Chapter 6).

Assessing cognitive learning
In each case, we assessed cognitive learning by the participants. In order to assess cognitive learning, we repeatedly assessed stakeholder perspectives using Q methodology (Brown 1980; McKeown and Thomas 1988; Stephenson 1953). Q methodology aims to elicit individual perspectives and to summarize these perspectives in a limited number of shared perspectives. It consists of five steps: 1) collection of all possible statements about the issue at stake, 2) selection of the most relevant statements, 3) selection of respondents, 4) ranking of statements by respondents, according to their individual agreement with each statement ("Q sorting", resulting in individual "Q sorts"), and 5) identification and interpretation of shared perspectives using factor analysis (Donner 2001; van Exel and de Graaf 2005).

We selected Q methodology as a method for eliciting perspectives for two reasons. First, during the Q sorting, respondents have to carefully consider each statement in relation to the other statements. This decreases the risk of arbitrary or biased sorting and increases the repeatability of the sort. Second, the resulting Q sorts are quantitative representations of a perspective. This enables grouping of perspectives using factor analysis (step 5 in Q methodology). Moreover, this enables assessing the correlation between perspectives and analyzing changes in perspectives over time, using common statistical analysis.

At the beginning of the collaborative research process in each case, we used all steps of Q methodology to elicit and group the perspectives of the involved stakeholders. At the end of the collaborative process, we repeated the Q sorting (like Niemeyer 2004; Pelletier et al. 1999). Unlike Niemeyer and Pelletier et al., we did not perform a factor analysis of the ex post Q sorts in order to identify changes in (individual membership of) shared perspectives over time. Instead,

we analyzed changes in individual perspectives using common statistical analysis. This supported direct analysis of the degree and content of change in individual perspectives, including a focused assessment of learning from the research results. We analyzed the degree and content of change in overall perspectives, the degree of change in the direction of the research results and the degree of change in the correlation between the perspectives of multiple individuals (or consensus) over time. The results could be used to analyze the influence of individual exposure to explicit knowledge and individual framing on individual cognitive learning (Section 3.3). In section 4.3 we explain in more detail how we conducted and analyzed the repeated Q sorting.

In addition to assessing changes in perspectives, we measured the participants' perceptions of their learning with workshop evaluations and ex post interviews. In the evaluations, we asked the participants whether they learned from other participants and from the presented research results, and whether additional consensus developed. In the interviews, we asked the participants whether and how their perspectives on the issue at stake changed over time, confronted them with the findings of the repeated Q sorting and asked them whether they recognized the findings. Such triangulation of methods for collecting and analyzing data can increase the quality of the results and conclusions (Yin 1994).

Assessing the collaborative process, the research process, the policy process and other processes

Besides measuring cognitive learning, we assessed the factors that may explain cognitive learning (see Table 4.1 for an overview of all applied assessment methods). In order to be flexible to deal with changing hypotheses about the factors that may influence cognitive learning, we collected a broad set of data, particularly about the collaborative process and the research process. Furthermore, we assessed many of the factors with multiple methods in parallel (methodological triangulation). After the end of the collaborative processes, we interviewed some of the participants to check whether our assessment of the presence of specific factors in collaborative process, research process, policy process and other processes was correct.

Table 4.1. Overview of applied methods

	Cognitive learning	Collaborative process	Research process	Policy process	Other processes
Repeated Q sorting	X			X	
Workshop evaluations	X	X	X		
Interaction analysis		X			
Content analysis		X	X	X	X
Qualitative process observation/description		X	X	X	X
Interviews	X	X	X	X	X

The collaborative process in each case was assessed using interaction analysis, content analysis, interviews and participants' evaluations. Interaction analysis (Bales 1955; Bales et al. 1979; Beck and Fisch 2000) was used to assess the intensity and fairness of the discussion of perspectives during the workshops. For each contribution to the discussion, we noted 1) who uttered it, 2) whether it was procedural or task-oriented, 3) whether it concerned a demand for or provision of information, and 4) whether it positively or negatively influenced the atmosphere (cf. Beck and Fisch 2000). After each workshop, we calculated how strongly individual participants participated in the discussions. Section 4.4 explains in more detail how we performed the interaction analysis. Furthermore, we recorded and transcribed the workshop discussions and analyzed the content of the discussions using qualitative analysis software (QSR Nvivo 7). The software helped to bring together raw data, such as reports and transcripts, and to encode text elements. When possible, we assigned a code for the name of the speaker and an interaction coding category to each speech act. In addition, we coded each piece of text that concerned one of the factors that may influence cognitive learning. Moreover, we identified substantial discussions that were related to the presented research results. The interaction and content analysis, as well as the interview results, participants' workshop evaluations and less formal observations of the process, were input for a qualitative process description. The qualitative process description provided information about the participants' willingness and ability to collaborate and learn. Furthermore, the description provided information about the intensity of collaboration of different participants in each others' activities. Finally, the qualitative process description included information about the relation between the collaborative process, the research process and the policy process.

With regard to the research process, we used workshop evaluations to assess the participants' perceptions of the relevance and quality of the research results and the attractiveness and comprehensibility of the researchers' presentations. The questions in the workshop evaluation forms were updated before each workshop, reflecting developments in our understanding of the factors that may influence cognitive learning (from research results). In addition, we analyzed the content of the workshop discussions concerning the research, the research results, and the presentation of the research results.

Concerning the policy process, we assessed the presence of strategic considerations, which may influence the collaborative research process and cognitive learning, using interviews and informal interactions and observations. Furthermore, we assessed the participants' values and interests using their ex ante Q sorts and interviews. We analyzed for each individual whether specific research results were in conflict with his or her values and interests or were of little relevance for the individual. To support our analysis, we searched for indications of such conflict in the workshop discussions. In addition, we assessed the prior technical knowledge of the participants through interviews. In the Delft case, we obtained a more complete view by adding questions

concerning the participant's education and work experience, level of technical knowledge about the issue at stake and specific fields of expertise to the ex ante Q sorting questionnaire.

Finally, with regard to other processes, we analyzed the content of the workshop discussions, asked the respondents to the ex post Q sorting in which processes they were confronted with relevant technical knowledge and followed the media and other technical studies.

Assessing the relation between collaboration and learning
We used the results of both case studies to test and to further develop the conceptual framework about the relation between collaboration and learning (Section 3.3). First, we assessed differences in the degree, content and direction of cognitive learning between the participants and a control group of non-participants. For that purpose, we also asked respondents to the ex ante Q sorting who were not involved in the collaborative process to repeat the Q sorting[6]. Such analysis may result in statistical evidence for the hypothesis that participating in a collaborative research process enhances (specific forms of) cognitive learning. However, we also set out to improve insight in the influence of more specific factors - related to the collaborative process, the research process, the policy process and other processes - on cognitive learning. For that purpose, we analyzed differences in the degree and content of cognitive learning between individual participants that were influenced by these factors in different ways. We compared the relations between the independent and dependent variables in the cases to the hypothesized relations in the conceptual framework, and determined whether the case study findings supported the hypotheses (cf. pattern matching in Yin 1994). For practical reasons, we focused on explaining learning from research results. After initial analysis, we interviewed a selection of the participating policymakers, societal stakeholders and technical researchers to check whether our preliminary findings about the factors that influenced learning were congruent with their perception of the factors that influenced learning.

The next sections explain in more detail how we applied Q methodology and interaction analysis. Details about the specific application in each case are discussed in Chapter 5 and 6. We refer readers interested in how to conduct interviews, questionnaires, or content analysis to other literature (e.g., Denzin and Lincoln 2000; Wood and Kroger 2000).

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[6] In the Delft case only two non-participants completed both the ex ante and the ex post Q sorting. Therefore, the added value of analyzing the difference between the participants and the control group was small in that case.

4.3. Q methodology

Measuring perspectives
Among the methods that can be used for identifying individual perspectives are interviewing (e.g., Denzin and Lincoln 2000), cognitive mapping (e.g., Eden 1988; Ridder et al. 2005), and card sorting (e.g., Pahl-Wostl and Hare 2004; Rugg and McGeorge 1997). Traditionally, these methods were used to elicit expert knowledge, but they can also be used for obtaining lay knowledge (cf. Evans 1988), values and interests. To identify major knowledge gaps and conflicts of interest, and to support presentation and discussion of perspectives, it is useful to summarize differences and similarities by grouping individual perspectives. Compared to other elicitation methods, Q methodology supports an objective and reproducible grouping of perspectives relatively well. A strength of Q methodology is that it does not require shared perspectives, or groups of subjects that share them, to be known or hypothesized in advance (Donner 2001). Moreover, it analyses each individual perspective as a whole, and does not aim to generate correlations between objective attributes that are abstracted from the individual (Steelman and Maguire 1999), such as nationality, gender, age and preferred management strategy. Q sorting can be performed by a small, selected sample of individuals and is not intended to generalize the results to a larger population (Steelman and Maguire 1999).

Q methodology requires careful interpretation of sophisticated statistical results (Rugg and McGeorge 1997). Therefore, a new Q analyst should do some reading in order to be introduced in the methodology. Below, we describe the five basic steps in a Q methodological study (cf. Donner 2001; van Exel and de Graaf 2005), as well as the main choices we made in the application of Q methodology in the cases.

1. Collection of all possible statements about the issue at stake (the "concourse")
We collected the concourse of statements by means of interviewing relevant stakeholders and studying policy documents, newspapers and scientific literature. This way, we developed a broad concourse that contained elements of the perspectives of all stakeholders. In order to improve the understandability and recognizability of the statements, we kept the formulation of the statements close to the original formulation.

2. Selection of most relevant statements (the "Q set")
The selection of the most relevant statements from the concourse is a crucial activity in Q methodology. No matter what effort is undertaken, however, obtaining a balanced set remains "more an art than a science" (Brown 1980). The selection can be done according to a fixed structure - either imposed on the concourse (e.g., Dryzek 1993) or emerging from it - or in a more intuitive way. In the case studies we used an intuitive or bottom-up approach. We are of the opinion that, when a practical management issue is at stake, such an approach is

more useful than a strict theoretical framework, because it allows for including the most relevant aspects from a practical management point of view. The number of statements in the Q set usually varies between 40 and 60, depending on the complexity of the issue at stake and on the time the respondents are willing to spend. In the cases, we kept the number of statements close to 40, in order to limit the time required for the sorting. At the same time, we tried to select Q sets that were broad and clear enough to activate the tacit criteria, or underlying values, of all respondents (cf. Donner 2001). We selected in particular statements on which opinions were expected to diverge. We discussed preliminary Q sets with colleagues and with the most strongly involved stakeholders in the cases and adapted the Q sets accordingly. Finally, we edited the statements and inserted them in an online Q sorting tool[7].

3.   Selection of respondents (the "P set")

The P set should be a structured sample of relevant stakeholders who may be expected to have clear and distinct viewpoints. The P set should maximize the likelihood that all major perspectives on the issue are included (Brown 1980). The number of respondents is usually between 20 and 40. In the Lower Rhine case, we addressed a large and varied group of organized stakeholders that we found to be involved in the issue at stake. In the Delft case, however, we addressed only the stakeholders that were already involved in the ongoing collaborative research process.

4.   Ranking of statements by respondents ("Q sorting")

We addressed the stakeholders in the P set by email and asked them to complete the Q sorting online[8]. The respondents were instructed to rank the statements in the Q set according to their personal agreement with each statement, by assigning a fixed number of statements to seven score categories. This resulted in a fixed, uni-modal, and symmetric distribution of statements over score categories (see Table 4.2). Such a fixed distribution forces respondents to carefully compare the statements relatively to each other. This is assumed to decrease the risk of arbitrary or biased sorting, for example under influence of the respondent's mood at the time of sorting, and thus to increase the repeatability of the sort. However, respondents may be dissatisfied about the time and effort required to iteratively put a fixed number of statements in each score category, and about the fact that their perspective cannot be expressed well using the given distribution (cf. Rugg and McGeorge 1997, who see this as a major disadvantage of Q sorting). Such dissatisfaction could be prevented by allowing respondents to freely distribute statements over score categories, without prescribing the shape of the distribution (e.g., Steelman and Maguire 1999). This has no significant consequences for the factor analysis (McKeown and Thomas 1988). When respondents are not at all stimulated to evaluate their agreement with one statement relatively to their agreement with another, however, accuracy of the elicited perspectives will be low.

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[7] Freely available at http://q.sortserve.com/.
[8] In the Delft case, we also performed two face-to-face Q sorting interviews.

Table 4.2. Example of fixed distribution of statements over score categories

Meaning	Most disagree						Most agree
Score category	-3	-2	-1	0	1	2	3
Number of statements	4	5	9	10	9	5	4

We used an online Q sorting tool, because it allowed respondents to perform the sort at any convenient time. Furthermore, it significantly reduced the time that we needed to conduct the sort. Disadvantages of an online set-up are the potentially lower response rate, the limited possibilities to explain respondents how to perform the task and the limited flexibility to deviate from the fixed score distribution. There is no apparent difference, however, in reliability and validity of computer- and interview-based Q sorts (van Tubergen and Olins 1979 in van Exel and de Graaf, 2005) .

Before the actual ex ante Q sorting we asked the respondents some questions about their background. Directly after the ex ante Q sorting, we asked the respondents why they agreed strongly with the statements that they gave the score "+3" and why they disagreed strongly with the statements that they gave the score "-3". This supported a valid and fast interpretation of factors in the last step of Q methodology (cf. Steelman and Maguire 1999). Furthermore, we asked the respondents after each sort whether they encountered technical problems or problems with understanding the statements, and whether they missed any statement. Performing the sorting task and answering the questions cost the respondents about 15-30 minutes.

5. *Analysis and interpretation*

We used the PQMethod software[9] to support analysis of the obtained Q sorts (individual scoring patterns) using factor analysis. Factor analysis is a statistical data reduction technique that is used to explain as much of the variability among the observed Q sorts as possible in terms of a few unobserved scoring patterns, which can be called "shared perspectives" or in more technical terms "factors"[10]. First, PQMethod used principal component analysis to calculate the eight factors with the highest explanatory value, as well as the ratio of the total variance between the Q sorts that each factor explained. Then, we chose the number of factors to be included in the analysis. Only factors that explained more of the total variance than a single Q sort could be included (in other words, the Eigenvalue of each factor should be larger than 1; Donner 2001). Other criteria for the choice of the number of factors were the number of Q sorts that determined each factor, and the number and internal logic of the statements that distinguished each factor from the other factors. Thus, in order to choose the number of factors, we had to repeatedly analyze the content of sets of different numbers of factors.

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[9] Freely available at http://www.qmethod.org/.

[10] Both terms are used interchangeably in this thesis.

After we chose an appropriate number of factors for further analysis, PQMethod clarified the structure of the factors by objectively maximizing variance between each of them using Varimax rotation[11]. PQMethod also calculated the "factor loadings", which express the correlation between each individual Q sorts and each factor. Subsequently, we selected which individual Q sorts would define each factor. We selected all Q sorts with a statistically significant and clean loading on a specific factor. A factor loading is significant when it exceeds a threshold value that is based on the number of statements in the Q set[12] and it is clean when it exceeds the loading on other factors with a certain threshold value[13]. In Figure 4.1 for example, Q sort 1 does not have a significant loading on factor A or B. Q sorts 2 and 3 have a significant and clean loading on factor A, and Q sorts 5 and 6 on factor B. Q sort 4 has a significant loading on both factors, but the loading is not clean. Therefore Q sort 4 is selected as a defining Q sort for neither factor A nor factor B.
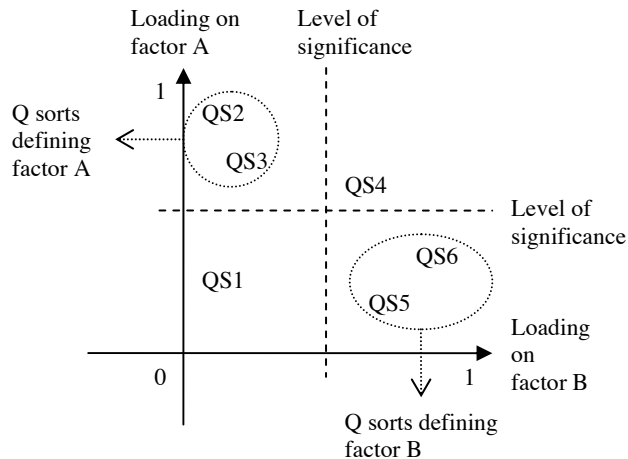
Figure 4.1. Factor loadings and the Q sorts defining a factor (QS = Q sort)

After we selected the defining Q sorts, PQMethod calculated ultimate factor scores and factor Q sort values for each statement under each factor. Ultimate

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[11] Alternatively, more subjective manual factor rotation can be used when the analyst aims to confirm a certain prior idea or theory (van Exel and de Graaf 2005).

[12] The limit for the statistical significance of a factor loading is calculated as the multiplier for the desired level of statistical significance (2.58 for $p < 0.01$) divided by the square root of the number of statements N (van Exel and de Graaf 2005).

[13] Since at first we could not find threshold values for a clean loading in literature, we decided to use fixed values of 0.1 (Lower Rhine case) and 0.12 (Delft case, where the Q set was smaller). Later we found the appropriate formula for calculating whether two factors loadings significantly differ (Brown 1980, p. 301) and found out that the values we used reflect a confidence interval of only circa 65%.

factor scores are the average scores of the respondents defining that factor, weighted by their factor loadings[14]. To obtain factor Q sort values, the statements are ranked according to their ultimate factor score and integer values from -3 to +3 are assigned to them, according to the same distribution that is used for the individual Q sorting (e.g., the score distribution in Table 4.2).

In addition, we calculated the standard error for the ultimate factor scores (SE_{fs}), using Equations 4.1-4.3 (Brown 1980, p. 264 and 297). Equation 4.1 calculates the standard deviation of a Q sort score (s_x), based on the scores in the distribution (x_i), the frequency with which each score occurs (f_i) and the total number of statements in the Q set (N). Equation 4.2 calculates the factor reliability ($r_{xx,factor}$). The factor reliability is based on the test-retest reliability of a Q sort (r_{xx}) and the number of defining respondents for the factor (M). The test-retest reliability is the expected correlation of two Q sorts repeated by the same person, reflecting the variability in sorting without cognitive learning. We adopted the conservative figure of 0.8 for the test-retest reliability (Frank 1956 in Brown 1980, p. 297). Finally, Equation 4.3 calculates the standard error for the ultimate factor scores (SE_{fs}). This number indicates the probable range within which the true factor scores are likely to be located. Since errors may be assumed to fall within a normal distribution, the true factor score will deviate at maximum 1.96 times the standard error from the ultimate factor score with a confidence level of 95% (two-tailed z-test with $p < 0.05$).

$$s_x = \sqrt{\frac{\sum_{i=1}^{N} f_i x_i^2}{N}} \qquad (4.1)$$

$$r_{xx,factor} = \frac{M r_{xx}}{1 + (M-1) r_{xx}} \qquad (4.2)$$

$$SE_{fs} = s_x \sqrt{1 - r_{xx,factor}} \qquad (4.3)$$

PQMethod produced several outputs that were useful for further analysis. Essential were the contention statements, for which factor scores differed significantly between at least two factors, and consensus statements, for which factor scores did not differ significantly between any pair of factors. Based on these outputs, we interpreted the logic of each factor and named each factor. We combined Q methodology with argumentation theory (Fischer 1995; Hoppe and Peterse 1998; Toulmin 1958; see Figure 3.1), in order to recognize the internal logic of each factor. We reconstructed the argumentation structure for each factor, using only the highest and lowest scoring statements in that factor[15].

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[14] Individual Q sorts with high factor loading get a bigger relative weight.
[15] With factor Q sort values of -3, -2, +2 and +3.

After analyzing each factor separately, we analyzed the main points of agreement and disagreement between the factors in order to outline areas of consensus and conflict (cf. Steelman and Maguire 1999). We identified conflicting values and interests and conflicting technical knowledge.

Finally, we disseminated and used the results of the analysis in order to 1) support the set up of the research and the collaborative process in each case, by identifying controversial issues that should be discussed (cf. Focht 2002), 2) promote reflection among the collaborating stakeholders in the cases and increase awareness of similarities and differences between their perspectives, and 3) raise awareness among a broad audience[16].

Assessing changes in perspectives over time
We used common statistical analysis to assess the differences between the individual perspectives before and after the collaborative process. More specifically, we analyzed the degree and content of change in overall perspectives, the degree of change in the direction of the research results and the degree of change in the correlation between the perspectives of multiple individuals over time.

First, we calculated the correlation between the Q sorts of an individual before (X_1) and after the collaborative process (X_2). Equation 4.4 (Brown 1980, p. 272) calculates Pearson's correlation coefficient for forced distribution data between two Q sorts X and Y (r_{xy}), in which x and y are deviation scores around the mean of the scores in Q sorts X and Y (which is 0). A correlation between X_1 and X_2 (r_{x1x2}) that is significantly lower than the test-retest reliability r_{xx} indicates a significant change in the perspective. To assess the significance of the difference between r_{x1x2} and r_{xx}, we transformed both values into Fisher's Z (Equation 4.5; Brown 1980, p. 287) and calculated the standard error SE_{Zr} (Equation 4.6; Brown 1980, p. 287). Then we performed a one-tailed z-test ($p < 0.025$) to test whether the difference between the two Z_r-values was significantly greater than 0 (Equation 4.7).

$$r_{xy} = \frac{\sum_{i=1}^{N} x_i y_i}{\sqrt{(\sum_{i=1}^{N} x_i^2)(\sum_{i=1}^{N} y_i^2)}} \tag{4.4}$$

$$Z_r = 1.15129 \log_{10}\left(\frac{1+r}{1-r}\right) \tag{4.5}$$

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[16] We only used the identified shared perspective in the Lower Rhine case to raise awareness among a broad audience, by presenting them at a conference (Raadgever et al. 2007) and in a scientific journal (Raadgever, Mostert and van de Giesen 2008).

$$SE_{Zr} = \frac{1}{\sqrt{N-3}} \qquad (4.6)$$

$$z = \frac{Z_{rx1x2} - Z_{rxx}}{SE_{Zr}} \qquad (4.7)$$

Second, we analyzed changes on the level of individual statements. A large difference between an individual's ex ante and ex post score on a statement would indicate that the individual learned about that statement. To be able to assess the significance of the difference scores, we calculated the difference scores D_i (Equations 4.8), as well as the standard deviation SE_D of the difference scores for each individual (Equation 4.9). Then we performed a two-tailed z-test ($p < 0.05$) to test whether each difference score was significantly greater than 0 (Equation 4.8).

$$D_i = X_{2,i} - X_{1,i} \qquad (4.8)$$

$$SE_D = \sqrt{\frac{\sum_{i=1}^{N}(D_i - D_{i,average})^2}{N-1}} \qquad (4.9)$$

$$z = \frac{D_i}{SE_D} \qquad (4.10)$$

Third, we identified about which themes the perspectives changed most strongly, based on the ratio of significant changes in the scores of statements about specific themes, averaged over groups of respondents. This way, we analyzed whether the respondents' perspectives on problems, goals and management strategies changed over time (cf. Figure 3.1), and whether specific groups learned more about specific themes than other groups.

Fourth, we calculated changes in the average scores of groups of respondents on specific statements and calculated whether these changes were significant using a sample-sample t-test. We used Equation 4.11 to calculate the standard error of the difference score of a group of M respondents on one statement. Then we performed a two-tailed t-test ($p < 0.05$) with M-1 degrees of freedom to test whether the difference between the ex ante sample and the ex post sample of scores on a specific statement was significantly greater than 0 (Equation 4.12). The results of this analysis provide an overview of the content and direction of change in specific groups of respondents. The results should be treated with some care, however, because Q methodology measures entire perspectives, in which the statement scores of individuals are mutually related.

$$SE_D = \sqrt{\frac{\sum_{j=1}^{M}(D_j - D_{j,average})^2}{M-1}}$$ (4.11)

$$t = \frac{D_{j,average}}{SE_D / \sqrt{M}}$$ (4.12)

Fifth, we analyzed whether individual perspectives changed in the direction of the presented and discussed research results. We first selected the statements that were clearly supported or rejected by the research results and determined for each of these statements which score would reflect the research results best. When the research results strongly supported the statement, we assigned the score "+2/+3", and when the research results strongly rejected the statement, we assigned the score "-2/-3"[17]. Then, we determined for each respondent to what extent his or her Q sorting scores on the selected statements changed in the direction of the scores that were expected based on the research results. The final measure of (individual) leaning from the research results was obtained by summing up the changes in scores in the direction of the research results and subtracting from this sum the changes in the opposite direction. The total was divided by the sum of the expected changes in scores based on the research results. When the resulting value turned out to be larger than 0.1, we concluded that the individual perspective changed predominantly in the direction of the research results. When it turned out lower than -0.1, we concluded that the individual perspective changed predominantly in the opposite direction. We did not test the statistical significance of the changes.

Finally, we assessed whether individual perspectives converged, towards a greater consensus among groups of respondents. Consensus between multiple Q perspectives, at a specific moment in time, was calculated as the average of the correlation coefficients (r_{xy}) between each pair of individual Q sorts in a specific group of respondents. An increase in the average correlation coefficient indicates an increase in consensus. To test the statistical significance of the change in consensus in a group respondents we calculated the difference $D_{ri,j}$ between the ex ante correlation coefficient r_{i1j1} and the ex post correlation r_{i2j2} for each pair of Q sorts. This resulted in M values for $D_{ri,j}$, for which we calculated the mean value and standard error (cf. Equation 4.11). Then, we performed a t-test with M-1 degrees of freedom to check whether the difference between the ex ante sample and the ex post sample was significantly larger than 0 (two-tailed t-test with $p < 0.05$; cf. Equation 4.12).

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[17] A more specific judgment was considered unfeasible, since different interpretations are possible of the discussed uncertainties, conditions of exception, and emphasis that the statement received during the workshops. Furthermore, the claims about a statement may be different in different sub group discussions.

4.4. Interaction analysis

Interaction analysis consists of two steps: 1) encoding of speech acts, such as speech turn or sentences (cf. Schrire 2006; Strijbos et al. 2006), and 2) quantitative analysis of the frequency of occurrence of different types of speech acts. There is a large variety of methods for interaction analysis, ranging from simple to very complex, which all have different coding categories and different possibilities for analysis. The encoding in most of these methods is that difficult that the encoder must be trained in it. The duration of the training varies from one week, for relatively simple approaches, to six weeks, for complex approaches (Beck and Fisch 2000), such as the multi-level SYMLOG method (Bales et al. 1979). Because we are no experts in the field of interaction analysis, we developed, tested and applied a simple method. It builds on a distinction between three types of interaction (Beck and Fisch 2000; Fisch 1994):

- task-oriented speech acts, which concern the content of the issue at stake;
- procedural speech acts, which concern the organization of the collaborative process, the research process or the policy process[18];
- and social-emotional acts, which reflect how individuals feel about other individuals and about the group.

For each of these categories of speech acts, we adopted two subcategories, which are a simplification of the 12 original categories of Bales (1955) and the 15 categories of Beck and Fisch (2000). First, we distinguished between task-oriented speech acts that ask for specific knowledge, or elements of a perspective, and those that provide specific knowledge. Similarly, we distinguished between speech acts that ask for procedural information or opinions and those that provide procedural knowledge. Finally, we distinguished between socio-emotional speech acts that positively influence the atmosphere and the relations between participants and socio-emotional speech acts with a negative influence. As in the developed approach it is possible to assign multiple codes to each speech act, socio-emotional speech acts can occur on their own, or in combination with task-oriented or procedural speech acts. The coding categories are described in more detail in Table 4.3, including some examples.

During the collaborative workshops in the cases, we encoded all plenary discussions while we listened to them. We used the speech turn as the unit for coding and analysis. This means that we did not consider the length of the speech turn and that long presentations were coded in the same way as short questions. In addition, however, we noted who had the opportunity to present and we analyzed how much time there was during each workshop for interactive discussion. For each speech turn, we noted, in a coding table, 1) an abbreviation of the name of the speaker, 2) a code for the category of speech act, and 3) key

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[18] The distinction between task-oriented and procedural speech acts is somewhat ambiguous, since procedural knowledge about the (policy) process can be considered to concern the content of the issue at stake as well.

words for the content of the speech act or any other remark. Furthermore, we occasionally noted the time. During most of the workshops in the cases, the participants either had nameplates or were asked to introduce themselves before speaking. Sometimes, however, participants forgot to introduce themselves, which resulted in gaps in the encoding. We tried to encode each speech acts in the way it was perceived by the interacting participants. When a person uttered multiple types of speech acts in one speech turn, all were coded. When available, sound recordings or transcripts of the discussion were used to improve the encoding before further analysis.

Table 4.3. Encoding categories

Category	Description	Examples
Ta Asks for task-oriented information or opinion.	Question concerning others' perspectives about the issue at stake, e.g., specific research results.	"What are the main uncertainties in the model results?" "Is dike heightening an effective flood management strategy?"
Tg Gives task-oriented information or opinion.	Expression of perspective on the issue at stake. Includes showing agreement and disagreement.	"The models shows that the average river discharge in 2050 will be 2.500 m^3/s" "I agree with Mr. X that dike heightening is an effective strategy."
Pa Asks for procedural information or opinion	Question concerning the collaborative process, research process or policy process (what to do, why and how). Includes suggestions about what to do.	"Which themes do you want to discuss today?" "How can we assess the effectiveness of dike heightening?"
Pg Gives procedural information or opinion	Expression of perspective on the collaborative process, research process or policy process (what to do, why and how). Includes suggestions about what to do.	"I think we need to discus this topic a bit longer." "We will assess the effectiveness of dike heightening with a hydraulic model."
SE + Positive socio-emotional expression	Positive, friendly evaluation of persons, relations or collaboration, or other expressions creating a positive atmosphere. Includes friendly jokes, laughing, etc.	"I am really happy with the teamwork in this workshop."
SE – Negative socio-emotional expression	Negative, hostile evaluation of persons, relations or collaboration, or other expressions creating a negative atmosphere. Includes cursing, shouting, etc.	"I don't like the way I am treated!"

After obtaining the raw data, we determined the number and ratio of different types of speech acts. We hypothesized in our conceptual framework that an intensive discussion of perspectives enhances cognitive learning. Such an intensive discussion may be reflected in a high ratio of task oriented speech acts, including questions and answers. However, a certain degree of procedural speech acts is needed as well, in order to have fair and comprehensive

collaboration process. Furthermore, discussion of the research methods may increase insight in the research quality and the reliability of the results. Finally, a good socio-emotional atmosphere may increase the willingness to collaborate and learn, whereas negative socio-emotional acts can limit further discussion and collaboration. The optimum equilibrium of different types of speech acts is dependent on the goals to be realized, the participants, and the specific activity (cf. Bales 1953 in Beck and Fisch 2000).

Furthermore, we calculated the Gini coefficient (Hartmann 1985), which is a standardized measure for the equality of the distribution of speech acts over all participants. The Gini coefficient is calculated by dividing the area between the Lorentz curve and the line of perfect equality by the total area under the line of perfect equality (see Figure 4.2). The Lorenz curve is the graphical representation of the standardized cumulative distribution of speech acts over participants, starting with the participants that contributed least. If all would utter exactly the same amount of speech acts, the Gini coefficient would be 0. In the other extreme situation, in which only one participant would contribute to the discussion (or rather monologue), the Gini coefficient would be 1.

Figure 4.2. The Lorentz curve

Finally, we assessed the participation of the individuals that completed both the ex ante and the ex post Q sorting in the workshop discussions. The number of speech acts uttered by each individual was divided by the average number of speech acts uttered per participant and averaged over the discussions in which the individual participated.

Chapter 5

Case study "Future flood management in the Lower Rhine basin" [19]

In this chapter, we analyze a collaborative, transboundary scenario study concerning future flood management in the Lower Rhine basin in Germany and the Netherlands (Section 5.1). Together with other researchers, consultants and policymakers, we organized three collaborative scenario workshops in which scenarios, strategies and goals for future flood management were developed. The workshop results were input for a model study concerning the effects of autonomous developments and management strategies on peak discharges. In turn, the model results were input for the workshops (Section 5.2). Before the workshops took place, we identified three shared perspectives about expected developments, the goals to be achieved and the preferred management strategies. We named them A) "Anticipation and institutions", B) "Space for flooding" and C) "Knowledge and engineering" (Section 5.3). Subsequently, we analyzed the collaborative research process and its results. The main findings of the model study were that climate change increases peak discharges, flooding in Germany strongly decreases downstream discharges, and retention measures reduce discharges to a lesser extent (Section 5.4). In order to assess the effects of the collaboration, we compared the degree of learning by the participants with the degree of learning by a control group. About 60% of the respondents in both groups changed their overall perspective significantly over time, and about 50% of the respondents in both groups learned from the research results. Consensus among the participants increased slightly, whereas consensus in the control group decreased (Section 5.5). We also assessed the collaborative process, the research process, the policy process, and other processes and identified factors that may have supported or hindered learning (Section 5.6). Overall, our findings suggest that the collaborative process did not significantly enhance learning. This can be explained by, among others, the limited intensity of collaboration, the limited "newness" of the research results, and the large influence of other research and the media (Section 5.7). The chapter ends with a summary and conclusions (Section 5.8).

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[19] This chapter is based on the following publications:

Raadgever, G. T., Mostert, E., and van de Giesen, N. C. (2008). Identification of stakeholder perspectives on future flood management in the Rhine basin using Q methodology. *Hydrology and Earth System Sciences,* 12(4): 1097-1109.

Raadgever, G.T. 2008. Does collaboration enhance learning? The case of future flood management in the Rhine basin. Submitted to: *Ecology and Society*.

5.1. Future flood management in the Lower Rhine basin

The Rhine is a large river with a basin of almost 200 000 km^2 that is shared by nine European countries (see Figure 2.5). Originating in the Swiss Alps, the river runs through Germany and the Netherlands into the North Sea. The Rhine has a combined rainfall-snowmelt driven flow regime. Peak discharges occur in winter, originating from precipitation in Germany and France (Silva et al. 2004). In 1993 and 1995, floods in the Rhine basin caused significant damage in Germany. During the 1995 flood 250 000 Dutch people had to be evacuated. The highest discharge measured during these floods was 12 600 m^3/s at the German-Dutch border.

In Northrhine-Westphalia and The Netherlands strong dikes have been constructed to protect the land from flooding. The safety standard varies between about 1:200 in the south of Northrhine-Westphalia to 1:10 000 in the west of The Netherlands. This means that the dikes are designed to withstand the high water level that is expected to occur once every 200 up to 10 000 years. Just across the border in The Netherlands, the safety standard is 1:1 250. The design discharge connected to this safety standard is based on observed yearly peak discharges and is regularly reviewed. In 2001, the design discharge was adjusted from 15 000 m^3/s to 16 000 m^3/s. To be able to facilitate (increasing) design discharges, both The Netherlands and Northrhine-Westphalia developed flood management policies that embrace the idea of giving back space to the river, instead of heightening dikes. Moreover, both established a set of flood management measures that should be implemented until 2015 (Landesministerium für Umwelt und Naturschutz Landwirtschaft und Verbraucherschutz Nordrhein-Westfalen 2006; Rijkswaterstaat 1998). In Northrhine-Westphalia, planned measures consist of renovation and relocation of dikes and creating controlled retention areas. The Dutch measures focus on excavation of floodplains, establishment of bypasses and local relocation of dikes (cf. Silva et al. 2004).

In The Netherlands, flood protection on the large rivers is the responsibility of the national Ministry of Transport, Public Works and Water Management. In Northrhine-Westphalia, the Ministry of the Environment and Conservation, Agriculture and Consumer Protection is not responsible for flood protection, but influences it through financing the work done by local organizations ("Deichpflichtigen"). International agreements and regulations, such as the Flood Action Plan of the ICPR (IKSR 1998) and the new European Flood Directive (2007/60/EC), may also influence flood management.

Since 1997, a broad range of governmental actors from Northrhine-Westphalia and The Netherlands exchange knowledge and conduct joint research in the German-Dutch Working Group on Flood Management. In February 2007, they agreed on a new work plan for the years 2007-2012. Focus points in this plan include studying the consequences of climate change and spatial and

socioeconomic changes (Provincie Gelderland et al. 2007). Climate change is expected to increase future peak discharges of the Rhine, increasing the probability of flooding. At the same time, social and economic changes are expected to increase potential damage of flooding and may also decrease available space for additional retention. Therefore, possibly additional measures are needed to mitigate future flood risk.

5.2. The collaborative research process

The collaborative research process in the case (see Table 5.1) was initiated in 2005 by researchers from the projects ACER and NeWater. The ACER project is aimed at quantifying the effects of long term autonomous developments and management strategies on the frequency and magnitude of floods and droughts in the Rhine, by developing an integrated Rhine model[20]. The NeWater project explores new approaches to adaptive water management under uncertainty[21] and focused in this specific case study on assessing collaboration and learning. Researchers from the two projects integrated their research plans and established contacts with the Dutch-German Working Group on Flood Management. After several meetings between the researchers and the policymakers in the Working Group, we agreed to jointly organize a series of scenario workshops. The jointly formulated aims of the workshops were: 1) to learn from each other, in particular from stakeholders across the border and from research results, 2) to develop scenarios and strategies, 3) to develop a modeling chain in order to evaluate the strategies under different scenarios, and 4) to develop a joint vision on future flood management.

Table 5.1. Important events and activities in the case study

Time / Period	Activity / event
Sep 2005 - Sep 2006	Preparatory meetings
Jan 2006 - Mar 2006	Ex ante interviews
Sep 2006 - Oct 2007	Ex ante Q sorting
Sep 2006	First workshop
Jun 2006	Additional interviews / presentations
Sep 2007	Second workshop
Apr 2008	Third workshop
May - Jun 2008	Ex post Q sorting
Aug - Sep 2008	Ex post interviews
2009 (planned)	Final workshop / conference

After the preparation phase, three scenario workshops took place in September 2006, April 2007 and April 2008 (see Table 5.2). The workshops took place in Arnhem and Cologne and lasted for 1-1.5 day(s). The workshops were co-organized and facilitated by Seecon, a consultancy firm specialized in

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[20] See also http://ivm5.ivm.vu.nl/adaptation/project/acer/.
[21] See also http://www.newater.info/.

organizing participatory processes. The activities during the workshops included presentations from technical experts and others, plenary discussions and work sessions in sub groups (see Figure 5.1). Between the workshops, researchers from the ACER project assessed the outcomes of different strategies under different scenarios, using atmospheric, hydrological, hydrodynamic and damage modeling. (Preliminary) results were fed back to the participants during the workshops.

Table 5.2. Characteristics of the scenario workshops

	Workshop 1	Workshop 2	Workshop 3
Time	September 2006	April 2007	April 2008
Location	Arnhem (The Netherlands)	Arnhem (The Netherlands)	Köln (Germany)
Length	1.5 days	1 day	1 day
Number of participants	Government: 12 Research[†]: 9 Society[‡]: 0	Government: 12 Research[†]: 7 Society[‡]: 2	Government: 15 Research[†]: 8 Society[‡]: 7
Goals	- Develop enthusiasm - Determine process goals, rules & steps to take - Explore future developments and strategies to reach management goals	- Get acquainted with four scenarios from literature - Tailor scenarios towards Rhine basin	- Develop strategies for each scenario - Agree on indicators - Initial evaluation of strategies
Activities	1) Introduction project, participants and expectations 2) Expert presentations about future changes in land use, climate and institutions 3) Presentation results of the preparatory interviews 4) Cognitive and spatial mapping of future changes and their impact on goals 5) Develop future strategies in sub groups 6) Plenary discussion	1) Introduction participants and expectations 2) Presentations project , climate change modeling, and scenarios from literature 3) Headline exercise to get acquainted with scenarios 4) Tailor scenarios to Rhine in sub groups 5) Plenary discussion	1) Introduction participants and expectations 2) Presentation ACER modeling and first results 3) Introduction and prioritization indicators and measures 4) Prioritize and elaborate indicators and strategies for each scenario in sub groups 5) Plenary discussion and individual evaluation of strategies

[†] Including two facilitators from Seecon.
[‡] Participants from NGOs and businesses and citizens.

For the first workshop, only policymakers from the Working Group and researchers and consultants from the ACER and NeWater projects were invited. The main goals of the workshop were to develop commitment to the collaborative process and to explore future developments. The first goal was reached only to a limited extent, since the Working Group decided after the

workshop that they did not want to collaborate intensively in the remainder of the process as the Working Group, but individual members could cooperate. The researchers then decided to continue with the workshops, involving the members of the Working Group that were still interested, as well as stakeholders from other sectors (e.g., spatial planning), other German federal states and NGOs (e.g., citizen's initiatives).

Figure 5.1. Pictures of the workshops

At the second workshop, the number of participants was equal to the number of participants at the first workshop, but participants came from a much broader range of backgrounds. After the broad and open exploration of the future at Workshop 1 the researchers decided to work with a set of four scenarios from literature in the remainder of the scenario study[22]. The main aims of Workshop 2 were to get acquainted with the scenarios and to tailor them to the specific case of flood management in the Rhine basin. Because at Workshop 2 and 3 the participants were asked to think along the lines of these scenarios, instead of

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[22] The main advantages of using scenarios from literature over jointly developing new scenarios were that the scenarios from literature covered a broad variety of autonomous developments, were well grounded in science and offered (often quantitative) data about many aspects of the future. A disadvantage of using scenarios from literature was that they were not specifically tailored towards flood management and that the stakeholder did not automatically understand and "own" the scenarios (Raadgever and Becker 2008).

along their own perspective, the risk of conflict was limited. The major controversial issues were raised in a "playful" way, since they were reflected in the differences between the scenarios. At the third workshop, the number of participants was higher than at the first two. The main aims were 1) to develop appropriate flood management strategies under each scenario developed at the second workshop and 2) to develop a set of indicators that could be used to assess these strategies. Furthermore, the first modeling results were presented (see Section 5.4). At the moment of writing this thesis, the process is still ongoing; a concluding workshop to discuss the final results with interested stakeholders is planned in 2009.

5.3. Perspectives on the issue at stake

Conducting the Q sorting
We started the case study by exploring (ex ante) stakeholder perspectives concerning future flood management in the Rhine basin. First, we conducted 23 exploratory, semi-structured interviews, in order to develop the "concourse" for the Q sorting. We interviewed all members of the Working Group, as well as some other governmental actors and NGOs. The interviews concerned four issues that are relevant in a scenario study: 1) the current or general situation, 2) expected autonomous developments, 3) management strategies and 4) the desired future situation (or: management goals). Based on the interview results and literature study, we composed a broad "concourse" of statements and reduced it to a "Q set" of 46 statements (see Appendix B). We discussed preliminary Q sets with several colleagues, in order to test their consistency and completeness. Subsequently, we translated the statements into German[23] and Dutch and inserted them in the online Q sorting tool.

In order to identify a broad variety of perspectives, we invited more than 200 stakeholders by e-mail to complete the online Q sorting, including policymakers, researchers and societal actors. In total, 47 people (22%) responded to the Q sorting questionnaire (see Table 5.3), with a good balance between Dutch and German respondents. More than half of the respondents worked for governmental organizations - at local, regional or national level - and about one fourth for universities. NGOs, citizens, businesses and German scientists were relatively underrepresented.

Analysis of the obtained Q sorts with PQMethod supported the identification of a common basis of agreement, as well three distinct "shared perspectives" or "factors". Each factor was determined by more than five Q sorts and more than ten statements significantly distinguished each factor from the others. The three factors explained 43% of the total variance between all 47 individual Q sorts.

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[23] In a later stadium, comments on the meaning of particular statements by German respondents resulted in a few minor reformulations.

We selected individual Q sorts with a statistically significant[24] and clean[25] loading on a factor as defining variables for that factor. In total, 36 individual Q sorts were selected as variables that defined the factors. Three Q sorts did not have a significant loading on any of the factors and eight Q sorts did not have a clean loading. In other words, the individual perspectives of three respondents did not have much in common with the perspectives of the others and for eight respondents it was hard to tell with whom they had most in common. Table 5.4 shows the composition of the groups that defined each factor.

Table 5.3. Respondents to the ex ante Q sorting

Group of respondents	Period of Q sorting	Number Addressed	Number of Responses
German-Dutch Working Group on Flood Management	Sep '06	17	7
Other interviewees & researchers	Sep '06 – Feb '07	30	13
Union of Dutch River Municipalities (VNR)	Sep '06 – Feb '07	45	6
Hochwassernotgemeinschaft Rhein (Local governments, citizens and businesses)	Sep '06 – Feb '07	81	10
Participants 2nd workshop, including upstream *Bundesländer*	Apr '07	10	6
ICPR, Working Group on Flood Management and Observers	Sep '07 – Oct '07	30	5
Total		213	47

Table 5.4. Number of respondents (per category) that define each factor

Factor	Affiliation[†]					Country[‡]		Total
	Gov_{LOC}	Gov_{REG}	Gov_{NAT}	Sci	Soc	DE	NL	
A	6	3		6	3	9	9	18
B		2	8		1	9	2	11
C	1		1	4	1		7	7
Total	7	5	9	10	5	18	18	36

[†] GOV = Policymakers, LOC = Local, REG = Regional, NAT = National, Sci = Researchers, and Soc = Societal stakeholders.
[‡] DE = Germany and NL = The Netherlands.

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[24] Higher than 0.38, with $p < 0.01$ (see also Section 4.3).
[25] Exceeding the loading on other factors with at least 0.1 (see also Section 4.3).

Finally, PQMethod calculated the ultimate factors scores and the factor Q sort values for each factor[26]. The factor Q sort values per statement are presented in Appendix B. We analyzed the logic within each factor by analyzing the highest and lowest scoring statements in each factor as policy arguments (see Figures 5.2-5.4). We named the factors: A) "Anticipation and institutions", B) "Space for flooding" and C) "Knowledge and engineering".

Agreement between perspectives
Five statements in the Q set do not significantly distinguish between any pair of shared perspectives. The shared perspectives agree that it is not very important to pay more attention to smaller floods and local issues (statement 14). Furthermore, flood management should not become more decentralized and controlled by local government (statement 27), but NGOs and the public should be involved more actively (statement 26). Concerning flood management strategies, the general opinion is shared that creating space between the river dikes is not a completely sufficient strategy for the period until 2050 (statement 24). In addition, socio-economic developments in flood prone areas should be mitigated through spatial planning and construction regulation (statement 36).

Factor A) "Anticipation and institutions"
A large group of respondents from different backgrounds, with relatively many stakeholders from local governments (see Table 5.4), share perspective A "Anticipation and institutions" (see Figure 5.2). This group expects many significant autonomous developments that will increase both probability and potential damage of floods and that will limit options for future measures. Although climate change will significantly increase peak discharges, discharges at the German-Dutch border will not exceed 17 000 m^3/s, because floods in Germany will "top off" peak discharges. The potential damage in flood-prone areas will increase significantly, and increasing spatial pressure will lead to a decreasing range of possible measures.

Furthermore, this group thinks that it is important to act quickly and to cooperate at river basin level. Physical measures that are considered appropriate include holding back water in the basin through land use changes and local infiltration, and adjusting the timing of peak flows from the main tributaries. Dike heightening is not considered effective and efficient. Most proposed measures concern institutions, e.g., law, policy and organizational structures. They include transboundary harmonization of methods to determine safety standards, creating a simple governance structure and a strong river basin authority, and better integration of water and spatial planning.

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[26] The standard error for the ultimate factor scores was 0.20 for factor A, 0.25 for factor B and 0.32 for factor C.

Data	Qualifier	

unless

because

Condition of exception

Strategy / measures
It is important to **take action fast (10)** in order to deal with significant future changes, prevent floods and minimize damage. Measured should be adjusted at the basin level. Preferred measures are:

Effectiveness / efficiency measures
- Holding back water upstream is useful to decrease peak discharges (28)
- Changing the timing of peak discharges from the tributaries is useful for lowering the peak discharge of the Rhine (29)
- Dike heightening is <u>not</u> effective and efficient (37)

Current situation / general
- Risk awareness is more important than feeling of safety (11)
- Looking 10 years ahead is <u>not</u> sufficient for policy development (8)

Autonomous developments (until 2050)
- Effects of climate change are clear enough to take action now (17)
- Climate change significantly increases peak discharges (15)
- Flooding in Germany ensures that discharge at the border stays below 17 000 m^3/s (16)
- Increasing spatial pressure limits possible measures (10)
- Potential damage in NRW and NL significantly increases (18)

Desired future situation (2050)
- Strong river basin authority (41)
- Lower safety levels than current not acceptable (46)

- Harmonization (DE and NL) of methods to determine safety standards / design discharges (40)
- Simple governance structure (12)
- More active involvement of NGOs / public (26)
- Better integration of water management and spatial planning (30)
- Better disaster management plans (34)
- Adjusting the timing of peak flows of tributaries (29)
- Land use change and local infiltration to hold back water (28)
- <u>No</u> decentralization / local control (27)
- <u>No</u> dike heightening (37)

Figure 5.2. Argumentative structure for factor A) "Anticipation and institutions" [27]

Factor B) "Space for flooding"
Perspective B, which we named "Space for flooding", is determined mostly by high-level (national) German governmental actors (see Table 5.4). As in perspective A, the message is that action needs to be taken fast because spatial pressure along the river is increasing (see Figure 5.3). However, perspective B focuses on the current situation. The Flood Action plan of the ICPR is considered useful to increase the efforts of riparian countries and informal cooperation is considered essential for transboundary flood management. Concerning user functions, perspective B suggests that agriculture and economy

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[27] Statements in bold significantly distinguish this factor from other factors with p < 0.05. The number between brackets refers to the statement in the Q set. Appendix B provides the complete formulation of each statement.

are already valued enough and that a clearer perspective on ecological goals is needed[28]. In the vision for 2050, the Rhine offers opportunities for a broad range of user functions and the river landscape is open and enjoyable to live and recreate in. The strategies concentrate on minimizing potential damage by controlled flooding, compartmentalization and mitigating socio-economic developments through land use planning and construction regulation. As perspective A, this perspective favors a simple governance structure and considers dike heightening not to be effective and efficient. In contrast to perspective A, holding back water in the basin is not considered useful for decreasing peak discharges of the Rhine.

Data	Qualifier	Strategy / measures

because → unless

Condition of exception

Effectiveness / efficiency measures
- **Holding back water upstream is not useful for decreasing peak discharges (28)**
- Dike heightening is not effective and efficient (37)

Current situation / general
- **Risk awareness is more important than feeling of safety (11)**
- **Informal transboundary cooperation is essential (5)**
- **ICPR Flood Action Plan increases efforts of countries (2)**
- **Clearer perspective on ecological goals are needed (7)**
- **Agriculture and economy are valued enough (3)**

Autonomous developments (until 2050)
- Increasing spatial pressure limits possible measures (10)
- Spatial pressure along the river will not decrease because of decreasing agricultural land use (19)

Desired future situation (2050)
- **Opportunities for different users functions (43)**
- **Open and enjoyable river landscape (45)**
- Lower safety levels than current are not acceptable (46)

Strategy / measures
Because of increasing spatial pressure, action has to be taken fast (10). Flood damage should be minimized through:

- **Better disaster management plans (34)**
- **Controlled flooding / compartments (38)**
- Simple governance structure (12)
- More active involvement of NGOs / public (26)
- Mitigation of socio-economic developments (36)
- **No land use change and local infiltration to hold back water (28)**
- No decentralization / local control (27)
- No dike heightening (37)

Figure 5.3. Argumentative structure for factor B) "Space for flooding" [27]

Factor C) "Knowledge and engineering"
Perspective C (see Figure 5.4), which we named "Knowledge and engineering", is fully determined by seven Dutch respondents, who are mostly scientist (see Table 5.4). Perspective C claims that expert knowledge should play a larger role in policymaking and that a long-term perspective should be developed, aimed at

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[28] It is unclear whether this means that ecology should receive more or less attention.

establishing safety against flooding more than at improving spatial quality. In the future, perspective C expects improvements in computer technology and simulation models and consequently more insight in the behavior of the river system. Furthermore, it suggests that the discharge at the German-Dutch border will remain below 17 000 m^3/s, because of flooding in Germany. In the desired future situation, the Rhine offers opportunities for a broad range of user functions, but dikes are not retreated and the river is not revitalized. The proposed measures are mostly engineering activities, such as dike heightening in combination with better maintenance of existing rivers, floodplains, and dikes. In addition, damage in case of flooding should be reduced by differentiation of safety standards based on the values to be protected in each area, mitigation of socio-economic developments, and integration of water management and spatial planning. Perspective C opposes the development of emergency flood detention areas to control flooding.
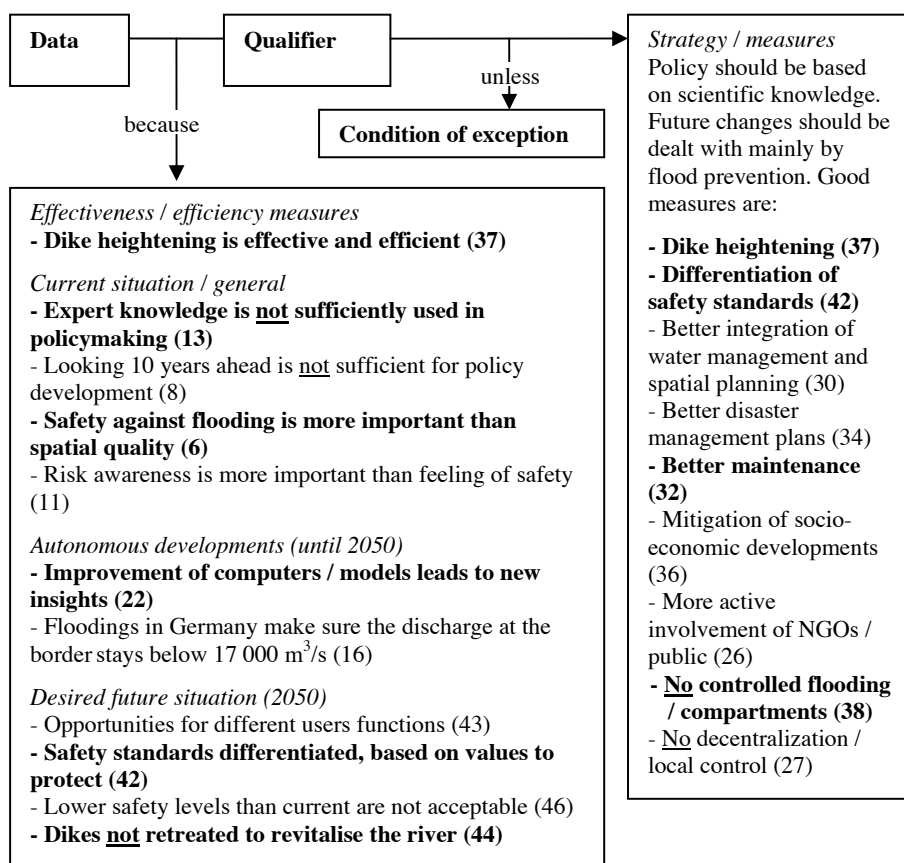

Figure 5.4. Argumentative structure for factor C) "Knowledge and engineering" [27]

Analysis

Although we identified three different perspectives, there is in fact a lot of agreement between the stakeholder perspectives. The lowest correlation that we found between an individual Q sort and a factor, or between two individual Q sorts, was -0.22[29]. Table 5.5 presents the correlation between the different factors. All pairs of factors are significantly positively correlated, with correlation coefficients above 0.38, which indicates that the shared perspectives agree on most of the statements.

The highest correlation can be found between factor A and B. This is no surprise because both emphasize the need for fast action and advocate many similar measures. The main difference between the perspectives is that A emphasizes the influence of autonomous developments, including climate change, whereas B focuses more on the current situation. Perspective C has a relatively low correlation with other factors, because it focuses on other developments - knowledge - and not on the need to act quickly. Besides that it proposes a strategy that other factors oppose - dike heightening. The main technical points on which the shared perspectives do not agree include the effects of climate change on peak discharges, the influence of new technology and new insights, and the development of spatial pressure along the river. Furthermore, the perspectives do not agree on the efficiency and effectiveness of dike heightening, holding back water in the basin and adjusting timing of peak flows from tributaries.

Table 5.5. Correlation between factors

Factor	A	B	C
A	1.00	0.54 ± 0.20	0.46 ± 0.23
B	0.54 ± 0.20	1.00	0.38 ± 0.25
C	0.46 ± 0.23	0.38 ± 0.25	1.00

[†] The uncertainty bounds are an approximation of the 95%. confidence interval, assuming a normal distribution of the standard error of the correlation (see for formula Brown 1980, p. 284).

The different perspectives as represented in Figures 5.2-5.4 include claims and warrants, but no backings and data to support them and no qualifiers and conditions of exception. This is the result of the composition of the Q set. In reality, many of the claims and warrants can be related to previously performed research. An example of an influential report was the research into the transboundary effects of extreme floods on the Niederrhein (Lammersen 2004), which suggested that due to flooding in Germany peak discharges at the German-Dutch border can not exceed 15 500 m^3/s at present and are not expected to exceed 16 500 m^3/s under future climate change.

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[29] Whereas the theoretical minimum correlation would be -1.

The warrants in a policy argument contain goals that are worthy to be promoted, which in turn depend on general values or worldviews and on specific, local interests (cf. Fischer 1995; Sabatier 1998). We elicited the values or worldviews indirectly, since they are usually implied in the arguments and actions of the stakeholders rather than applied consciously, and asking directly for values may result in unreliable artificial answers. We analyzed the content of the shared perspectives in a qualitative and informal way in order to find underlying values that could explain them. In all perspectives, safety seems to be a central value that should be protected now and in the future. Moreover, all factors aim for more active involvement of NGOs and the public, but it is unclear whether public participation is seen as a means for empowerment and direct democracy, or as a means to educate the public and obtain support for management, which would be compatible with a government and science centered worldview (cf. Mostert 2005c; Webler and Tuler 2006).

In addition to the values that all three perspectives share, some values are more specific. The main values underlying perspective A, besides safety, seem to be concern for the future and international cooperation. A central value in perspective B seems to be minimizing costs. This perspective anticipates only changes in spatial pressure and proposes to assign emergency flood detention areas to ensure safety, which requires little government investments. Perspective C positively values economic efficiency and technology. It argues to invest in well-known, cost-efficient engineering measures and it relies on development of knowledge and technology. Furthermore, factor C suggests spatial differentiation of safety standards based on values to protect, which may improve efficiency of flood protection.

5.4. Substantive results of the collaborative research

This section describes the main results of the discussions during the three scenario workshops, as well as the technical research results that were presented. The latter is particularly relevant for the assessment of learning from the research results, which is described in Section 5.5.

Autonomous developments, management strategies and evaluation criteria
During the first workshop, the participants discussed future changes in a relatively open way. The main conclusions were that the impact of climate change on the synthesis of Rhine discharges from the main tributaries was still unknown. Furthermore, the participants expected various institutional changes. Some of these changes were considered desirable. For example, a stronger Rhine authority was considered beneficial for basin-wide harmonization of flood management. Technical flood management measures that were considered promising were to create more room for the river and to establish new retention areas. In addition, concepts like "flood risk management" were considered appealing.

In preparation of the second workshop, the research team prepared four scenarios for flood management in the Rhine basin until 2050. The scenarios were based on an often used distinction using two decisive dimensions of uncertainty: "values" and "governance" (Berkhout et al. 2002). The "values" dimension represents political and social priorities and the distribution of public and private responsibilities. The "governance" dimension describes political and economic power relations and spatial and structural orientation of decision-making. More specifically, the scenarios were based on the Dutch WLO scenarios (Janssen et al. 2006) and the English Foresight scenarios (Evans et al. 2004)[30]. The four resulting scenarios were named: "Market", "European Union", "National Identity" and "Regional Sustainability". At the second workshop the scenarios were elaborated. At the third workshop a suitable management strategy was developed for each scenario, as well as a list of criteria for evaluating these strategies. Table 5.6 gives a (far from complete) impression of the content of the expected autonomous developments and the accompanying strategies. The list of evaluation criteria included 1) probability of flooding, 2) potential damage from flooding, 3) quality of the environment and landscape, 4) cost of implementing measures, 5) social fairness, acceptance, and support, 6) flexibility, keeping options open, 7) self-help capacity, and 8) consequences for the population.

Table 5.6. Impression of the developed scenarios

Scenario	Expected autonomous developments	Management strategies
Market	- Developments in flood prone areas - Weak authorities, little regulation	- Dike heightening (urban area) - Flood warning - Individual insurance
European Union	- EU Directives and funds - Long-term strategies	- Holding back water - Flood warning - General insurance
National Identity	- Agricultural goals - Little regulation - Ad hoc reactions	- Dike heightening - Compartments
Regional Sustainability	- Social and ecological goals - Public participation	- Education - Compensation funds

Technical research results
During the workshops, researchers presented their model results concerning future peak discharges of Rhine and how these may be influenced by climate change and retention measures. The research results were particularly related to four Q sorting statements (see Table 5.7). Because setting up the atmospheric, hydrological and hydrodynamic modeling chain took quite some time, the first model results were presented only during the third workshop. During the first

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[30] The WLO and Foresight scenarios were most considered the most appropriate basis for scenarios about future flood management in the Rhine basin because they address similar issues (Foresight addresses flood management) and similar geographical areas (WLO addresses the Netherlands).

two workshops, however, results from previous model studies were presented. The main argument was that the climate is changing due to human action, and that future climate change will increase the precipitation and the mean discharge of the Rhine in winter. The model results presented at the third workshop suggested that 1) climate change will significantly increase peak discharges of the Rhine, 2) flooding in Germany leads to an enormous reduction of downstream peak discharges, 3) planned retention measures in the Lower Rhine area significantly reduce peak water levels at Köln and Lobith and 4) additional retention results in an additional significant reduction (te Linde et al. 2008).

Table 5.7. Q sorting statements concerning technical research results

Number	Statement
15	Climate change will significantly increase peak discharges of the Rhine between now and 2050.
16	Floodings in Germany will prevent the occurrence of Rhine discharges larger than 17.000 m^3/s at Lobith until 2050.
17	Because the effects of climate change on peak discharges are still unclear and contradictory, it is better to wait than to take action now.
33	The Rhine countries should develop more controlled retention polders and optimise their use for the whole Rhine basin.

Table 5.8 presents the Q sorting statement scores that reflect the presented research results. The score "2/3" indicates that the statement was strongly confirmed by the research results, whereas the score "-2/-3" indicates that the statement was strongly rejected by the research results. Table 5.8 also presents the statement scores that reflect the workshop discussions concerning the research results. Most often the workshop discussions confirmed the presented research results, but sometimes the discussions reflected other nuances.

Table 5.8. Q sorting statement scores that reflect the research results as presented and discussed during the workshops

State-ment	Workshop 1 and 2[†]		Workshop 3	
	Presented	Discussed	Presented	Discussed
15	2 / 3	2 / 3, but still "knowledge gap"	2 / 3	2 / 3, but peak discharges NL are reduced by flooding in DE[‡]
16	n/a	2 / 3 (in 1 sub group)	2 / 3	2 / 3 (plenary and 1 sub group)
17	-2 / -3	-2 / -3 (1 sub group), but still "knowledge gap"	-2 / -3	-2 / -3
33	n/a	2 / 3 (plenary and sub groups), but operation is difficult	2 / 3	Retention scores average (plenary), and is selected as useful measure in 2 sub groups

[†] The claims made during workshop 1 and 2 were similar.
[‡] DE = Germany and NL = The Netherlands.

Other outcomes
Although we focused on assessing cognitive learning about the issue at stake, we also came across other interesting outcomes of the collaborative process. The results of the ex post interviews suggest that the good collaboration in the scenario study supported the improvement of relations between stakeholders from different countries, organizations and disciplines. This may be useful for future transboundary and multidisciplinary collaboration in the Lower Rhine basin. Furthermore, different participants stated to have learned how to think in an open way about possible futures. Many participants, in particular from Germany, were not familiar with interdisciplinary scenario studies before.

5.5. Observed learning

The ex ante Q sorting questionnaires were completed between September 2006, before the first workshop, and April 2008, before the third workshop. We conducted the ex post Q sorting in May and June 2008. Of the 55 stakeholders that completed the ex ante Q sorting, we addressed the 24 workshop participants and the 22 stakeholders that were not connected to the collaborative process at all. In total, 16 workshop participants and 11 non-participants completed the repeated Q sorting. The latter would function as a control group. Among the responding participants were 11 governmental stakeholders, 4 societal stakeholders and 1 scientist. Eleven responding participants were German and 5 were Dutch. The control group was composed different. Among the non-participants were 5 governmental stakeholders, 2 societal stakeholders and 4 scientists. Four of them were from Germany and 7 from The Netherlands. The time between the ex ante and the ex post Q sorting varied from 1 month up to 20 months[31].

In the text below we analyze differences between the ex ante and ex post perspectives of the respondents. More specifically, we analyze changes in overall perspectives on the issue at stake, changes in correlation between perspectives and individual learning from the research results. In addition, we briefly reflect on what the researchers learned from the policymakers and societal stakeholders.

Changes in overall perspectives on the issue at stake
First, we calculated Pearson's correlation coefficient between the ex ante and ex post perspective of each individual respondent. In the participant group, the correlation ranges from 0.28 to 0.76, with an average of 0.58. The perspectives of 10 of the 16 participants changed significantly (one-tailed z-test with $p <$ 0.025[32]). Similarly, the average correlation between individual ex ante and ex

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[31] Remarkably, assessment of the factors that influenced cognitive learning showed no clear influence of the time between the Q sorts on the degree of cognitive change.
[32] All applied statistical tests have been described in Section 4.3.

post Q sorts in the control group is 0.60. The perspectives of 6 of the 11 non-participants changed significantly (one-tailed z-test with $p < 0.025$).

Eleven of the 16 participants completed a workshop evaluation form and filled in their names. All stated to have learned, averagely or strongly, from others' perspectives, even though according to the Q sorting the perspectives of three of them had not changed significantly. In contrast, four of the seven ex post interviewees stated that their perspective did not change substantially, but according to the Q sorting the perspective of one of them did change significantly.

Second, we identified statistically significant changes in individual and average Q sorting scores on specific statements. Table 5.9 shows the percentage of statistically significant changes in individual Q sorting scores (two-tailed z-test with $p < 0.05$) in the participant group and the control group for different themes. The findings suggest that the participant group learned more about future developments, future strategies and future goals, whereas the control group learned more about the current situation and general issues.

Table 5.9. Percentage of significant changes in Q sorting scores per theme

	Current / general[†]	Expected developments[†]	Strategies[†]	Goals[†]	Total
Participants	3%	4%	7%	10%	6%
Control group	7%	1%	3%	5%	4%

[†] The following statements are related to each category: Current/general (1-14), Expected developments (15-23), Strategies (24-39), Goals (40-46), see for formulation of statements Appendix B.

Table 5.10. Significantly changed average Q sorting scores on specific statements for the participant group and control group

Statement[†]	Participant group		Control group	
	Ex ante score[‡]	Ex post score[‡]	Ex ante score[§]	Ex post score[§]
17	-1.5	-1.2	-1.5	-2.2[∣]
30	1.3	1.2	1	1.8[∣]
33	0.8	1.7[∣]	0.1	0.8
44	-0.5	0.5[∣]	-1.1	-0.5

[†] See Appendix B for the formulation of the statements.
[‡] Average Q sorting score of the 16 workshop participants for a specific statement.
[§] Average Q sorting score of the 11 non-participants for a specific statement.
[∣] Significant change in average Q sorting score (two-tailed t-test with $p < 0.05$).

Table 5.10 shows the statistically significant changes in the average scores of the participants and the control group on specific statements (two-tailed t-test with $p < 0.05$). Only four significant changes occurred: two in the participant group and two in the control group. Concerning expected developments, the control group became more convinced that the effects of climate change on peak

discharges are certain enough to take action now (statement 17). Concerning strategies, the control group became more convinced of the need for a better integration of water management and spatial planning (30). The participants agreed more strongly that more controlled retention polders should be developed and that their use should be optimized for the whole Rhine basin (33). Finally, concerning the goals to achieve, the participants became more in favor of retreating the dikes to allow the river to meander again (44).

Changes in consensus between the respondents
Third, we analyzed whether the correlation between the individual Q sorts within each group increased over time. In the participant group, the average of the correlation coefficients between each pair of individual Q sorts increased over time from 0.30 to 0.33 (non-significant in a two-tailed t-test with $p < 0.05$). According to the workshop evaluations, however, most participants thought that mutual agreement concerning possible future scenarios and future flood management strategies had developed well. The average of the correlation coefficients in the control group decreased significantly from 0.32 to 0.26 (two-tailed t-test with $p < 0.05$). Since we did not analyze the exposure to knowledge and the framing of knowledge by the members of the control group, we cannot explain why the consensus in the group decreased.

Cognitive learning from the research results
Fourth, we focused our analysis on learning from the technical research results that were presented and discussed during the workshops. We analyzed to what extent the participants' Q sorting scores on the statements about future peak discharges changed in the direction of the scores that would be expected based on the research results (see Table 5.8). For each individual, we summed up the changes in scores in the direction of the research results and subtracted from this sum the changes in the opposite direction. We divided the total by the sum of the expected changes in scores on the basis of the research results (see Table 5.11).

The results suggest that the perspectives of eight participants changed predominantly in the direction of the research results and that the perspectives of four participants changed predominantly in the opposite direction (no test for significance applied). In the control group, six respondents changed their perspectives predominantly in the direction of the research results and two in the opposite direction.

The participants' perceptions of their learning from the research results were remarkably congruent with the learning that we measured with the repeated Q sorting. Of the five participants that stated in their workshop evaluations that they learned about the influence of climate change on future peak discharges, four indeed changed their perspective predominantly in the direction of the research results (and none predominantly in the opposite direction). And of the six participants that stated that they did not learn about the influence of climate

change, four changed their perspective predominantly in the opposite direction (and none predominantly in the direction of the research results). In addition, the ex post interviews confirmed most of the measured changes in scores on statements 15, 16, 17 and 33.

Table 5.11. Individual cognitive learning

Partici-pant	Correlation ex ante and ex post perspective	Total observed changes[†]	Total expected changes[‡]	Learning from research results
1	0.76	1	3	0.3[ǀ]
2	0.49[§]	5	11	0.5[ǀ]
3	0.38[§]	3	7	0.4[ǀ]
4	0.51[§]	-1	1	-1.0
5	0.75	-2	3	-0.7
6	0.74	1	5	0.2[ǀ]
7	0.54[§]	1	3	0.3[ǀ]
8	0.70	0	3	0.0
9	0.72	-1	4	-0.3
10	0.61[§]	-2	3	-0.7
11	0.28[§]	5	9	0.6[ǀ]
12	0.38[§]	0	6	0.0
13	0.51[§]	0	7	0.0
14	0.71	-1	8	-0.1
15	0.57[§]	2	5	0.4[ǀ]
16	0.62[§]	2	5	0.4[ǀ]

[†] The sum of changes in scores on statement 15, 16, 17 and 33 in the direction of the research results minus the sum of changes in the opposite direction.

[‡] Changes are expected when the ex ante Q sort score and the Q sort score based on the expert knowledge differ with at least 1 point (the scores 2 and 3 are treated as 2 and the scores -2 and -3 are treated as -2, because of the relatively low frequency of these scores).

[§] Significant change in Q sort according to a one-tailed z-test with $p < 0.025$.

[ǀ] Change that is considered predominantly in the direction of the research results.

Learning by the researchers

None of the researchers involved in the collaborative process completed the repeated Q sorting, but we asked two of them whether they learned something from the other participants. One researcher stated that she learned about the daily experiences, priorities, responsibilities and work strategies of the policymakers and societal stakeholders. In addition, she learned about the time and location of floods in recent history. The other researcher stated that he learned that bottom-up, participative, multi-disciplinary processes are very slow, but often have some interesting results in the end. Both researchers learned that there are large cultural and organizational differences between The Netherlands and Germany, e.g., a more hierarchical culture in Germany and a more deliberative culture in The Netherlands.

5.6. Observed collaboration and other potential influences on learning

The collaborative process
The collaborative process was, in general, conducive to learning, but not all relevant stakeholders were willing and able to be involved. As discussed, the initiative for collaboration came from the researchers. They actively and persistently tried to convince the other stakeholders to collaborate intensively since they needed their input for the scenario modeling (ACER project). Moreover, they were flexible about incorporating aspects that arose during the collaborative process in the modeling, e.g., a German climate scenario. Yet, many choices concerning the research had already been made and the researchers were careful not to promise more than they could deliver.

Staff from a governmental research institute and a consultancy firm specialized in organizing participatory processes functioned as intermediaries between the involved researchers and other stakeholders and increased the ability to collaborate. The governmental research institute knew both the policymakers and the researchers and helped them to understand each other. The consultancy firm supported the organization of a fair process in which the expectations of all participants were addressed.

The policymakers in the Working Group had an institutionalized objective to learn about the impact of future climate change and socio-economic developments on flood management (see Provincie Gelderland et al. 2007). In practice, however, many policymakers and other participants were not willing or able to collaborate intensively. This was illustrated by the decreased involvement of the Working Group in the collaborative research after Workshop 1 and the low continuity of participation: 11 of the 16 participants that responded to the repeated Q sorting attended only one workshop (see Table 5.12). Four different reasons were given by participants for their limited collaboration: 1) their daily work had a higher priority than long-term thinking, 2) the goals of the collaborative research process were unclear, 3) they were not used to intensive cooperation with researchers, and 4) too many new topics and methods were introduced.

The discussion of perspectives was quite intensive and fair. The results of the interaction analysis revealed a balanced mix of task-oriented and procedural speech acts during the workshop discussions, with a slight focus on task-oriented discussions concerning the content of future flood management (see Figure 5.5). This was confirmed by the content analysis of the workshop discussion. The interaction analysis, in addition, revealed that the atmosphere during the workshops was positive: socio-emotional speech acts were predominantly positive (see Figure 5.5).

Table 5.12. The intensity of individual collaboration

Participant	Workshops attended	Participation in discussion[†]
1	1, 2, 3	1.3
2	1, 3	1.1
3	1, 2	0.4
4	2	0.4
5	2, 3	0.4
6	3	0.5
7	3	1.2
8	2, 3	1.7
9	2	1.3
10	2	1.2
11	2	0.2
12	3	0.6
13	3	0.1
14	3	0.1
15	3	0.4
16	3	0.5

[†] The values were calculated by dividing the number of speech acts uttered by the participant by the average number of speech acts uttered per participant, and averaging it over the discussions in which the individual participated (except for the sub group discussions that could not be analyzed).
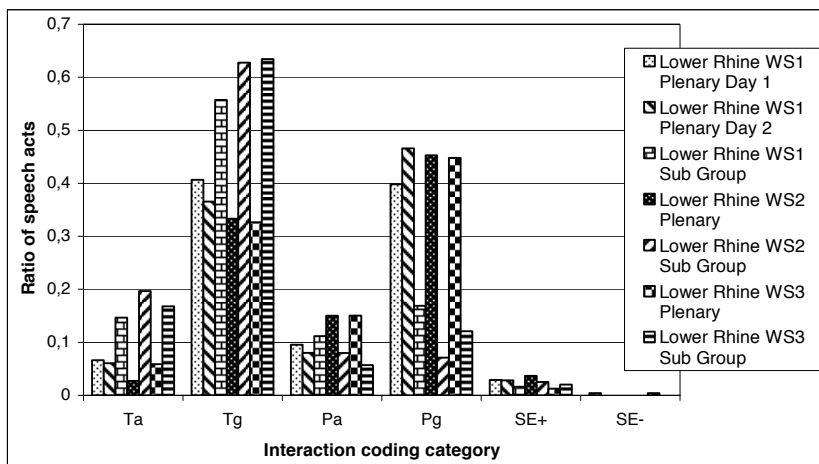
Figure 5.5. Ratio of speech acts concerning specific interaction categories[33]

The number of contributions to the workshop discussions was more evenly distributed over the participants than in the discussions analyzed in Fietkau and

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[33] The abbreviations in the Figures have the following meaning: WS = Workshop, Others = Societal actors. The interaction coding categories Ta, Tg, Pa, Pg, Se+ and SE- are explained in Section 4.4.

Trénel (2002)[34]. In particular, splitting up participants into sub groups supported an equal participation of all participants. Furthermore, the participating policymakers and societal stakeholders contributed a lot to the discussion, in comparison to the researchers and facilitators (see Figure 5.6). Finally, we assessed how actively each workshop participant participated in the discussion. Of the 16 participants that completed the repeated Q sort, 6 had participated more actively than the average and 10 less actively (see Table 5.12).
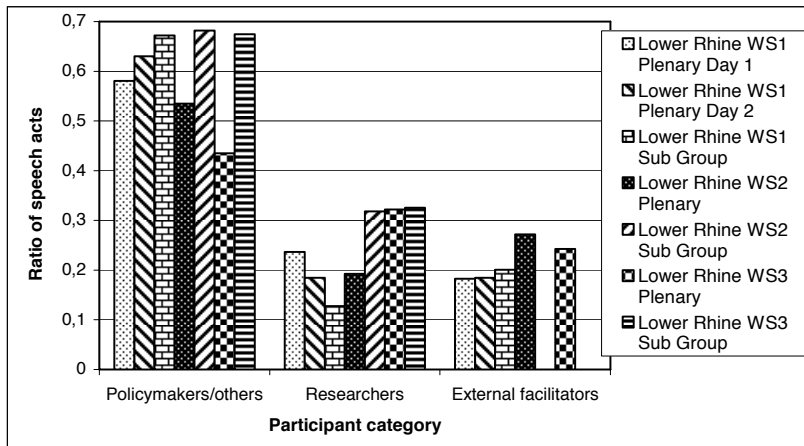
Figure 5.6. Ratio of speech acts uttered by groups of participants[33]

The research process, policy process and other processes
The perceptions of the research were mostly positive. All participants stated in the workshop evaluations that the workshop themes and the presented research results were relevant (see Table 5.13). From the final interviews we learned, however, that only a few participants were really interested in learning from the research results. Some participants attended the workshops only because their superior sent them, others were mainly interested in learning from other policymakers and societal stakeholders, e.g., from other countries, and in learning about the scenario method. Moreover, all interviewees mentioned that the presented research results did not significantly add to the existing body of knowledge and that this strongly prevented learning. The workshop evaluations and the final interviews indicated that most participants trusted the quality of the research and the models used, which are well-known in the water sector (see Table 5.13). Only one of the 16 participants considered the discussion of assumptions and uncertainties to be insufficient. The presentations of research results were considered sufficiently attractive (see Table 5.13). For Workshops 2 and 3 we also obtained evidence that the presentations were considered comprehensible and that the questions after the presentation were considered

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[34] This is also reflected in relatively high Gini coefficients in relation to the Delft case (see Section 7.1).

well-answered. The presentations at Workshops 1 and 3 were appreciated more than the presentation at Workshop 2, which may have been due to the use of more maps, tables, graphs, and illustrations in these presentations.

Table 5.13. Participants' perceptions of the research

Participant	Perceived relevance[†]	Perceived trust in research[‡]	Perceived quality presentations[§]
1	n/a	n/a	n/a
2	n/a	n/a	n/a
3	4	5	4
4	4	4	2
5	4	3	4
6	n/a	n/a	n/a
7	4	4.3	3.3
8	3	3	3
9	4	1	3
10	4	4	3
11	4	4	4
12	3	3.3	4
13	3	3.7	4
14	n/a	n/a	n/a
15	4	3.3	4
16[|]	n/a	n/a	n/a

[†] During Workshop 1 the participants' evaluations were completed anonymously. For Workshop 2, we displayed the participant's evaluation of the relevance of the workshop theme. For Workshop 3, we displayed the participant's evaluation of the relevance of the presented research results. For all scores in this table a five-point scale was used (1 = very poor, …, 5 = very good).
[‡] For Workshop 2, we displayed the participant's evaluation of the discussion of uncertainty in all presentations. For Workshop 3, we displayed the average of the participant's evaluation of the suitability of the applied models, the discussion of relevant uncertainties and assumptions, and the quality of the presented research results.
[§] For Workshop 2, we displayed the participant's evaluation of the presentation of research results. For Workshop 3, we displayed the average of the participant's evaluation of the presentation of research results in general, the attractiveness of the presentation, and the comprehensibility of the presentation.

There was no direct link to an ongoing policy process because ongoing policy processes had a much shorter time horizon than the collaborative process. Yet, strategic considerations were not completely absent from the process. Policymakers in the Working Group did not want to damage the trust that had been built up in recent years by discussing sensitive issues. One of the involved intermediaries even stated that the involvement of the Working Group in the collaborative research process was decreased after Workshop 1 because some of the Working Group members wanted to keep transboundary cooperation purely technical and were not willing to participate in discussions at the strategic or political level, e.g., about the desired situation in 2050. Furthermore, analysis of the interviews, ex ante Q sorts and workshop discussions revealed differences in values and interests among the participants. For example, the members of citizens' initiatives challenged the status quo in current flood management

during the second and third workshop. Participant 8 stated that he was dissatisfied with the way the local government managed flood risk and that he intended to challenge the status quo from a citizen's perspectives. This resulted in an intensive discussion between the citizen and a representative from the respective municipality later in the workshop.

The background of the participants may also have influenced their learning. Twelve of the 16 participants had a technical background in engineering or hydrology. The workshop evaluations and final interviews indicated that people with a technical background were more critical towards the quality of the research than people without such a background.

Finally, there were many external factors that may have influenced learning. As possible sources of new technical insights, the participants and control group mentioned conferences, participation in (research) projects, discussions with colleagues, reports, news (papers) and magazines. For example, one member of the control group mentioned that scientists in general were becoming more and more certain that climate change will have a significant impact and that this was reflected in the media.

5.7. The relation between collaboration and learning

Because it is very difficult to establish causal relations between the multitude of independent variables (factors that may have influenced learning) and the dependent variables (different measures of cognitive learning), we can only present well-founded speculations about whether the collaborative research process enhanced cognitive learning. We first compared the observed cognitive learning between the participants and the control group and between participants with different intensities of collaboration. Subsequently, we analyzed for each individual participant which specific factors related to the collaborative process, the research process, the policy process and other processes influenced his or her learning.

The relation between the intensity of collaboration and learning
The degree of cognitive learning by the participants was almost equal to the degree of cognitive learning by the control group. On average, individual perspectives in both groups changed to a similar extent and changed to a similar extent in the direction of the research results. This suggests that the collaborative research process did not enhance cognitive learning among its participants. It may be explained by the limited amount of new technical insights obtained through the research and the relatively large influence of factors external to the analyzed workshops and research process. All interviewed participants stated that they learned more outside the workshops than at the workshops. Analysis of the topics of change, however, reveals that the participants learned more about the future and the control group learned more about the current situation.

Furthermore, consensus among the participants increased slightly, which contrasts with the decreasing consensus in the control group. The latter results suggest that the collaborative process did have some influence on cognitive learning by the participants.

In addition, we analyzed whether the intensity of collaboration by individual participants influenced their learning. The results suggest that participants who collaborated more intensively – attended multiple workshops, contributed a lot to the discussion, or both – changed their overall perspective *less* than the other participants. The overall perspectives of the five participants who attended multiple workshops changed less, on average, than the perspectives of the participants who attended only one workshop. Similarly, the overall perspectives of the five participants who contributed a lot to the discussion changed, on average, slightly less than those of the participants who contributed little. This contradicts the hypothesis that intensive collaboration enhances learning. A possible explanation is that the more active participants already had a more developed perspective on the issues at stake at the start of the process. In line with the hypothesis that collaboration enhances learning, the more active participants did learn slightly more from the research results.

Factors that influenced individual learning
Participant 1 collaborated most intensively, by attending three workshops and participating actively in the discussions. Furthermore, participant 1 functioned as an intermediary between researchers and policymakers, by participating in the Working Group, co-organizing the workshops, and supporting the hydrological modeling. We speculate that the participant's strong involvement in the collaborative research process caused the change of her perspective in the direction of the research results. A reason for the limited change in the participant's overall perspective may be her large initial knowledge about the issue at stake. After participant 1, participants 2, 3, 5, and 8 collaborated most intensively, by attending two workshops. Only participants 2 and 3, however, changed their overall perspective and learned from the research results. In contrast, the perspectives of participants 5 and 8 did not change significantly and not predominantly in the direction of the research results. A reason for the limited learning of participant 5 may be his large initial knowledge about the issue at stake. Furthermore, the participant indicated that, although he was interested in learning from the research results, the presented results did not add to his prior technical knowledge. A reason for the limited learning of participant 8 may be his motivation to defend the interests of citizen's and to express the need for more anticipatory flood management. This focus may have made him less open to the perspectives of others.

The remaining participants participated only in one workshop. The perspectives of participants 9 and 14 did not change significantly and did not change in the direction of the research results, which can be explained by their limited workshop attendance. Moreover, participant 9 was very critical of the research

results in both the workshop evaluation and the final interview. He stated to be influenced by many sources of technical expert knowledge and to trust the outcomes of technical models only when multiple models give the same outcomes.

The perspectives of participants 4, 10, 12 and 13 changed significantly, but not predominantly in the direction of the research results. The latter can be explained by the interests of the participants, their evaluation of the relevance and presentation of the research results, their motivations to participate and their limited workshop attendance. Participant 4 indicated during the workshop and in the final interview that he intended to learn about long term changes and from others' perspectives. Conversely, he did not intend to learn from the presented research results. Another explanation for the participant's limited learning from the research results is that he did not consider the presentation of the research results to be clear and attractive. Participant 13 also intended to broaden his horizon by learning from others and considered the research results of limited relevance. Participant 12 was strongly focused on reducing the residual risk of flooding. He may have learned little from the research results, about the impacts of climate change and retention measures, because these developments were not so relevant within his focus. This was reflected in the participant's evaluation of the relevance of the presented research results. Finally, participant 10 indicated to be more interested in learning about changes until 2020 than in learning about changes until 2050. The latter would encompass too much uncertainty. In addition, the participant considered the presentation of research results only of average quality.

In contrast, the overall perspective of participant 6 did not change significantly, but did change in the direction of the research results. We cannot explain the observed learning based on the collected data.

The perspectives of participants 7, 11, 15 and 16 changed significantly and in the direction of the research results, even though the participants only attended one workshop. Participant 7 stated that her main goal was to represent the citizens and voice their problems and arguments. Although this focus may have decreased her openness to learning from others, there were many other factors that may have supported her learning, such as her active participation in the discussion and her positive evaluation of the presented research. Participant 11 stated in the final interview that he was sent to the workshop by his superior and did not expect to learn from the research results. He stated that he learned mainly from his own thinking and from external sources of knowledge. Participant 15 is an interested consultant who may have learned strongly, because he was motivated to learn and because his framing was not strongly influenced by values and interests. Finally, we cannot explain why participant 16 learned so strongly. The strong learning may be related to her non-engineering background and limited prior (technical) knowledge about the issue at stake, which provided a lot of opportunity to learn. On average, however, the

participants without a technical background learned slightly less, in general and from the research results, than the participants with a technical background. We speculate that most participants with a technical background understood the (technical) discussions better, and therefore learned slightly more, even though they were more critical.

5.8. Summary and conclusions

In this chapter we assessed a collaborative scenario study concerning future flood management in the Lower Rhine basin in Germany and The Netherlands. In this part of the Rhine basin, current safety standards are high, but flood risk may increase due to climate change and socio-economic developments. We elicited the perspectives of a broad range of stakeholders about the changes that they expected until 2050 using Q methodology. We identified three shared perspectives, which we named: A) "Anticipation and institutions", B) "Space for flooding", and C) "Knowledge and engineering". These three perspectives share a central concern for the provision of safety against flooding, but disagree on the expected autonomous developments and the preferred measures. In perspective A, the expected climate change and economic growth call for fast action. To deal with the increasing flood risk, mostly institutional measures are proposed, such as the development of a stronger basin commission. In perspective B, an increasing spatial pressure on the river area is expected, and the proposed measures are focused on mitigating damage, e.g., through controlled flooding and compartmentalization. In perspective C, the role of expert knowledge and technological improvements is emphasized. Preferred strategies include strengthening the dikes and differentiation of safety standards.

Subsequently, together with other researchers, consultants and policymakers from the German-Dutch Working Group on Flood Management, we organized three collaborative scenario workshops, in which we developed a set of scenarios, strategies and criteria for success of future flood management. The results were input for a technical model study concerning the effects of expected changes and strategies on peak discharges. The main substantive findings of the modelling, which were presented during the third scenario workshop, were that climate change increases peak discharges, flooding in Germany strongly decreases downstream discharges and retention measures reduce discharges to a lesser extent

In the context of the collaborative scenario study, we assessed cognitive learning by the participants and by a control group of non-participants. We found that different individuals learned to different degrees and about different topics. Some of the individuals changed their perspectives in the direction of the presented research results and some in the opposite direction. For example, in line with the research results, the participants became, on average, more convinced of the need for controlled retention areas. The finding that not all

presented research results were incorporated in the individual perspectives of the participants, however, reveals that there are also barriers to learning.

More interestingly, we assessed whether participating in the collaborative research process enhanced cognitive learning. The results show that the overall perspectives of the participant group and the control group, on average, changed to the same degree. Both groups also learned to the same degree from the research results. These results suggest that participating in the collaborative process did not enhance learning. However, we also found that the participants learned more about the topics that were discussed during the workshops than the control group and that the perspectives of the participants converged slightly, whereas the perspectives in the control group diverged. These results suggest that participating in the collaborative process may have had some influence on cognitive learning.

Furthermore, we analyzed whether differences in the degree of learning between the participants in the collaborative process could be explained by factors related to the collaborative process, the research process, the policy process and other processes. Based on the results of the analysis, we speculate that all factors that were identified in the conceptual framework as potential influences on cognitive learning influenced cognitive learning of one or more participants. The results suggest that three factors were dominant. First, the willingness to collaborate and learn was limited, because there was no pressing policy issue. We speculate that this reduced overall learning. Second, the relevance of the research results that were presented during the collaborative process was limited, because there was no pressing policy issue and the modeling produced little "new" scientific insights. We speculate that this limited learning from the research results. Third, the participating individuals were relatively strongly exposed to others' perspectives about flood management outside the collaborative process. We speculate that this limited learning within the collaborative research process.

We were able to explain the observed learning for most participants by using the observed factors (selectively). Yet, we could not have predicted the observed learning based on the observed factors, because often we identified a mix of supportive and hindering factors, without being able to assess the relative influence of each factor. Thus, the empirical evidence from the case study gives no clear-cut answers to the question how collaboration and other factors influence learning. To obtain better insight in the relative influence of different factors and differences in their influence in different contexts, more case studies are needed. We speculate that the relation between collaboration and cognitive learning will be more obvious in cases in which 1) more new research results are produced, 2) expert knowledge is directly needed for decision-making and 3) external influences on cognitive learning about the issue at stake are relatively small. The Delft case, which is discussed in the next chapter, is an example of such a case.

Chapter 6

Case study "Groundwater management in Delft"

In this chapter, we analyze a collaborative research process concerning the reduction of a large groundwater abstraction in the city of Delft (Section 6.1). In the process, researchers, policymakers and NGOs collaborated during steering group meetings and three workshops. In parallel to these meetings, a model study was performed in order to assess the effects of reducing the abstraction, e.g., on groundwater levels and ground level movement, and to assess the costs and benefits of alternative management strategies. This information was urgently needed to support decision-making (Section 6.2). When we got involved in the collaborative process, we identified four shared perspectives about the expected effects of ending the abstraction, the goals to be achieved, and the preferred management strategies. We named them A) "Natural sustainability", B) "Cost limitation", C) "Damage prevention", and D) "Good relations" (Section 6.3). Subsequently, we analyzed the collaborative process and its results. The main findings of the model study were that the abstraction cannot be reduced substantially without problems: it will endanger the stability of levees, cause local ground level rise and result in nuisance due to wet cellars and rising damp. Intensive monitoring, additional drainage and strengthening levees may help to deal with these effects (Section 6.4). Assessment of the cognitive learning that occurred in the collaborative process demonstrated that the overall perspectives of 11 of the 12 participants changed significantly, that 7 participants learned from the research results and that consensus increased between the 3 steering group members only (Section 6.5). Furthermore, assessment of the collaborative process, the research process, the policy process and other processes revealed specific factors that may have supported or hindered learning (Section 6.6). Overall, the results suggest that only intensive collaboration, such as occurred during the steering groups meetings, increases consensus and learning from research results substantially. The results also suggest that learning from the research results in the case was strongly influenced by individual interests, strategic considerations, the fairness of the collaborative process and individual perceptions of the research (Section 6.7). The chapter ends with a summary and conclusions (Section 6.8).

6.1. Reducing a groundwater abstraction in Delft

In this case, the issue at stake is the reduction of a large groundwater abstraction in the city of Delft, which is located in a polder area in the low-lying western part of the Netherlands. Before introducing the specific issue, we shortly introduce how groundwater levels in Dutch polders are controlled and which governments have which responsibilities in groundwater management.

Dutch polders are drained artificially in two steps (see Figure 6.1). First, excessive water is pumped from the surface waters in the polder to the main drainage canals or "boezems". Since the water level in boezems is higher than the water level in polders, levees have to protect the polder against flooding from the boezem. Second, excessive water in the boezems is pumped to rivers or the sea. Groundwater levels in polder areas are controlled by managing surface water levels. In addition, drains have been constructed in many areas, in order to transport excessive groundwater to the surface water. Still, high groundwater levels cause problems to the users of the land in many polders. In dry periods the river supplies water to the polder system. The water is used to flush the polder and boezems and to maintain desired groundwater levels.
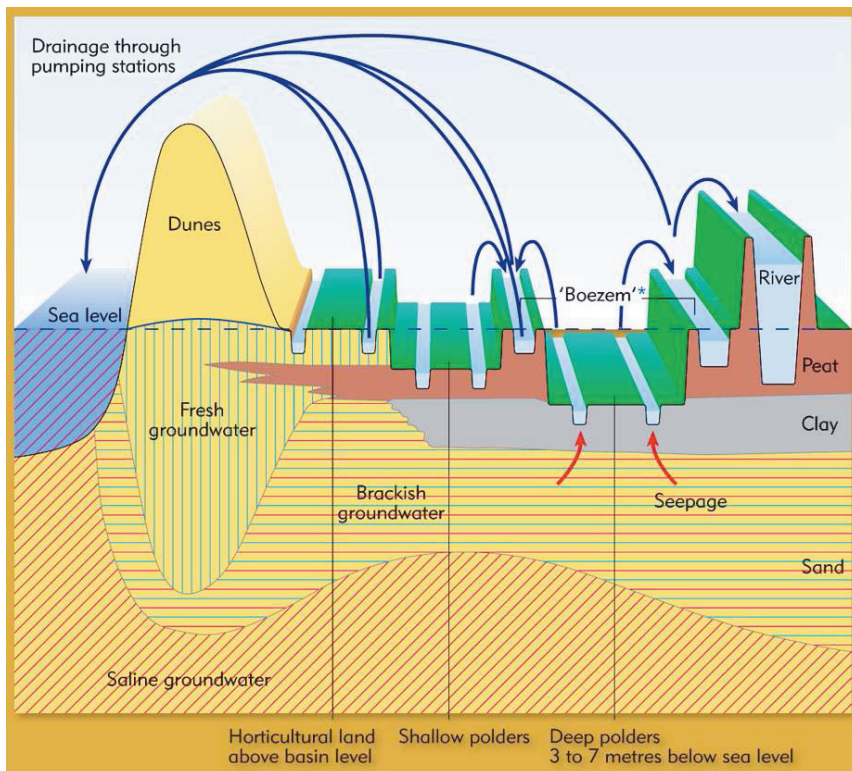

Figure 6.1. Drainage of polders in wet periods (copied from Huisman 2004)

Provinces, water boards, and municipalities have different responsibilities related to quantitative groundwater management. Provinces are responsible for regulating groundwater abstractions and infiltrations, among others by issuing permits. Groundwater users have to pay the province a fee per cubic meter abstracted groundwater[35]. Provinces can use the fee only for specific purposes, including investigating the damage caused by abstractions and taking measures to prevent nuisance and damage due to abstractions. Water boards are responsible for managing surface water levels in polders and boezems and for protecting the polders against flooding from the boezems. Finally, since January 2008 municipalities are responsible for taking measures against structural groundwater nuisance. In particular situations, however, it may be unclear whether provinces, water boards or municipalities have to take measures to prevent groundwater nuisance (Mostert 2008). An example of an issue for which the responsibilities of the involved governments have not clearly been defined is the reduction or ending of a groundwater abstraction.

The case study concerns the reduction of a large groundwater abstraction. In the region around Delft, the upper 10 to 20 meters of the ground form a Holocene layer, which consists of clay, sand and peat and has a low permeability. The intake filters of the discussed groundwater abstraction are located below the Holocene layer, at 25-45 meter below mean sea level. At this depth, sand layers with a high permeability (aquifers) alternate with clay layers with a low permeability (aquitards). Because of the low permeability of the Holocene upper layer, the effects of reducing the abstraction on the phreatic groundwater level are much smaller than the effects on the groundwater head in the aquifers (Roelofsen 2008; Roelofsen and Goorden 2008).

The discussed groundwater abstraction existed for almost 90 years. The abstracted water was used by the large industrial company DSM as process water and cooling water. The province of Zuid-Holland (referred to as "the province") issued the permit for the abstraction. The water board of Delfland (referred to as "the water board") transported the water, after it was used, to the North Sea[36]. In 2004, however, DSM announced that they would strongly reduce the abstraction, since they needed less water in their production process. The municipality of Delft, the province, the water board and a group of researchers from well-known research institutes and consultants[37] reacted to this announcement by starting a research project. In the first phase of the project, the Quickscan, a qualitative analysis of potential problems, solutions and costs was made. A broad range of stakeholders was involved in the exploration of

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[35] In addition, abstractors of groundwater have to pay a tax to the national government per cubic meter abstracted groundwater.

[36] DSM paid a tax to the water board for transporting and discharging the brackish (and polluted) water. The water board paid a tax to the national governmental organization Rijkswaterstaat for discharging the water into the North Sea.

[37] TNO (Department Built Environment and Geosciences), WL | Delft Hydraulics, Geodelft, Syncera and KIWA.

potential problems, with a questionnaire and at a first workshop, and the development of alternative solutions, at a second workshop. After the workshops, three alternative solutions were elaborated and the societal costs and benefits of each alternative were estimated. The results of the Quickscan were disseminated in September 2005.

The Quickscan revealed that ending the abstraction could have an impact in an area of about 50 km^2 (see Figure 6.2) and could affect many stakeholders. Expected negative effects of reducing or ending the abstraction were 1) nuisance and damage due to higher groundwater tables, 2) reduced water quality due to an increased transport of salt and nutrients to the surface water, and 3) damage to constructions due to an increase in deep groundwater pressure and swelling and settling of the ground. Ending the abstraction could also have positive effects, such as restoring a more "natural behavior" of the water system. Alternative solutions to the problem were to 1) utilize the abstracted water for alternative purposes, 2) reduce the abstraction only partially in order to limit negative effects, or 3) fully shut down the abstraction, but mitigate or compensate the effects. The estimated net societal costs (minus benefits) varied from 0 Euro for alternative utilization up to ca. 100 million Euros for full termination of the abstraction (Gehrels et al. 2005). All costs that we mention in this chapter are the total costs for the coming decades against Net Present Value.
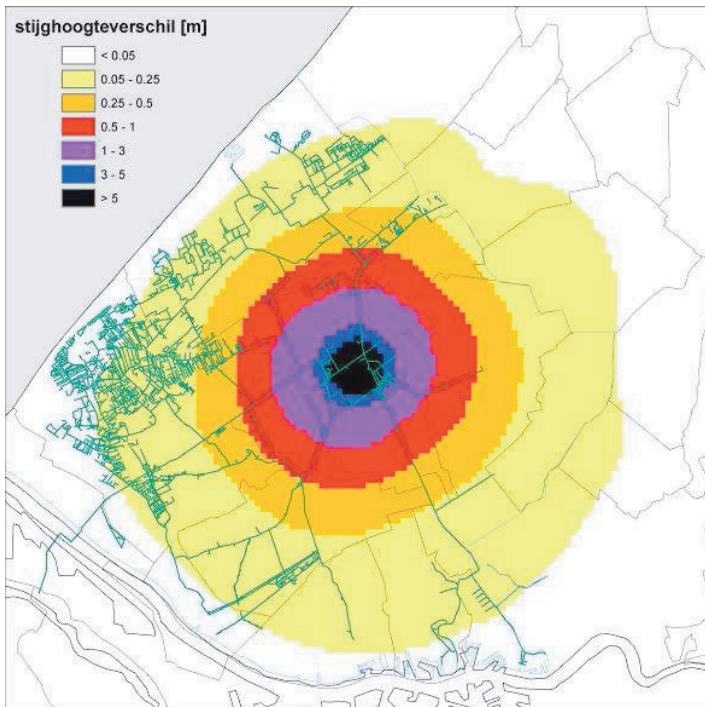
Figure 6.2. Increase in the groundwater head in the upper aquifer (in m) when the groundwater abstraction would be ended (Roelofsen 2008)

The results of the Quickscan suggested that reducing the abstraction could have significant impacts for the water management tasks of the province, the water board and the municipality of Delft. Therefore, these governmental bodies and researchers from TNO, Geodelft and WL | Delft Hydraulics initiated a quantitative follow-up study, in order to obtain more trustworthy knowledge about the effects of reducing the abstraction and the appropriateness of different management alternatives. They planned to pay special attention to the influence of the planned railway tunnel in Delft on the effects and management alternatives. Furthermore, the governments decided in dialogue with DSM to continue the abstraction until more knowledge was available about the impacts of reducing it. Because the abstraction, transport and discharge of the groundwater are very costly, there was a lot of political pressure to find a solution fast. In parallel to the research, DSM and the three most involved governments were involved in a legal procedure to find out who was responsible for the costs of continuing the abstraction.

6.2. The collaborative research process

The goals of the process
Some time after the Quickscan had been finalized, the second phase of the collaborative (Delft Cluster) research started in 2006. The goals of the second research phase were to (Gehrels et al. 2006):

1. Set up a monitoring strategy in order to measure the effects of reducing the abstraction and constructing the railway tunnel, and to improve the models;
2. Quantify, substantiate and detail the effects of reducing or ending the abstraction, in combination with the construction of the railway tunnel;
3. Define the most efficient preventive or compensation measures.

There was a need for detailed knowledge about the influence of the abstraction on the groundwater head in the aquifer and on the phreatic water table at different locations, and about the effectiveness and efficiency of the measures to prevent damage. Therefore, a detailed geological model of the Holocene upper ground layer was developed, which served as a basis for a coupled groundwater and surface water model, a salt transport model and a geotechnical model (Gehrels et al. 2006). Based on the physical results, the researchers would deliver a refined overview of the cost and benefits of different management alternatives. This information would be the basis for further discussion about alternative solutions. In parallel to the Delft Cluster study, the possibilities for alternative utilization of the abstraction would be analyzed by the consultancy firm DHV.

The process organization
The stakeholders were divided in four groups, with different levels of involvement in the project:

- The project group consisted of researchers from the involved research institutes;
- The steering group consisted of representatives from the municipality of Delft, the province of Zuid-Holland, and the water board of Delfland[38];
- The interest group consisted of officials from seven surrounding municipalities;
- The sounding board consisted of non-governmental organizations (NGOs) with specific interests and representatives from governmental and NGOs with specific relevant knowledge.

The steering group and project group formulated the research questions and methods together. The research was financed with contributions from the governments in the steering groups, contributions from the research institutes and a subsidy from the Delft Cluster research program. The most intensive collaboration between policymakers and researchers took place during the steering group meetings, which took place every 2-4 weeks in 2007 and every 1-2 month(s) in 2008. The project leader from TNO represented the project group at all steering group meetings and other researchers from the project group joined when appropriate. At the steering group meetings, the progress of the research was discussed and further research, meetings and workshops were planned. The members of the interest group and sounding board were informed of the progress of the research by newsletters and were invited to the workshops.

The start of the process
After finalizing the research proposal, the second research phase started in April with a start-up meeting for members of the steering group and the project group (see Table 6.1). They discussed mostly organizational matters. In October 2006 a broader start-up workshop took place, involving the steering group, project group and many people from the interest group. The aim was to inform the participants about the ongoing and planned research, the role of the interest group, the link with politics and communication with citizens. After a series of presentations there was room for plenary discussion. In January 2007 another meeting of the project group, steering group and interest group took place. At this meeting the (preliminary) monitoring strategy was presented for the themes groundwater nuisance, groundwater quality, surface water quality and ground level movement, followed by a plenary discussion about how to organize the monitoring.

We became involved in the project in January 2007. From then until October 2008 we attended almost all steering group meetings. In February and March 2007 we conducted the exploratory interviews and the first round of Q sorting. Furthermore, we attended all workshops that were organized after January 2007

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[38] Besides the observed steering group meetings at the level of government officials (which we refer to as policymakers), there were also steering group meetings at the political level.

and observed the collaboration at the workshops in detail. We did not attend the meetings at the political level.

Table 6.1. Important events and activities in the case

Time / period	Activity / event
Nov 2004	DSM announces intention to strongly reduce abstraction
Apr 2005	Start first phase of research: Quickscan
Sep 2005	Finalization and dissemination results Quickscan
Mar 2006	Start of legal procedure (summoned by DSM)
Apr 2006	Start second phase of research
Oct 2006	Broad start-up meeting of research
Jan 2007	Workshop about monitoring strategy
Feb 2007	Ex ante interviews (this research)
Mar/Apr 2007	Ex ante Q sorting (this research)
Mar 2007	First observed workshop
Jun 2007	Legal judgment and appeal
Jul 2007	Second observed workshop
Nov 2007	Third observed workshop
Feb 2008	Presentation preliminary research results to politicians
Sep 2008	Research report finalized
Oct 2008	Ex post Q sorting (this research)
Nov/Dec 2008	Ex post interviews (this research)
2009 (planned)	Dissemination research results and decision-making

The collaborative workshops
In the period between March and November 2007, three workshops took place (see Table 6.2). The workshops were prepared and facilitated by the steering group and the project group. The project group, steering group, interest group and sounding board were invited for each workshop. The workshop participants were mostly officials representing the governments in the steering group or interest group, or researchers from the project group. Societal stakeholders and other members of the sounding board were underrepresented. The workshops were to a large extent filled with presentations by project group members about the research approach and preliminary results. During all workshops there was room for plenary discussion about the presented content. At the first two workshops a variety of preliminary results was printed on posters and stuck to the wall. This way, the participants could walk by each poster, discuss the results and give comments based on their local knowledge, e.g., by sticking notes in specific areas (see Figure 6.3).

Workshop 3 was the most interactive workshop, as the participants had to design and test strategies for dealing with a reduced groundwater abstraction, in three breakout groups. Each breakout group focused on the strategies in a particular area. The two strategies that were explored were the construction of new drains and the relocation of the central abstraction to multiple strategic locations (with a small abstraction at each location). Each group was facilitated by a member of the steering group and a member of the project group, who inserted the proposed strategies in the interactive computer model (iMOD) and showed the effects on

the groundwater table. iMOD used a precalculated Impuls-Response database, which enabled direct visualization of the spatial distribution of the effects of the measures.

Table 6.2. Characteristics of the observed collaborative workshops

	Workshop 1	Workshop 2	Workshop 3
Time	March 2007	July 2007	November 2007
Location	Delft	Delft	Delft
Length	½ day	½ day	¾ day
Number of participants	Gov[†]: 14 Res[‡]: 4 Soc[ǀ]: 1	Gov[†]: 14 Res[‡]: 10 Soc[ǀ]: 1	Gov[†]: 17 Res[‡]: 8 Soc[ǀ]: 1
Goals	- Disseminate research results - Get feedback from local experts to improve models	- Disseminate research results -Discuss results and methodology	- Disseminate research results - Explore effects and costs of measures (drainage, relocation of abstraction)
Activities	- Presentation groundwater model, results, and sensitivity - Interactive validation of results on maps - Plenary discussion	- Presentations research approach (expert models, iMOD, Social Cost Benefit Analysis) - Presentation effects of different scenarios for a reduced abstraction - Plenary discussion	- Presentation perspectives - Presentation results concerning: groundwater, ground level movement, stability of levees - Presentation tradeoff and time path of possible measures - Work in 3 breakout groups using iMOD - Plenary discussion

[†] Governmental actors (from the steering group, interest group and sounding board).
[‡] Researchers (from the project group).
[ǀ] Societal actors (from the sounding board).

Figure 6.3. Discussion of the research results represented on large maps during workshop 1 (left), and presentation of sub group findings to the plenary during workshop 3 (right)

After the Workshop 3 the groundwater, surface water and water quality modeling, the geotechnical modeling and the cost–benefit analysis had to be

brought to an end. Because there was a lot of political pressure to present the results of the research, a management summary containing the main conclusions of the research was written and used as input for a political meeting in February 2008. Afterwards, some parts of the research still had to be finished. In September 2008 a newsletter containing the management summary of the research findings was sent to the interest group and the sounding board. The main report of the research (Roelofsen 2008) was finalized in September 2008, printed in December 2008 and spread in January 2009.

6.3. Perspectives on the issue at stake

Conducting the "ex ante" Q sorting questionnaire
When we became involved in the project, we started with an exploration of the perspectives of the involved stakeholders concerning the issue at stake. First, we interviewed 11 involved stakeholders from a large variety of backgrounds. The stakeholders represented the municipality of Delft, the water board, the province, TNO and WL | Delft Hydraulics, as well as the surrounding municipalities of The Hague, Rijswijk and Midden Delfland, an agricultural organization and a nature organization. Second, we used Q methodology to measure and group the perspectives of the involved stakeholders. Based on the interview results, we selected a "Q set" of 37 statements (see Appendix C). The statements concerned 1) the effects of ending the abstraction, 2) strategies for ending, reducing or continuing the abstraction, and 3) the goals to be achieved. Preliminary Q sets were discussed with stakeholders from the municipality of Delft, the province, the water board and TNO, in order to test their consistency and completeness. Then, the final set of statements and the instructions on how to sort them were inserted in an online Q sorting tool.

In March and April 2007, a total of 35 stakeholders were asked by email to complete the online Q sorting questionnaire and to send the questionnaire to relevant colleagues. In addition, two stakeholders were asked to perform the Q sorting during a face-to-face interview. This resulted in 21 responses[39]: 16 from a broad range of governmental organizations and five from NGOs, including nature organizations, an agricultural organization and a drinking water company. Before the actual sorting, the respondents had to answer three questions related to their education, work experience and specific expertise. First, they were asked for their name, affiliation, education and work experience. Second, they were asked for their field(s) of expertise related to the effects of reducing the abstraction and strategies to deal with the effects. Third, the respondents were asked to score their knowledge concerning the functioning of the natural system (groundwater, surface water and ground) in the region.

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[39] We obtained three additional Q sorts after finishing the identification of shared perspectives. Consequently, we did not consider these perspectives in the analysis.

Results of the "ex ante" Q sorting questionnaire
Analysis of the obtained Q sorts with PQMethod supported the identification of four distinct "shared perspectives" or "factors". Each factor was determined by more than three Q sorts and more than 11 statements significantly distinguished each factor from the others. The factors explained 55% of the total variance between all individual Q sorts. After identifying the factors, the individual Q sorts that had a statistically significant[40] and clean[41] loading on a factor were selected as defining variables for that factor. Of the 21 Q sorts, one did not have a significant loading on any of the factors and one did not have a clean loading on any of the factors. Thus, 19 Q sorts were selected as defining variables. Table 6.3 shows the composition of the groups that define each factor.

Table 6.3. Number of respondents (per category) that define each factor

	MD, PZH, WBD[†]	Surrounding municipalities	Other governmental organizations	NGOs	Total
Factor A	2	1	1	3	7
Factor B	1	2			3
Factor C	1	2	2		5
Factor D	2	2			4
Total	6	7	3	3	19

[†] Municipality of Delft, Province of Zuid-Holland, and Water Board of Delfland.

Then, PQMethod calculated the ultimate factors scores and the factor Q sort values for each factor[42]. The statements that were sorted and the factor Q sort values are presented in Appendix C. Only one significant consensus statement was identified: all factors agree to some extent that additional drainage would be necessary to prevent groundwater nuisance when the abstraction would be ended. Finally, we revealed the logic within each factor by analyzing the highest and lowest scoring statements in each factor as policy arguments (see Figures 6.4-6.7). The four factors, which we named A) "Natural sustainability", B) "Cost limitation", C) "Damage prevention", and D) "Good relations" are discussed below.

Perspective A) "Natural sustainability"
Factor A (see Figure 6.4) is defined by seven respondents, among which all NGOs that defined a factor. The emphasis of factor A is on guaranteeing the sustainability of the natural system. Factor A claims that, in order to guarantee sustainability, the abstraction should be reduced or ended. This would have some positive effects: natural dynamics would be restored and biodiversity would increase. Ending the abstraction would, however, also result in a decrease in infiltration and an increase in seepage in an area of 50 km^2 around Delft and would cause nuisance due to higher groundwater levels. The factor claims that

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[40] Higher than 0.42, with $p < 0.01$ (see also Section 4.3).

[41] Exceeding the loading on other factors with at least 0.12 (see also Section 4.3).

[42] The standard error for the ultimate factor scores was 0.28 for factor A, 0.42 for factor B, 0.33 for factor C and 0.37 for factor D.

all effects should be analyzed in the context of more rainfall, sea level rise and the termination of other abstractions. Furthermore, the factor emphasizes the need for a fair distribution of costs over the stakeholders, in order to maintain good relations. The government would be responsible for taking measures to prevent damage and not individual real estate owners. By implementing these measures in phases, the total costs would decrease.
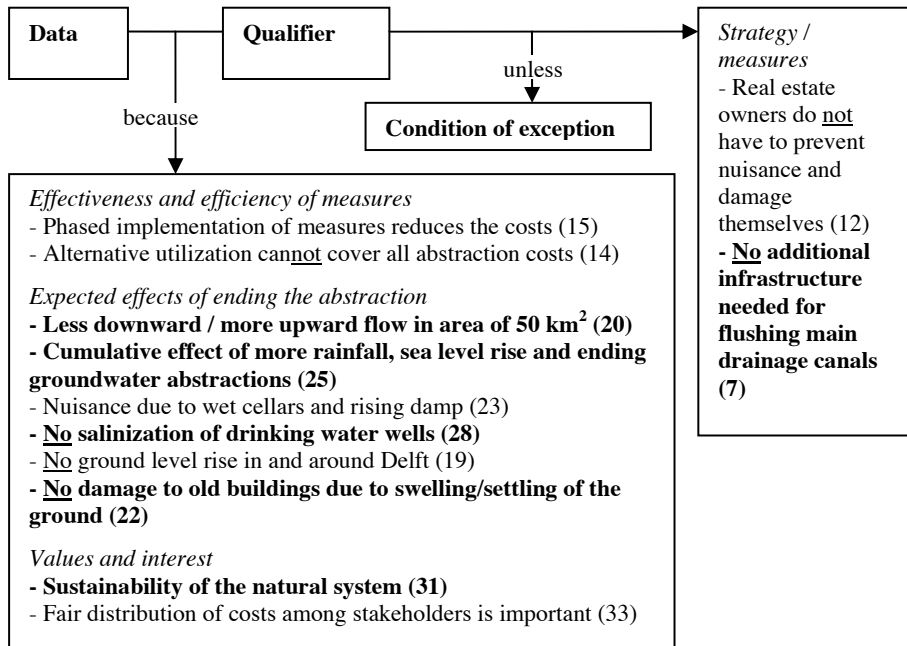
Figure 6.4. Argumentative structure for factor A) "Natural sustainability" [43]

Perspective B) "Cost limitation"
Factor B (see Figure 6.5) is defined by three respondents. The most important aim within this factor is to find a solution at low cost for society as a whole. Maintaining good relations between stakeholders is, however, considered of little importance. Ending the abstraction, or reducing it with 50%, is expected to cause significant damage. Besides groundwater nuisance in urban areas, the probability of failure of deep constructions is expected to increase, as a consequence of the increased groundwater head in the aquifer. Factor B is ambiguous concerning the strategy to employ. If there would be no possibilities for alternative utilization of the abstracted water, the involved governments would need to continue the abstraction. This situation may, however, be of temporary nature, since two of the three defining respondents also state that the abstraction should be reduced in a number of steps. Such a phased

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[43] Statements in bold significantly distinguish this factor from other factors with $p < 0.05$. The number between brackets refers to the statement in the Q set. Appendix C provides the complete formulation of each statement.

implementation would decrease the costs, which, according to one of the defining respondents, should be covered by the parties that benefitted from the abstraction before.
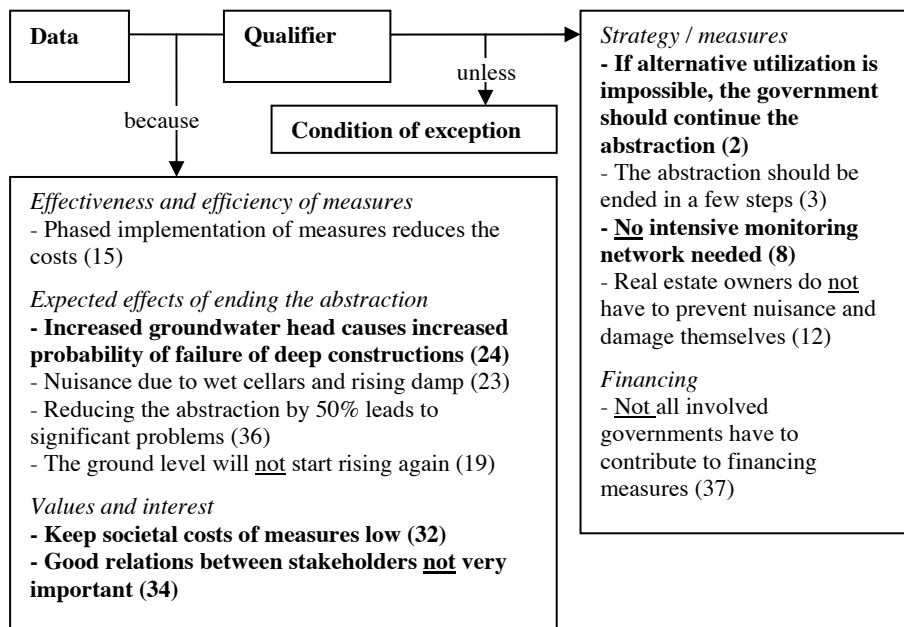
Figure 6.5. Argumentative structure for factor B) "Cost limitation" [43]

Perspective C) "Damage prevention"
Factor C (see Figure 6.6) is defined by five respondents. The focus of perspective C is on measures to prevent the negative effects that would occur when the abstraction would be ended. The respondents expect that continuing the abstraction would on the long term result in salinization of the groundwater and that ending the abstraction would affect a large area, including Leiden, Gouda and Rotterdam. The factor does not express a clear preference for continuing, alternative utilization or ending the abstraction, but emphasizes the need for constructional measures in order to prevent nuisance and damage caused by reduction of the abstraction. The factor also stresses the need to monitor the effects of reducing the abstraction intensively and to inform citizens about the expected effects. Furthermore, factor C supports a phased implementation of measures in order to reduce the costs (as factor A and B), and rejects that all involved governments should contribute to financing the measures (as factor B).
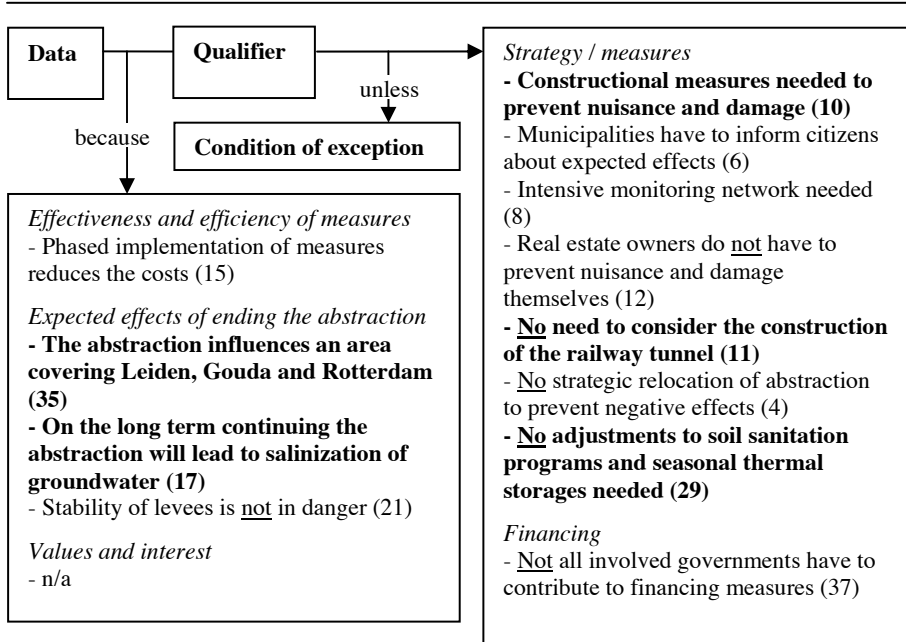
Figure 6.6. Argumentative structure for factor C "Damage prevention" [43]

Perspective D) "Good relations"
Factor D (see Figure 6.7) is defined by four respondents, who aim to maintain good relations and distribute the costs in a fair way. The expected effects of ending the abstraction are not very widespread and do not include significant problems for agriculture, nature and recreation. Since it would be impossible for market parties to utilize the abstraction in a cost-effective way, two of the respondents suggest that the government should stimulate alternative utilization (financially). When this appears unfeasible, even with governmental support, the four respondents agree that the abstraction should be ended in a few steps. In that case the reduction should be controlled by intensive monitoring and additional drains needs to be constructed.

Analysis of shared perspectives
The identified shared perspectives reflect different problems perceptions, different goal, and different preferred strategies, which cover all alternatives studied in the Quickscan. We analyzed qualitatively whether the values that are important in the factors, and according which we named the factors, are reflected in the organizational background of the respondents that define the factor, the expected effects when the abstraction is reduced and the preferred strategies. We did not find a clear relation between the organizational background of the respondents and the values that are reflected in the factors which they define, because respondents from the same organizational background define different factors (see Table 6.3). The only exception is that the two respondents from nature organizations, and remarkably also the

respondent from the agricultural organization, focus on the value of natural sustainability by defining factor A. We did find logical relations between the important values and the expected effects of ending the abstraction in factor A (focusing on the effects on natural dynamics and biodiversity) and B (focusing on economic damage in urban areas). In factor C and D this relation was less obvious. Finally, we found an obvious relation between the important values and the preferred strategy only in factor A (end the abstraction because this enhances natural sustainability). Factor B, C, and D do not demonstrate a clear preference for the overall strategy to employ.

Data		Qualifier		Strategy / measures

Data — **Qualifier** — unless → **Condition of exception**

because ↓

Effectiveness and efficiency of measures
- Alternative utilization can<u>not</u> cover the full abstraction costs (14)

Expected effects of ending the abstraction
- The abstraction does <u>not</u> influence an area covering Leiden, Gouda, Rotterdam (35)
- **Salinization and wetter farmland cause <u>no</u> damage to agriculture / horticulture (27)**
- **Salinization and eutrophication form <u>no</u> threat to swimming water and nature (26)**

Values and interest
- **Good relations between stakeholders very important (34)**
- Fair distribution of costs over stakeholders is important (33)

Strategy / measures
- **Intensive monitoring network needed (8)**
- **Stimulate alternative utilization by market (1)**
- If alternative utilization is impossible, government should <u>not</u> continue the abstraction (2)
- The abstraction should be ended in a few steps (3)
- **Additional drainage is needed to prevent nuisance (5)**
- **Adjustment surface water levels in polders <u>not</u> needed (9)**

Figure 6.7. Argumentative structure for factor D "Good relations" [43]

The finding that the relation between some of the components within factor B, C and D are not logical suggests that the defining respondents, at the moment of sorting, did not have a clear perspective about how to manage the issue at stake. A possible explanation for this is that the issue emerged only two years before the Q sorting and that there was relatively little knowledge about the effects of reducing the abstraction and about the feasibility, effectiveness and efficiency of different management alternatives.

Table 6.4 displays the correlation between the shared perspectives. The highest correlations occurred between factor A and C and between factor A and D. Factor A and C are both in favor of ending the abstraction. The main difference is that factor A aims to increase natural sustainability, whereas factor C focuses on the measures to take to prevent nuisance and damage in urban areas. Factor D

prefers a different strategy: alternative utilization of the abstraction. When this would appear unfeasible, however, factor D is in favor of ending the abstraction as well. Another similarity between factor A and D is that both aim for a fair distribution of costs.

Table 6.4. Correlations between factor scores

Factor	A	B	C	D
A	1.00	0.25 ± 0.30	0.36 ± 0.28	0.37 ± 0.28
B	0.25 ± 0.30[†]	1.00	0.23 ± 0.31	-0.04 ± 0.32
C	0.36 ± 0.28	0.23 ± 0.31	1.00	0.13 ± 0.32
D	0.37 ± 0.28	-0.04 ± 0.32	0.13 ± 0.32	1.00

[†] The uncertainty bounds are an approximation of the 95% confidence interval, assuming a normal distribution of the standard error of the correlation (see for formula Brown, 1980, p. 284).

The lowest correlation, which is even slightly negative, occurred between factor B and D. These factors do not agree on 1) the goals (e.g., the importance of good relations), 2) the significance of the effects (e.g., groundwater nuisance), and 3) the strategy to follow (continuing the abstraction versus alternative utilization or ending the abstraction). At the level of individual respondents, the lowest correlation between an individual Q sort and a factor was -0.30 and the lowest correlation between two individual Q sorts was also -0.30. Thus, the level of controversy is high, at least in comparison to the Lower Rhine case.

In order to enhance understanding of the existing controversies among the involved stakeholders, we disseminated the results of the analysis to all involved stakeholders in a paper (in Dutch) and presented the results at the third workshop. We also advised the project group and the steering group about the topics that still needed to be researched or discussed in order to increase consensus among the involved stakeholders. Topics that required additional attention included 1) the area that is influenced by the abstraction, 2) the effects of reducing or ending the abstraction on ground level movement, constructions, agriculture and water quality, 3) the need for intensive monitoring and informing citizens and 4) the overall strategy to employ (continue, reutilize, end or reduce the abstraction).

6.4. Substantive results of the collaborative research

In this section we interpret the technical results from the collaborative research, which were presented and discussed during the three workshops, in terms of the statements in the Q set. This is particularly relevant for the assessment of learning from the research results, which is described in the next section. We identified eight statements that were either clearly supported or clearly rejected

by the research results (see Table 6.5)[44]. Whether each statement was clearly supported or rejected was determined based on a) the presentations and discussions during Workshop 1, 2 and 3[45] and b) the management summary of the final report (Roelofsen 2008). In Table 6.6 we expressed the level of support to each statement in a Q sorting score for each statement. The score "2/3" reflects that the research results strongly support a statement. The score "-2/-3" reflects that the research results strongly reject a statement. The project leader validated our interpretation of the research results in terms of Q sorting scores. In addition to the quantified summary of the technical research results in Table 6.6, we summarize the content of the research results in a qualitative way below.

Table 6.5. Q sorting statements that concern the technical research results

Number	Statement
4	Negative impacts of ending the central abstraction should be prevented by strategically located small abstractions.
5	Additional drainage is needed, in order to prevent groundwater nuisance.
8	An intensive monitoring network is needed to monitor the different effects of ending the abstraction.
19	When the abstraction is ended, the ground level in and around Delft will rise again.
21	When the abstraction is ended, the stability of a number of levees will be endangered so much that measures for strengthening the levees are required.
23	When the abstraction is ended, this will result in nuisance due to wet cellars and rising damp.
35	The current abstraction influences an area covering Leiden, Gouda and Rotterdam.
36	The abstraction can be reduced by 50% without causing any problems.

Table 6.6. Q sorting statement scores that reflect the research results as presented during the workshops and in the summary of the final report

Statement	Workshop 1	Workshop 2	Workshop 3	Summary final report
4	n/a	n/a	-2 / -3	-2 / -3
5	n/a	n/a	2 / 3	2 / 3
8	n/a	2 / 3	n/a	3/ 3
19	n/a	n/a	2 / 3	2 / 3
21	n/a	n/a	2 / 3	2/ 3
23	n/a	2 / 3	2 / 3	2 / 3
35	-2 / -3	-2 / -3	-2 /-3	n/a
36	n/a	-2 / -3	-2 / -3	-2 / -3

The monitoring strategy (statement 8) had already been discussed at a workshop in January 2007, before we started analyzing the process. Monitoring would support 1) the assessment of changes that would occur when the abstraction

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[44] In contradiction with the original plan, the research did not address the effects of the construction of the railway tunnel.
[45] Differences between the content of the presented research results and the workshop discussions were only minor.

would be reduced, 2) the improvement of the models and 3) decision-making about further steps. After the monitoring meeting, the steering group members had the impression that not all surrounding municipalities felt the need for intensive monitoring. Furthermore, the researchers kept adjusting the monitoring strategy until November 2007. Therefore, the monitoring strategy was discussed again during the analyzed workshops, in particular during Workshop 2. In these discussions the need for monitoring was stressed.

At the first workshop, there were no new research findings presented about the effects of ending or reducing the abstraction (e.g., statement 35 and 36). At the second workshop, the presented findings concerned only changes in the hydraulic head in the aquifer and in groundwater tables. The presented changes in the hydraulic head were similar to earlier findings from the Quickscan. These findings reflect that the current abstraction does not influence Leiden and Gouda and hardly influences Rotterdam (see Figure 6.2). The presented research results concerning the groundwater tables were new. It occurred that changes in groundwater tables were significant, even when the abstraction would be reduced by only one third. The groundwater model, however, was adjusted after the second workshop. The final results were presented at the third workshop. Figure 6.8 shows the patterns of change in groundwater tables as presented during Workshop 2 and Workshop 3. The expected effects decreased.
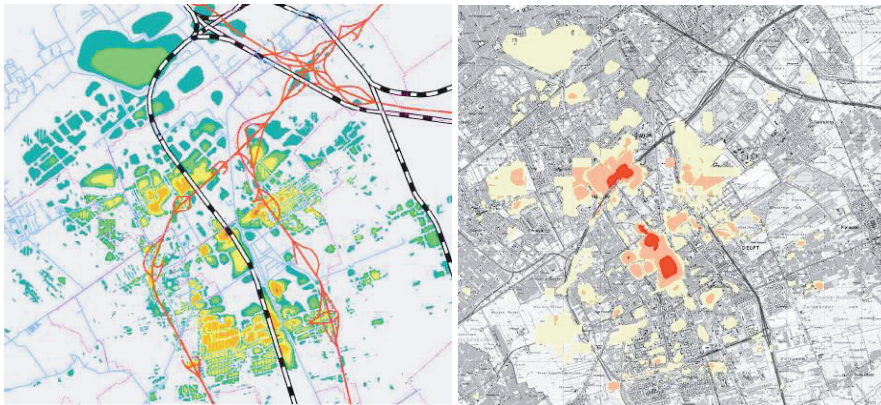
Figure 6.8. Effects of ending the abstraction on the groundwater table as presented at Workshop 2 (left) and Workshop 3 (right). The different colors represent an increase in the groundwater table between 0.05 and 0.5 m.

The effects of reducing the abstraction on groundwater nuisance (statement 23), ground level movement (statement 19) and stability of levees (statement 21) were also presented at the third workshop. Groundwater nuisance was framed as a phenomenon that could occur only in urban areas where the "mean high groundwater table" was high and where current drainage capacity was not sufficient. When in such areas a reduction of the abstraction would have a significant effect on the groundwater table, measures to prevent the additional

nuisance would be needed. Furthermore, the effect of ending the abstraction on ground level movement, over a period of 30 years, was presented. When the abstraction would be ended, the lowering of the ground level due to peat oxidation would be strongly reduced and in many areas the ground would even swell. Resulting changes in the gradient of the ground level were not expected to damage constructions such as old buildings and monuments. Because not only the movement of the surface, but also the movement of different ground layers may damage constructions, the risk of damage should be assessed in detail for specific constructions and the effects of reducing the abstraction should be monitored. Finally, a preliminary assessment of the risk of instability of levees was presented. This assessment was ordered by the water board and executed by an external consultant. The assessment revealed that, when the abstraction would be ended, the risk of failure would become unacceptable for many levees, which are spread over a large area[46].

Based on the presented effects, the effectiveness and efficiency of the measures "additional drainage" (statement 5) and "relocation of the abstraction" (statement 4) were discussed in sub groups, using the iMOD model. The groups identified areas in which additional drainage would be needed and concluded that the construction of drains in these areas would take at least 10-20 year. The total costs would strongly depend on the possibility to combine the construction of drains with the construction of new sewerage systems or other works. Furthermore, problems could arise when citizens would not collaborate by constructing drains on their own land. The workshop participants also explored whether relocating the central abstraction could help to prevent groundwater nuisance and effects that could not be prevented with drainage, such as instability of levees. It occurred that smaller, local abstractions had only small effects on the groundwater table and could not prevent the risk of failure of levees, because the levees at risk were spread out too much. The overall conclusion of the workshop was that the abstraction could only be reduced in small steps, allowing for monitoring the effects and taking measures such as constructing drains and adjusting levees. The reduction process would last for decades.

After the third workshop, the researchers calculated the full range of effects for four different abstraction scenarios and quantified the societal costs and benefits of different management alternatives. The following main research findings were included in the management summary of the final report (Roelofsen 2008), which was sent as a newsletter to the interest group and sounding board in September 2008:

▪ A small reduction of the abstraction would already increase the risk of levee instability. The total costs of adjusting the levees in order to prevent an

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[46] An interviewee from the water board explained that a detailed analysis, including field measurements of the levees, will take place in the coming years.

unacceptable risk range between 25 and 40 million Euros (Net Present Value[47]) in case of ending the abstraction.

▪ A small reduction of the abstraction would already lead to an increase in groundwater nuisance. It can be prevented by constructing drains, which costs up to 28 million Euros in case of ending the abstraction;

▪ Ending the abstraction would not lead to such strong changes in chloride concentrations in the surface water that additional flushing would be needed;

▪ When the abstraction would be reduced, a small to average damage to monuments and other buildings is expected due to swelling of the ground. In case of ending the abstraction, the total damage to monuments, or the costs of preventing such damage, may add up to 9 million Euros. Monitoring is very important to signal the effects before damage occurs;

▪ Other effects are only small and relatively inexpensive. Relocation of the abstraction is not an effective measure.

The conclusions and recommendations concerning the strategy to employ were similar to the overall conclusions of the third workshop. Because of the necessity to maintain a relatively large abstraction for a long period, it was recommended to search for alternative users of the abstracted groundwater[48].

6.5. Observed learning

We asked all members of the steering group, interest group, project group and sounding board to fill out the ex ante Q sorting questionnaire in March 2007, before the first workshop. Before the second and third workshop, we repeated our request to those who did not perform the Q sorting yet. In total 24 stakeholders completed the ex ante Q sorting, 17 of which attended at least one of the workshops or steering group meetings.

We intended to conduct the ex post Q sorting after the presentation of the final research results at a fourth workshop, but the process was delayed so much that we could not wait for this workshop. In October 2008, we invited all 24 respondents to the ex ante Q sorting to repeat the Q sorting. Fourteen of them completed the ex post Q sorting[49]. The time in-between their ex ante and the ex post Q sorting varied from 11 to 19 months.

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[47] Since only a stepwise reduction would be acceptable, the costs would probably be spread over multiple decades.

[48] A first exploration of the possibilities for alternative utilization by consultants from DHV indicated that it would be difficult to recover the full cost of the abstraction, but that there could be possibilities to recover part of the costs.

[49] Two stakeholders that performed the ex ante Q sorting, but did not participate in the workshops, replied that they did not want to perform the ex post Q sorting, since they were not involved in the process and thus did not learn from it.

The 14 respondents were stakeholders from the province, the water board, various municipalities, the government agency for land and water management, a nature organization and a research institute. Among them were five members of the steering group, six of the interest group, two of the sounding board and one of the project group[50]. All responding interest group members were from three larger, urban municipalities[51]. The smaller, rural municipalities did not participate in the repeated Q sorting. Twelve respondents participated in the collaborative research process by attending at least one workshop or steering group meeting. Three of them participated in the steering group meetings. The "control group" in this case was formed by only two respondents[52], who did not attend any meeting in the collaborative research process, but were informed about the process by means of newsletters.

In the text below we analyze the differences between the ex ante and ex post perspectives. We analyze changes in overall perspectives on the issue at stake, changes in correlation between perspectives, and individual learning from the research results. In addition, we shortly reflect on what the researchers learned from the policymakers and societal stakeholders.

Changes in overall perspectives on the issue at stake
In order to find out whether the respondents' overall perspectives on the issue at stake changed over time, we calculated the correlation between the ex ante and ex post perspective of each individual respondent. The correlation ranged from 0.26 to 0.65, with an average of 0.41 for the 12 participants[53]. In total, the perspectives of 13 of the 14 respondents changed significantly (one-tailed z-test with $p < 0.025$[54]).

Second, we identified statistically significant changes in individual and average Q sorting scores on specific statements. Table 6.7 shows the percentage of statistically significant changes in Q sorting scores (two-tailed z-test with $p < 0.05$) for the participants and non-participants for different themes. The findings suggest that the participants changed their scores on statements concerning the goals to be achieved and concerning strategies more strongly than on statements concerning the effects of ending the abstraction. This is remarkable, because the workshop discussions focused on the effects of reducing the abstraction. At the same time, improved insight in the effects may have triggered changes in perspectives concerning preferred strategies and goals.

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[50] From informal conversations with other researchers we understood that they perceive themselves as objective experts and did not want to make claims about statements about which they had little knowledge (e.g., which measures to employ), or about the goals to achieve.

[51] The municipalities of The Hague, Rotterdam, and Rijswijk.

[52] Who were members of the steering group and sounding board.

[53] In comparison, the average correlation between the ex ante and ex post perspectives of the two non-participants was 0.54.

[54] All applied statistical tests have been described in Section 4.3.

Table 6.7. Percentage of significant changes in Q sorting values per theme

	Effects of ending the abstraction[†]	Strategies / financing[†]	Goals[†]	Total
Participants	3%	4%	6%	4%
Non-participants	6%	3%	1%	5%

[†] The following statements are related to each category: Effects of ending the abstraction (17-30, 35-36), Strategies/ financing (1-16, 37) and Goals (31-34), see for statements Appendix C.

Table 6.8 shows the statistically significant changes in the average scores of the 12 participants and 2 non-participants on specific statements (two-tailed t-test with $p < 0.05$. Only four significant changes occurred and they all occurred in the participant group. Three changes concerned the effects of ending the abstraction and one change concerned the strategy to employ. On average, the participants got more convinced that reducing the abstraction would result in a recovery of natural dynamics and a larger biodiversity (statement 18), but not in salinization of drinking water wells (statement 28). The participants also got more convinced that reducing the abstraction would lead to problems with the stability of levees (statement 21), which is in line with the technical research results. Concerning the strategy to employ, the participants disagreed less, after the collaborative process, with the statement that owners of real estate have to take their own measures to prevent nuisance (statement 12)[55].

Table 6.8. Significantly changed average Q sorting scores on specific statements for the participants and non-participants

Statement[†]	Participant group		Non-participants	
	Ex ante score[‡]	Ex post score[‡]	Ex ante score[§]	Ex post score[§]
12	-1.1	-0.1[∣]	-1.0	-1.5
18	-0.5	0.4[∣]	-0.5	-0.5
21	-0.6	0.6[∣]	1.0	0.0
28	-0.8	-1.5[∣]	0.0	-0.5

[†] See Appendix C for the statements.
[‡] Average Q sorting score of the 12 participants for a specific statement.
[§] Average Q sorting score of the 2 non-participants for a specific statement.
[∣] Significant change in average Q sorting score (two-tailed t-test with $p < 0.05$).

The results from the repeated Q sorting are in line with the results from the participants' workshop evaluations. In the evaluations, the participants indicated to have learned about the functioning of the natural system, to have shared their perspectives on problems and solutions with other participants, and to have learned about others' perspectives. Furthermore, during the final interviews all interviewees stated to have changed their perspective on the issue at stake. Some reported only little change and others reported strong changes. The interviewees

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[55] For each of these statements, the score of only one participant changed in the opposite direction from the group average score.

reported to have learned about the effect of reducing the abstraction, strategies to deal with the expected problems and political sensitivities concerning the issue at stake.

Changes in consensus between the respondents
The average correlation between each pair of individual perspectives of the participants decreased over time, from 0.18 to 0.16 (non-significant in a two-tailed t-test with $p < 0.05$)[56], which suggests that the consensus about the issue at stake did not increase over time. This finding is in line with the participants' perception of the developed consensus according to their workshop evaluations: a substantial part of the participants indicated that little or no consensus was developed during the three workshops, in particular concerning management strategies.

Remarkably, the average correlation between the perspectives of the three stakeholders that participated in the steering group meetings did increase significantly, from 0.17 to 0.51 (two-tailed t-test with $p < 0.05$). The scores of the three participants converged on many statements. Concerning the effects of ending the abstraction, for example, they agreed in their ex post sorts that damage to farmers will be limited (statement 27) and that only limited changes to soil sanitation programs are needed (statement 29)[57]. Concerning the strategies, the participants agreed that relocation of the abstraction is not a good solution (statement 4) and that the involved governments should (to some extent) jointly finance management solutions (statement 37). Finally, they agreed ex post that maintaining good relations may be important (statement 34).

Cognitive learning from the research results
Subsequently, we focused on analyzing to what extent the participants' Q sorting scores on the statements 4, 5, 8, 19, 21, 23, 35, and 36 changed in the direction of the scores that would be expected based on the research results (see Table 6.6). For each individual, we summed up the changes in scores in the direction of the research results and subtracted from this sum the changes in the opposite direction. We divided the total by the sum of the expected changes in scores on the basis of the research results (see Table 6.9). The results suggest that the perspectives of 7 of the 12 participants changed predominantly in the direction of the research results, and that the perspectives of three participants changed predominantly in the opposite direction (no test for significance applied). Two of the three participants that attended the steering group meetings learned from the research results[58].

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[56] The correlation between the perspectives of the two non-participants increased slightly from 0.17 to 0.20.
[57] Soil sanitation programs are designed for a specific direction of horizontal groundwater flow and have to be adjusted when this direction changes strongly.
[58] Of the two non-participants, one perspective changed in the direction opposite from the research results and one perspective did not change much in relation to the research results.

According to the participants' workshop evaluations, some learned little about the functioning of the natural system and others a lot. There is, however, no clear correlation between the stated levels of learning and the levels of learning according to the repeated Q sorting. In the final interviews, the interviewees were confronted with their ex ante and ex post scores on the eight statements concerning the research results. They confirmed most changes and were able to explain why these changes occurred. However, some interviewees denied that the score on a specific statement changed in the way we measured.

Table 6.9. Individual cognitive learning

Respon-dent	Correlation ex ante and ex post perspective	Total observed changes[†]	Total expected changes[‡]	Learning from research results
1	0.26[l]	0	7	0
2	0.63[l]	2	8	0.3[¶]
3	0.45[l]	5	13	0.4[¶]
4	0.34[l]	-2	8	-0.3
5	0.43[l]	-2	14	-0.1
6	0.65	5	17	0.3[¶]
7	0.27[l]	-4	12	-0.3
8	0.29[l]	-3	18	-0.2
9	0.39[l]	1	4	0.3[¶]
10	0.33[l]	3	13	0.2[¶]
11	0.36[l]	5	16	0.3[¶]
12	0.40[l]	2	12	0.2[¶]
13	0.57[l]	-3	12	-0.3
14	0.50[l]	-1	9	-0.1

[†] The sum of changes in scores on statement 15, 16, 17 and 33 in the direction of the research results minus the sum of changes in the opposite direction.
[‡] Changes are expected when the ex ante Q sort score and the Q sort score based on the expert knowledge differ with at least 1 point (the scores 2 and 3 are treated as 2 and the scores -2 and -3 are treated as -2, because of the relatively low frequency of these scores).
[l] Significant change in Q sort according to a one-tailed z-test with $p < 0.025$.
[¶] Change that is predominantly in the direction of the research results.

Learning by the researchers
We also asked the two interviewed researchers whether they learned from the policymakers and societal stakeholders. The project leader stated to have learned that the influence of political interests, in relation to the influence of expert knowledge, is larger than expected. He learned this during a political meeting, where he had the impression that the knowledge he presented hardly changed the perspectives of the politicians. Furthermore, the project leader learned from the local knowledge of technical experts and policymakers from the involved governments. The other interviewed researcher mentioned that he used the knowledge from hydrologists from the water board for his modeling, but that he did not learn anything about how to collaborate with policymakers, as he had already a lot of experience with such collaboration. A final indication of learning by the researchers is that they adjusted the modeling based on inputs

from policymakers and societal stakeholders during the collaborative meetings (which will be discussed further in the next section).

6.6. Observed collaboration and other potential influences on learning

The collaborative process
In general, the collaborating stakeholders were willing to collaborate and learn from each other and from the research results. A driver for most involved governments was the burning policy question what to do with the abstraction. There was political pressure to take actions and the research findings were perceived as necessary to take well-informed decisions. Furthermore, the stakeholders were in general able to collaborate and learn. Intensive collaboration between the municipality of Delft, researchers, consultants and private parties started already many years ago and was continued in different projects. For example, most of the involved stakeholders already learned to know each other during the Quickscan. Consequently, the stakeholders understood each other well. In addition, the collaborating stakeholders had sufficient resources for a relatively intensive collaboration.

By analyzing the ex ante interview results, we also revealed the reasons to collaborate of specific stakeholder groups. The interviewed steering group members stated that they realized that they had to collaborate with each other, with the surrounding municipalities and with other stakeholders, in order to obtain the necessary local knowledge and to develop a well-supported solution. In addition, the water board needed the models that were developed to fulfill their new groundwater management tasks. Furthermore, the interviewed members of the interest group and sounding board stated that they participated in the workshops in order to learn about the effects of reducing the abstraction and strategies to deal these effects. Different interviewees, however, expressed different levels of willingness to collaborate. First, representatives of the municipalities The Hague and Rijswijk stated that they wanted to be involved more strongly in the collaboration, because they were afraid that the research would be used by the steering group members to support their own position. In order to increase their influence, representatives of these municipalities participated actively in the workshops and were very active at the political level. Second, representatives of the smaller, rural municipalities were less motivated to participate, since they expected to be less affected by the effects of reducing the abstraction. Third, only one sounding board member participated in the workshops. Another sounding board member stated in an interview that he wanted to stay informed of the research results, but did not have the time to attend the workshops. Finally, the interviewed researchers stated that their motivations to collaborate were 1) to obtain budget to do practical research, 2) to learn about the issue at stake, 3) to answer the questions of the policymakers, 4) to have an influence on decision-making, 5) to develop more sophisticated models and 6) to learn how to collaborate with policymakers.

Table 6.10 shows the number of workshops and steering group meetings that each of the analyzed participants attended, as well as the intensity of individual participation in the workshop discussions. The first three respondents attended multiple steering group meetings and the others attended only one, two or three workshops. The most intensive collaboration between researchers and policymakers took place during the steering group meetings. The steering group meetings provided opportunities for interaction between the involved policymakers and between the policymakers and researchers. According to the final interviews, the steering group members influenced the set-up of the research, monitored the progress, discussed the modeling and inherent uncertainties and adjusted the research when they felt it was needed. The project leader represented the researchers during the steering group meetings and sometimes other researchers were invited to perform specific tasks during the meetings, e.g., to give a presentation. The policymakers and researcher(s) in the steering group meetings jointly prepared the communication to the interest group and sounding board, such as newsletters, and the communication to the political level, such as the management summary. In that sense, the project leader and the policymakers in the steering group meetings functioned as intermediaries between the other involved researchers, policymakers and societal stakeholders.

Table 6.10. The intensity of individual collaboration

Participant	Workshops attended	Participation in discussion[†]
1	1, 2, 3 (+ 13 steering group meetings)	0.9
2	1, 3 (+ 10 steering group meetings)	0.4
3	n/a (+ 4 steering group meetings)	n/a
4	3	1.6
5	1, 2, 3	0.7
6	2, 3	0.4
7	2, 3	0.1
8	3	0.6
9	1, 2	0.1
10	1, 2, 3	0.9
11	2, 3	1.8
12	2, 3	2.1

[†] The values were calculated by dividing the number of speech acts uttered by the participant by the average number of speech acts uttered per participant and averaging it over the discussions in which the individual participated (except for the sub group discussions that could not be analyzed).

The workshops consisted for a large part of presentations about the research and its results and provided little space for mutual exchange about perceived problems, management goals and preferred strategies. Interaction analysis provided information about the topic of the workshop discussions, the atmosphere during the workshops and the level of participation of groups and individuals. The analysis revealed that the first two analyzed workshops were strongly oriented on procedures: the discussion focused on how the modeling

was executed. The third workshop was much more task-oriented, as the discussion focused on the model results. Furthermore, the analysis revealed that the atmosphere during all workshops was positive (see Figure 6.9). Finally, the interaction analysis revealed that certain groups and individuals contributed a lot to the discussions, whereas other contributed very little. The workshop discussions were dominated by researchers, who uttered 60-80% of all speech acts in the plenary discussions and about 50% in the analyzed sub group discussion during Workshop 3 (see Figure 6.10)[59]. One of the reasons for the many discussions between researchers during the workshops was that researchers from different institutes (and different geographical locations) did not regularly meet in the early stages of the research and thus used the workshop as an opportunity to discuss the research and its results.
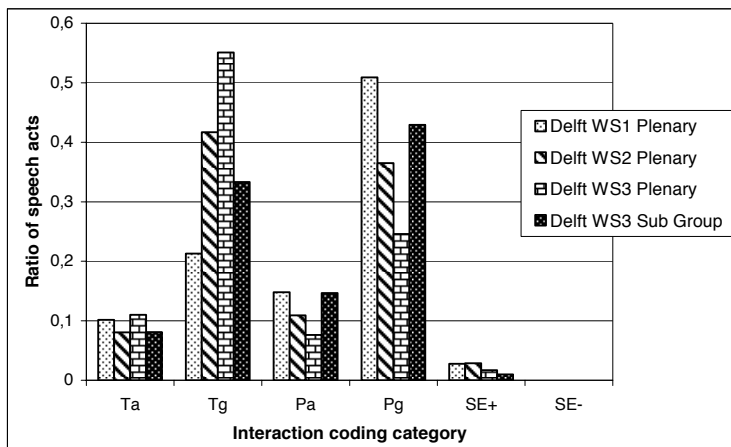

Figure 6.9. Ratio of speech acts concerning specific interaction categories[60]

The limited opportunity for policymakers and other stakeholders to contribute to the workshop discussions was reflected in the workshop evaluations. Four participants of Workshop 1 and six participants of Workshop 2 stated that they had little opportunity to express their perspective and to learn to know others' perspectives. Some participants even explicitly called for more interactive work sessions. The work sessions during Workshop 3 provided some more opportunities for exchanging perspectives, at least concerning the construction of additional drains and the relocation of the central abstraction to multiple smaller abstractions. This is reflected in the participants' evaluations: all but one participant stated that there was an average to good exchange of perspectives

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[59] This is also reflected in relatively low Gini coefficients in relation to the Lower Rhine case (see Section 7.1), which indicate an unequal distribution of speech acts over the participants.

[60] The abbreviations in the Figure have the following meaning: WS = Workshop, Sub Group = Sub group discussion, Others = Societal actors. The interaction coding categories Ta, Tg, Pa, Pg, Se+, and SE- are explained in Section 4.4.

and one participant stated explicitly that he learned about the problem perceptions of other municipalities.
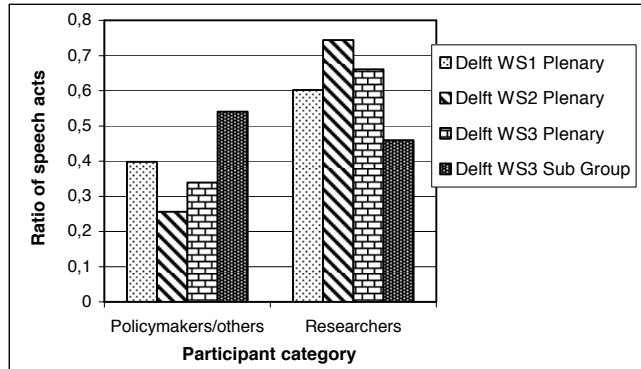
Figure 6.10. Ratio of speech acts uttered by groups of participants[60]

The discussion of the results on the posters during Workshop 1 and 2 and the sub group work during Workshop 3 provided most opportunities for the participants to interact intensively[61] and to have an input in the research. In the poster sessions, the participants evaluated preliminary research results using their local knowledge. For example, the participants at Workshop 1 noticed that the surface water levels were incorrect and that the groundwater model did not correctly simulate urban drainage. Based on these comments the model was improved. In the group work sessions, the participants provided valuable information about the effectiveness of current drainage, the locations where additional drains would be needed and the time and costs associated with constructing new drains. Operating the iMOD model appeared, however, to be a complex and time-demanding task, which limited active participation by others than the researcher who operated the model. Multiple participants indicated in their workshop evaluations that the use of iMOD had little added value.

The research, the policy process and other processes
In spite of the complexity of the modeling and some delays in the research process, the workshop evaluations indicated that all but one respondent to the repeated Q sorting questionnaire perceived the research to be of average to high quality. All participants stated that the applied models were suitable, but participants 4 and 5 stated that the assumptions were not well discussed. In addition, participant 8 mentioned in the final interview that models contained many assumptions and could therefore not establish conclusive proof of the negative effects of ending the abstraction. Furthermore, the workshop evaluations indicated that all respondents perceived the themes of the workshop as relevant and the final interviews indicated that they also perceived the

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[61] The interaction during the poster sessions could, however, not be incorporated in the interaction analysis.

research results as relevant. Finally, according to the workshop evaluations, all but two respondents perceived the quality of the presentations as average to good (see Table 6.11).

Table 6.11. Participants' perceptions of the research and their technical knowledge

Participant	Perceived relevance[†]	Perceived trust in research[‡]	Perceived quality presentations[§]	Technical knowledge[ǀ]
1	4	3.5	3.6	Strong
2	4	4	3.6	Strong
3	n/a	n/a	n/a	Average
4	3	3	2.8	Strong
5	4	2.3	2.9	Average
6	3	3	3.1	Strong
7	3	3.5	3.4	Average
8	4	5	4.5	Average
9	4	4	3.6	Average
10	5	4.3	4.6	Strong
11	4	4.5	3.9	Average
12	n/a	n/a	n/a	Strong

[†] The average of the participant's evaluation of the relevance of the theme for each workshop. For all scores in this table a five-point scale was used (1 = very poor, …, 5 = very good).
[‡] The average of the participant's evaluation of the quality of the presented results of the technical research for each workshop.
[§] The average of the participant's evaluation of the 1) average usefulness of all presentations concerning the research and its results, 2) average comprehensibility of the presentations, and 3) average comprehensibility of the answers to related questions.
[ǀ] The participants' perception of their own knowledge about the natural system (groundwater, surface water and ground) in the region.

The policy process influenced the collaborative research process in at least two ways. First, there was a lot of tension around the question "Who is responsible for the problem and for financing solutions?". During the steering group meetings and workshops this question was not addressed. However, it may have influenced the behavior of some of the participants, including how they interpreted the research results. One interviewee stated that he could not trust the conclusions of the research, because the governments in the steering group paid for it and thus had a relative strong influence on it. This interviewee even stated that a rational process was not possible because of the large differences in interests. The influence of individual interests on individual learning is illustrated with some examples in Section 6.7.

Second, the policy process influenced the timing of the research and the presentation of the research results. At the steering group meeting in August 2007 it became clear that the political superiors of the policymakers in the steering group wanted to see some results quickly. The pressure to make a decision and take action had been increased by the court order that stated that the governments had to pay for the continuation of the abstraction, and not

DSM, and by the announcement of DSM that they wanted to fully end their abstraction in March 2008. Because of this pressure, the steering group decided to organize Workshop 3 as soon as the progress with the groundwater modeling would allow it. In February 2008 the project group had established sufficient results to present a management summary to the most strongly involved politicians. The management summary served as input for further political negotiations about possible solutions and the distribution of costs. Although the research report was finalized in September 2008, it was not disseminated to a broader audience until the beginning of 2009. According to the communication strategy, the research report had to be approved by the boards of the involved governments first. This would prevent the dissemination of incorrect information related to the research results, which could disturb ongoing negations between the involved governments and DSM about future management and continuation of the abstraction.

Furthermore, the background and prior knowledge of the involved policymakers and societal stakeholders may have influenced their learning (from research results). In the ex ante Q sorting questionnaire, we asked the respondents to score their own knowledge about the natural system in the region[62]. We found that all involved participants had an average to strong prior technical knowledge (see Table 6.11). This was reflected in the final interviews, in which all respondents stated that they could understand the presentations and discussions during the workshops and steering group meetings well.

Finally, we assessed the influence of other processes on learning. For that purpose, we asked all respondents of the ex post Q sorting questionnaire with which sources of technical knowledge, concerning the effects of reducing the abstraction or alternative solutions, they were confronted in the period between their ex ante and ex post Q sorting. We also asked the respondents to rank these sources of knowledge in order of the influence on their perspective. The results are displayed in Table 6.12. The sources of technical knowledge that were mentioned included sources within the collaborative process and the research process (the steering group meetings, workshops, newsletters and modeling), as well as external sources (meetings within the organization, bilateral meetings, other studies and the media). The general picture that follows from Table 6.12 is that the collaborative research, and in particular the steering group meetings and workshops, had the largest influence on the respondents' perspectives.

Some participants, however, stated that sources of knowledge outside the collaborative research process were dominant. Unfortunately, we could not analyze the influence of meetings outside the collaborative process, apart from the influence of the meetings in the policy process that we already described above. Furthermore, we could not track all information in the media. As far as

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[62] In order to check whether these scores were reasonable in comparison with the scores of others, we also asked the participants to describe their education, work experience, and relevant expertise concerning the issue at stake.

we know, however, the amount of specific technical knowledge about the issue at stake that was discussed in the media was very limited. This was confirmed by one of the interviewees. Finally, we found a number of other studies that took place before, or in parallel to, the collaborative (Delft Cluster) research process. Some studies concerned the same aspects as the Delft Cluster research and could therefore influence learning from the research results, whereas other studies concerned other aspects of the issue at stake. We could not analyze the results of external studies in detail, but in order to get a feeling for their (relative) influence we analyzed the workshop discussions in which they were mentioned, asked two interviewees to what extent and how they were influenced by these studies and analyzed the comparison of the results of the Delft Cluster research and an earlier study in the end report.

Table 6.12. Sources of technical knowledge that influenced cognitive learning

Respondent	Sources within the collaborative research process[†]	Sources outside the collaborative research process[†]
1	1. Steering group meetings 2. Workshops	3. Other studies 4. Meetings in organization
2	1. Steering group meetings 2. Workshops	
3	1. Steering group meetings	
4		1. News, media 2. Feeling and intuition
5	1. Workshops	2. Meetings in organization
6	1. Workshops / newsletters	2. Other studies
7	n/a	n/a
8	1. Results research and common sense 2. Workshops / newsletters	3. Other studies 4. Meetings in organization 5. Media
9	1. Workshops	2. Other meetings between organizations
10	2. Workshops	1. Other study
11	1. Workshops 3. Newsletters	2. Other studies 4. Meetings in organization 5. Media
12	1. Own modelling	n/a
13	None	None
14	n/a	1. Media

[†] The numbers represent the order of influence on the individual perspective of different sources of technical knowledge, concerning the effects of ending or reducing the abstraction and concerning alternative solutions, as stated by the individual respondents directly after performing the ex post Q sorting.

When the preliminary research results were discussed at the end of Workshop 2, representatives from the municipalities of The Hague and Rotterdam mentioned that they also performed groundwater modeling to explore the effects of ending the abstraction. A representative of the municipality of Rotterdam stated that the results that they obtained with their model, which was less accurate but better focused on the area of Rotterdam, were very similar to the presented results of the Delft Cluster project: the effects of ending the abstraction would be very

small in Rotterdam. A representative from the municipality of The Hague, however, mentioned that the effects according to the Delft Cluster model were larger than the effects according their own model. Furthermore, he suggested that their own model was more accurate and better applicable for the The Hague area, which was contested by a project group member. As a reaction, it was suggested to compare the models and their results later. From the ex post interview with a representative of the municipality of The Hague, and further contacts with another representative of the municipality, we learned that a consultant (Wareco) was performing the modeling study for the municipality. Although in earlier model runs the results of both models differed, in later runs the results were very similar. This was confirmed by an interviewee from the municipality of Rijswijk, who received the modeling results from the municipality of The Hague.

In the final Delft Cluster research report the results of the Delft Cluster study were also compared to the results of a study carried out in 2005 by consultants from Royal Haskoning, by order of DSM (Zaadnoordijk 2005). From the comparison, it followed that the two studies agree on the effects of ending the abstraction on groundwater nuisance. The study by Royal Haskoning, however, does not assess the effects related to water quality, ground level movement and levee instability. The conclusions of the two studies concerning the possibilities to reduce the abstraction are therefore different.

6.7. The relation between collaboration and learning

Because it is very difficult to establish causal relations between the multitude of independent and dependent variables, we can only present well-founded speculations about whether the collaborative research process enhanced cognitive learning. Below, we first speculate about the relation between the intensity of collaboration and learning. Subsequently, we speculate for each individual participant which factors can explain his or her degree of learning from the research results.

The relation between the intensity of collaboration and learning
First, we analyzed whether intensive collaboration enhanced the degree of change in overall perspectives, without paying attention to the direction of change. The results do not provide a clear picture. On the one hand, the hypothesis is confirmed by the finding that the perspectives of the participants changed more strongly than the perspectives of the two non-participants[63]. On the other hand, the hypothesis is inconsistent with the finding that the

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[63] Remarkably, the overall perspectives of the non-participants did change significantly. Although they stated that they were not involved in discussions concerning the issue at stake, the collaborative research process may have triggered their own thinking, or they may have been exposed to others' perspectives in informal conversation or by the media (as stated by respondent 14).

perspectives of the participants that attended the steering group meetings changed, on average, less than the perspectives of the participants that attended only the workshops.

We obtained a clearer picture of the relation between collaboration and learning by considering also the direction of change. The repeated Q sorting demonstrated that the perspectives of the three policymakers that attended the steering group meetings converged. We speculate that this is due to the abundance of opportunities for interaction during the steering group meetings. The participants in the steering group meetings spent a lot of time together, while performing the joint task of steering the research and in other policy meetings. Meanwhile, they (implicitly) exchanged their perspectives and reflected on each others' perspectives. This took place in an informal and cooperative atmosphere, which may have provided space for the development of mutual understanding and trust. In contrast, the perspectives of the participants that attended only the workshops did not converge. We speculate that there was too little opportunity for interaction among the participants to increase mutual understanding. The workshops did not provide sufficient space for mutual exchange about perceived problems, management goals and preferred strategies. This was reflected in the workshop evaluations, in which a substantial group of participants was critical about the possibilities to exchange perspectives and about the development of consensus about problems and solutions.

The attendants of the steering group meetings also learned relatively much from the research results: two changed their perspectives predominantly in the direction of the research and the other did not change his perspective in the direction of the research result (nor in the opposite direction). The relatively strong learning by the steering group members can be explained by their relatively strong involvement in and influence on the research. The policymakers that participated in the steering group meetings were strongly exposed to the (preliminary) research results. Because they often had to take actions based on the results, they had to fully understand them. For example, they discussed draft documents, co-organized the workshops, and co-wrote management summaries. Through this active involvement, the policymakers that attended the steering group meetings also influenced the research and co-produced some of the results. In their workshop evaluations and final interviews, they stated that they contributed to the production of high quality research results and the translation of the results to relevant input for the political negotiations.

On average, the respondents that did not participate in the steering group meetings learned less from the research results than those that did. The most obvious reason for the slightly lower level of learning is that the workshop participants were less intensively exposed to the research results. Most participants were only confronted with the research results during the workshops and through newsletters. During the workshops, many research results were

presented only quickly and could be easily missed. Because many workshop participants were only passively exposed to the research results, e.g., by listening to the presentations, and did not have to do anything with the results, they were not pressed to fully understand the results. The interviewed members of the steering group and project group also expressed their doubt that all workshop participants could fully understand the presented research results in such short time. Furthermore, most results that were presented during the workshops were preliminary and were finalized only after Workshop 3[64]. We speculate that preliminary results are less trusted than final results and thus cause less learning. In the steering group meetings after Workshop 3 the final results were discussed in detail. Finally, besides the more limited exposure to the research results, the participants that were not involved in the steering group also had less influence on the research. One participant indicated in his final interview that the research and its results were not neutral and that there was a risk that the governments in the steering group, who paid for the research, would use it to strengthen their own position in political negotiations and legal procedures. From this reaction we conclude that some participants that were less involved in the research did not feel ownership for the research and may have mistrusted the research and its results.

We also analyzed differences in cognitive learning between workshop participants who attended different numbers of workshops. We did not find a relation between the number of workshops attended and the degree of change in the overall perspective, but did find an indication of a positive relation between the number of workshops attended and the degree of learning from the research results. The two participants that visited only one workshop both did not change their perspective in the direction of the research results, but in the opposite direction, whereas the participant that attended two or three workshops on average changed their perspective in the direction of the research results. Furthermore, we analyzed the relation between the number of contributions to the workshop discussion by each participant and the degree of overall learning and learning from the research results. The results suggest that the participants who participated relatively strongly in the workshop discussion changed their overall perspective relatively much, but learned relatively little from the research results. In contrast, participants who contributed relatively little to the discussion learned relatively little in general and relatively much from the research results. Based on literature, we expected that the more active participants would learn more, but we did not expect that the more active participants would learn less from the research results. A possible explanation is that the participants who did not trust the research results actively asked critical questions, but could not be convinced of the quality of the research results.

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[64] The newsletter with the management summary did discuss the final results, but provided no detailed information about the expected effects.

Factors that influenced individual learning

Participants 1, 2 and 3 were involved in the steering group meetings. Since we already made a reasonable case for the strong learning of steering group meeting attendants, we analyze here why participant 1 did not clearly change his perspective in the direction of the research result. In the final round of interviews, we asked the participant to explain why his scores on three of the eight statements did not change in the direction of the research results. He answered that one of the changes must have been a sorting error. Another unexpected change had to do with his priorities: although the participant disagreed with the statement, he disagreed more strongly with others. The third change was a small reduction in agreement with statement 8 (from the score "2" to the score "1"), concerning the need for a dense monitoring network. According to the participant, the research produced results that indirectly lowered his perception of the efficiency of, and need for, monitoring. First, the research indicated that the costs of intensive monitoring were rather high. Second, the research demonstrated that ending the abstraction would increase the risk of levee instability, as well as nuisance and damage in the urban area. This finding increased the feasibility of continuing the abstraction and using it for alternative purposes. If the abstraction would be continued, there would be no need for intensive monitoring. Interestingly, also respondent 2 lowered his score on statement 8. He explained that he gained trust in the quality and usefulness of the model results, and lost trust in the quality and usefulness of monitoring data.

Of the nine respondents that participated only in the workshops, participants 6, 9, 10, 11 and 12 changed their perspectives predominantly in the direction of the research results. Participants 6, 9 and 10 were members of the interest group, participants 11 was a member of the sounding board, and participant 12 was a member of the project group. All these participants 1) had a positive perception of the relevance, quality and presentation of the research (or at least not negative), 2) were involved in two or more workshops, and 3) were not influenced by external sources of knowledge that contradicted the Delft Cluster results[65]. Furthermore, the influence of these individuals' values and interests on their learning from the research results appeared to be small. Still, analysis of the content of the ex ante and the ex post perspectives of participant 10, 11 and 12 revealed some influence of their personal or organizational values and interests. Because the model results suggested that ending the abstraction would have little effect on the area of concern of participant 10, he did not want to contribute financially to the continuation of the abstraction. The participant therefore 1) rejected that (costly) monitoring was needed, 2) did not strongly reject that the abstraction could be reduced by 50% without effects, and 3) did not strongly agree that effects such as ground level rise and levee instability

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[65] Participant 10 indicated to have learned most from the model study by the municipality of Rotterdam, which according to the discussion at workshop 2 resulted in similar findings as the Deft Cluster study.

would occur. Furthermore, learning by respondent 11 was slightly influenced by his focus on the goal of natural sustainability and learning by respondent 12 was slightly influenced by his focus on the results of the modeling that he performed himself. Finally, we speculate that learning by respondent 6 was enhanced by his active involvement in the policy process, his large exposure to relevant expert knowledge from multiple model studies (with similar results) and his strong technical knowledge about the issue stake. Participant 6 was the only participant whose overall perspective did not change significantly, which may be related to the strong prior knowledge of the participant as well.

Like participant 1, participant 5 did not clearly change his perspective in the direction of the research results, nor in the opposite direction. Potential reasons for the limited learning of participant 5 were found in his workshop evaluations. Participant 5 perceived the research quality as low, mainly because he missed a proper discussion of the line of thinking and of the reasons for making certain assumptions. In addition, he stated that the knowledge was not presented in such a way that it would sink in properly. Therefore, we speculate that the participants' limited involvement in the research and the way the workshops were organized decreased his learning from the research results.

The perspectives of participants 4, 7 and 8 changed in the opposite direction from the direction expected based on the research results. Participant 4 represented one of the governments in the steering group. We speculate that his limited learning was related to 1) his participation in only one workshop, 2) his criticism towards the presentation of the research results and the interactive modeling session and 3) the relatively strong influence he attributed to external sources of technical knowledge, including the media and his own feelings. Participants 7 and 8 were members of the interest group. Potential reasons for the limited learning of participant 7 were 1) his weak participation in the workshop discussion, 2) the fact that he did not receive the newsletters and was not able to access the project website and 3) the influence of his own interests. In the final round of interviews, the participant explained that he learned from the research that the effects of ending the abstraction would be very limited. This contrasts with the research findings that ending the abstraction may significantly increase groundwater nuisance and the risk of levee instability. The participant explained that he focused on the effects in his own municipality (The Hague) and on his own task (soil sanitation), which may have biased his perception of the effects. One possible reason for the limited learning of participant 8 is that he attended only one workshop. In addition, his personal interests may have influenced his learning from the research. Participant 8 explained in his final interview that at first he was afraid of huge damage claims from citizens and companies, but that this fear decreased over time. This was partly because he learned that the effects would be limited and partly because he concluded from the research that it would be impossible to prove the causal relation between ending the abstraction and the occurrence of nuisance or damage. The participant agreed that he focused mainly on the effects in his own

municipality and not so much on, for example, the instability of levees. As a possible reason for the strong influence of individual interests in general, the participant mentioned the political conflict, which would have prevented the involved participants from thinking rationally.

6.8. Summary and conclusions

This chapter discussed a collaborative research process concerning the potential reduction or ending of a large groundwater abstraction in Delft. Ending the abstraction could affect many stakeholders. It could have negative effects, such as nuisance due to higher groundwater tables and damage to constructions due to an increase in deep groundwater pressure and swelling and settling of the ground. It could also have positive effects, such as restoring a more "natural behavior" of the water system. Alternative solutions to the problem were to 1) utilize the abstracted water for other purposes, 2) reduce the abstraction only partially in order to limit negative effects, or 3) fully shut down the abstraction, but mitigate or compensate the effects. The involved stakeholders had different perspectives on the problems that the reduction would cause, the goals to achieve and the strategies to reach these goals. We identified four shared perspectives, which we named according to the values that are central in each perspective: A) "Natural sustainability", B) "Cost limitation", C) "Damage prevention", and D) "Good relations". By analyzing the factors, we found a logical relation the between the dominant values and the expected effects of ending the abstraction within factor A (focusing on the effects on natural dynamics and biodiversity) and within factor B (focusing on economic damage in urban areas). Furthermore, we found a clear relation between the dominant values and the preferred strategy within factor A (end the abstraction because this enhances natural sustainability). That we could not find a logical relation between some of the components within factor B, C, and D suggests that many respondents did not have a well-articulated perspective on the issue at stake, possibly because the issue emerged relatively recently.

In order to better understand the effects of reducing the abstraction and the suitability of different management strategies, three governmental organizations and a number of research institutes took the initiative to start a collaborative research process. The researchers performed an intensive modeling study, and the project leader communicated about the research with the three governments during regular steering group meetings. Other governmental and societal stakeholders were invited to participate in workshops, during which they were informed about the research and its results and had the opportunity to react on preliminary research findings and to discuss potential measures. The main substantive finding of the research was that the abstraction cannot be reduced substantially without problems; it will endanger the stability of a number of levees, cause local ground level movement and result in nuisance due to wet cellars and rising damp. Furthermore, the research results suggested that

intensive monitoring and constructing additional drains may help to prevent negative effects and that relocating the abstraction to multiple strategic locations is not effective.

In the context of this collaborative research process, we assessed cognitive learning using a repeated Q sorting questionnaire, which was completed by 12 participants and two non-participants. The repeated Q sorting questionnaire revealed that the perspectives of 11 of the 12 participants changed significantly. The perspectives changed concerning the goals to achieve, the problems that can be expected and preferences for management solutions. Furthermore, the repeated Q sorting revealed that only the perspectives of the participants that had been involved in the steering group meetings converged significantly over time. Finally, it revealed that the participants' perspectives changed to different extents in the direction of the research results.

We come to the most interesting, but also the most speculative part of the conclusions, when we address the question whether the collaborative research process enhanced cognitive learning. The results of the case study suggest that only intensive forms of collaboration, such as in the steering group meetings, lead to the development of mutual understanding and convergence of perspectives. In contrast, forms of collaboration with less opportunity for mutual exchange, such the collaboration during the workshops, do not lead to convergence of perspectives. The results of the case study also suggest that intensive collaboration enhances learning from research results. We speculate that the attendants of the steering group meetings learned relatively much from the research results, because they were most strongly exposed to the research results and were forced to fully understand the results in order to be able to apply them. In addition, the case study result suggest that individual learning from research result is slightly positively correlated with the number of workshops attended and slightly negatively correlated with the number of speech acts that the individual contributed to the workshop discussion. The latter finding was unexpected and may be explained by the tendency of participants with a negative attitude towards the research results to actively express their concerns.

Analysis of other factors that influenced individual learning from the research results indicates that when the intensity of collaboration is low, the relative influence of other factors is high. Factors that appeared to have a dominant influence on learning from the research results in the case were individual interests, strategic considerations, the fairness of the collaborative process and individual perceptions of the research. These factors were strongly interconnected. First, it appeared that the participants learned less from research results that conflicted with their interests or were of little relevance for them. For example, many involved policymakers learned less from research results that were not related to their specific task and geographical area of responsibility. Second, it appeared that strategic considerations influenced how the participants

collaborated and what they learned. Strategic considerations were strongly related to conflicting interests, e.g., about who should pay for continuing the abstraction or for measures to prevent negative effects. Third, it appeared that some participants were not open to learning from the research results, because they felt that the collaborative research process was controlled by other participants with (partly) conflicting interests. And fourth, it appeared that participants who were critical towards the quality, relevance and presentation of the research results, learned less from the research results. Participants appeared more critical towards the research when the research results conflicted with their interests or when they also obtained research results from other technical studies.

Chapter 7

Synthesis

"Only the curious will learn and only the resolute overcome the obstacles to learning."
(Eugene S. Wilson, quoted in Reader's Digest 1968)

This chapter synthesizes the research findings. First, we compare and synthesize the findings from the case studies. The analysis suggests that only intensive collaboration enhances cognitive learning from research results and the development of consensus. In addition, it suggests that cognitive learning is influenced by the research process and how it is perceived, the policy process and individual perspectives, other studies and meetings, self-reflection and the media (Section 7.1). Second, we discuss the strengths and weaknesses of the case study methodology that occurred in practice. Although we identified some methodological shortcomings, we consider repeated Q sorting to be a useful method for assessing cognitive learning, in particular in combination with interviews. Furthermore, process observation, interaction and content analysis, workshop evaluations, analysis of perspectives and interviewing appeared to be useful methods for identifying factors that may influence learning. Identifying causal relations between these factors and cognitive learning, however, proved to be difficult (Section 7.2). Third, we summarize our answers to the research questions. Concerning the first research question, we conclude that the institutional setting in the Rhine basin is relatively supportive to adaptive management, in which collaboration and learning are central. Concerning the second research question, we conclude that the applied methodology is effective for assessing cognitive learning and the factors that influence it. By answering the third research question we come to the main conclusions of the case studies: 1) only intensive collaboration appears to enhance cognitive learning and 2) other factors in the conceptual framework (Figure 3.3) appear to influence cognitive learning as well. Based on the two cases we cannot, however, draw general conclusions about which factors are dominant in which situations. Hence, we recommend analyzing the factors that influence learning in more case studies (Section 7.3). The chapter ends with recommendations for stakeholders who intend to enhance mutual learning from collaborative research in natural resources management. We recommend collaboration only when all stakeholders are highly motivated to collaborate and learn and have sufficient resources to collaborate intensively. Mutual learning may be supported by considering the factors that may influence learning (Figure 3.3) and applying the lessons for collaboration (Textbox 3.1) (Section 7.4).

7.1. Cross-case analysis

In this section, we compare and synthesize the evidence for the influence of collaboration and other factors on cognitive learning that we found in the case studies. We also compare our findings to the relevant findings in the natural resources management literature. First, we discuss whether cognitive learning occurred at all (research question 3a). Then, we discuss whether and how collaboration influenced cognitive learning (research question 3b). We focus in this part on the influence of the intensity of collaboration on changes in overall perspectives, on the development of consensus and on learning from research results. Finally, we discuss the influence of specific factors related to the research process, the policy process and other processes (see Section 3.3) on cognitive learning (research question 3c).

Cognitive learning
According to literature, stakeholders in environmental management change their perspectives about the issues at stake, on shorter time scales (e.g., Pelletier et al. 1999) as well as longer time scales (e.g., Driessen and Glasbergen 2002). Empirical evidence from both the Lower Rhine case and the Delft case confirms that stakeholder perspectives change over time. In the Lower Rhine case the perspectives of 16 of the 27 respondents changed with statistical significance and in the Delft case the perspectives of 13 of the 14 respondents changed with statistical significance.

A possible reason for the limited change in some of the perspectives is the relatively short period of time over which we measured the change, varying from one up to 20 months. The correlation between the individual ex ante and ex post Q sorts, averaged over all respondents in each case, is lower in the Delft case than in the Lower Rhine case (see Table 7.1). On first sight, this could be caused by the longer average time between the respondents' ex ante and ex post Q sorting in the Delft case. Analysis at the level of individual respondents, however, did not show a clear relation between the time between the ex ante and ex post Q sorting and the correlation between the Q sorts. An alternative explanation is that there was a more pressing issue in the Delft case, which may have increased the stakeholders' motivation to learn.

In addition, we analyzed the topics of the cognitive changes that occurred in the cases. In both cases, the respondents changed their perspectives about (current and possible future) water management problems, strategies and goals (see Tables 5.9 and 6.7). Remarkably, individual agreement with statements concerning water management goals in both cases changed more strongly than individual agreement with statements about problems and strategies. This is in line with the empirical finding in Pelletier et al. (1999) that values change on the short time scales. Other researchers (e.g., Argyris and Schön 1978; Sabatier 1988), however, claim that perspectives on problems and goals change less quickly than perspectives on how to solve problems and how to achieve goals. Alternative explanations for the observed changes concerning the goals to be

achieved are that the respondents recognized and resolved conflict in their own perspective (cf. Pelletier et al. 1999), acknowledged and internalized the values and interests of others (cf. Pelletier et al. 1999) and/or learned that the goals they initially pursued were unfeasible.

Table 7.1. Cognitive learning in the cases

	Case Lower Rhine		Case Delft		
	Partici- pants work- shops	Non- partici- pants	Participants steering group meetings	Partici- pants work- shops[‡]	Non- parti- cipants
Number of respondents	16	11	3	9	2
Average time between ex ante and ex post Q sorting (months)	12	17	16	18	19
Average correlation between ex ante and ex post perspective	0.58	0.60	0.45	0.38	0.54
Stated learning from others' perspectives at workshops[†]	4.3	n/a	3.0	3.8	n/a

[†] Average score based on participants' workshop evaluations, on a scale between 1 (very poor) and 5 (very good).
[‡] These participants attended only workshops (and no steering group meetings).

The influence of collaboration on changes in overall perspectives
Empirical evidence in the natural resources management literature supports the hypothesis that collaboration between different stakeholders enhances cognitive learning (e.g., Daniels and Walker 1996; Pelletier et al. 1999; Saarikoski 2000; Steyaert and Jiggins 2007). At the same time, the evidence suggests that there may be barriers to learning from collaboration, such as limited opportunities for discussion (Saarikoski 2000).

We first compared the degree of change in overall perspectives between respondents that collaborated at different levels of intensity within each case. The comparison did not result in convincing evidence that collaboration enhances cognitive learning. In the Lower Rhine case, the average degree of learning in the participant group and the control group was about the same. Similarly, in the Delft case, the perspectives of the participants in the steering group meetings did not change more than the perspectives of the workshop participants, who collaborated much less intensively. Finally, the intensity of participation[66] of individual workshop participants did not clearly influence the extent of change in their overall perspectives. Still, the participant group in the Lower Rhine case learned more about the future than the control group and stated to have learned strongly from each others' perspectives (see Table 7.1). Furthermore, the participants in the Delft case changed their overall perspectives

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[66] Reflected in the number of workshops attended and the level of participation in the workshop discussions.

slightly more than the non-participants[67] and also stated that they learned from others during the workshops.

Cross-case comparison of the degree of cognitive learning reveals that the workshop participants in the Delft case on average changed their perspectives more strongly than the workshop participants in the Lower Rhine case (see Table 7.1). The relatively strong learning in the Delft case cannot be explained by the intensity and fairness of the workshop discussions, since in the Lower Rhine case the workshop discussions were slightly more intensive and fair. Although the average number of attended workshops per participant was lower than in the Delft case, the time during which the average participant attended the workshops was higher. The discussions in the Lower Rhine case were also slightly more task-oriented than the discussion in the Delft case (see Figures 5.5 and 6.9). Moreover, the workshops in the Lower Rhine case were relatively open to the input of all participants, whereas the workshops in the Delft case were dominated by researchers who discussed the technical research results (see Table 7.2).

Table 7.2. The intensity of collaboration during the workshops

	Case Lower Rhine	Case Delft
Average number of workshops attended[†]	1.4	1.9
Average Gini coefficient plenary discussions[‡]	0.47	0.68
Average Gini coefficient group work	0.32	0.54[§]

[†] The workshops in the Lower Rhine lasted longer than the workshops in the Delft case.
[‡] Equality of the distribution of contributions to the discussion over the participants (see Section 4.4).
[§] Sub group work only occurred during the third workshop.

One alternative explanation for the stronger change in overall perspectives in the Delft case is that the participation of the policymakers and societal actors in the research was stronger, as well as the participation of the researchers in policymaking. Other alternative explanations are that the issue at stake was more urgent and emerged more recently. The stronger urgency may have caused a stronger motivation to learn and a more intensive discussion of the issue at stake outside the collaborative research process. Because the issue emerged only recently, stakeholders had only little time to reflect on their own perspective, to exchange their perspectives and to do research before the collaborative research process started. This may have increased the opportunity to learn about the issue stake.

The influence of collaboration on the development of consensus
Literature in the field of natural resources management also provides empirical evidence for the hypothesis that collaboration supports the convergence of

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[67] This is no strong evidence, however, because only two non-participants completed the repeated Q sorting.

perspectives, or in other words the development of consensus (e.g., Muro and Jeffrey 2008; Saarikoski 2000; Steyaert and Jiggins 2007). In the cases, we assessed how the average correlation between the perspectives in specific groups of respondents changed over time (see Table 7.3). The findings suggest that collaborating during a limited number of workshops is not sufficient to develop consensus, but that more intensive collaboration is needed to develop mutual trust and understanding (cf. Saarikoski 2000). This was most clear in the Delft case, where the correlation between the perspectives of the nine workshop participants decreased and the correlation between the perspectives of three participants who (also) attended the steering group meetings strongly increased. The average correlation between the perspectives of the workshop participants in the Lower Rhine case did not increase significantly either. Yet, compared to the decrease in consensus in the control group, the insignificant increase in the participant group indicates that attending workshops may enhance the development of consensus to some degree.

Table 7.3. Convergence or divergence of perspectives

	Case Lower Rhine		Case Delft		
	Partici-pants work-shops	Non-partici-pants	Participants steering group meetings	Partici-pants work-shops	Non-partici-pants
Average correlation between perspectives ex ante	0.30	0.32	0.17	0.18	0.17
Average correlation between perspectives ex post	0.33	0.26[‡]	0.51[‡]	0.14[‡]	0.20
Stated development consensus about problems and solutions[†]	3.5	n/a	3.4	3.4	n/a

[†] Average score based on participants' workshop evaluations, on a scale between 1 (very poor) and 5 (very good).
[‡] The difference between the pair-wise ex ante and ex post correlation coefficients in this group is significant according to a two-sided t-test with $p < 0.05$.

The influence of collaboration on learning from the research results
We focused on analyzing whether the respondents' perspectives changed in the direction of the technical research results that were presented, discussed and/or co-constructed during the workshops and other meetings. For this purpose, we only analyzed changes in the scores on the statements that clearly supported or rejected the research results. Our case studies suggest that the participants internalized the technical research results only to a limited extent (see Table 7.4; cf. Saarikoski 2000).

Of the different stakeholder groups that we analyzed in the two cases, the members of the steering group in the Delft case appear to have learned most strongly from the research results (see Table 7.4). This can be explained by their strong willingness and ability to collaborate, and the high intensity and fairness of their collaboration with each other and with the researchers. The willingness to collaborate was high because the steering group members felt responsible for

managing the issue at stake and needed better technical insights to do this. The ability to collaborate was high, because the policymakers and researchers already developed mutual understanding and trust in the years before the analyzed collaborative research process. This may have enabled the intensive discussions of perspectives and the relatively strong collaboration of the policymakers in setting up and steering the research. In addition, the three governments in the steering group contributed equally to the collaborative research process. They contributed equal amounts of money to finance the collaborative research, which provided an additional incentive to gain something from the collaboration. Furthermore, the governments had an equal say in the steering group meetings.

Table 7.4 Learning from the research results

	Case Lower Rhine		Case Delft		
	Partici-pants workshops	Non-partici-pants	Participants steering group meetings	Partici-pants workshops	Non-partici-pants
Measured learning from research results[†]	0.02	0.15	0.21	0.04	-0.18
Stated learning from research results[‡]	2.3	n/a	3.0	3.4	n/a

[†] We summed up the changes in scores in the direction of the research results, subtracted from this sum the changes in the opposite direction, divided the total by the sum of the expected changes in scores on the basis of the research results and finally averaged this number over the respondents in the group.

[‡] Average stated learning from the research results during the workshop, based on participants' workshop evaluations, on a scale between 1 (very poor) and 5 (very good).

The willingness and ability to collaborate of the participants who attended only one or more workshop(s) in the Delft case and the participants in the Lower Rhine case was much more limited, as well as the intensity and fairness of their collaboration. This appears to have reduced their learning from the research results. During the workshops in the Delft case, the opportunities for an intensive discussion of perspectives and an active involvement in the research were limited. In the Lower Rhine case, collaboration between researchers, policymakers and societal stakeholders had to start from scratch and a lot of time was needed to develop mutual understanding and trust. Since most policymakers were very busy with their daily work and the collaborative research process concerned a less urgent issue, their willingness to collaborate and to learn was limited. Furthermore, some policymakers were afraid that the collaborative research would mess up transboundary politics. As a consequence, the intensity of collaboration was low for most participants. In addition, researchers dominated the collaborative research process, by initiating, funding and organizing it.

Table 7.4 displays two other remarkable findings. First, the perspectives of the control group in the Lower Rhine case changed relatively much in the direction

of the research results. This may be because many of them were scientists who followed recent developments, e.g., in climate modeling. Second, the perceived strong learning from the research results by the workshop participants in the Delft case, according to their workshop evaluations, is not reflected by the changes in their Q sorts (see Section 7.2 for a further discussion).

The influence of the research process on cognitive learning
The research process itself was quite similar in both cases. Complex computer models were set-up, calibrated and used to predict the behavior of the natural system under different scenarios and management strategies. In both cases, many assumptions had to be made and the research results were surrounded by many uncertainties. A difference between the cases was that the research in the Delft case was more applied and was performed by research institutes, whereas the research in the Lower Rhine case had more fundamental components and was performed by universities. According to the conceptual framework, learning from research results is mainly influenced by the individual perceptions of the relevance and quality of the research and the attractiveness and clarity of the presentation of the research results. These perceptions are influenced by the research process and the collaborative process.

Table 7.5 indicates that the workshop participants in both cases considered the workshops and the research results to be relevant, the research and its results to be of good quality and the presentations to be clear and attractive. Only two participants considered the research to be of low quality and another participant considered the presentations to be of low quality. The perspectives of these participants did not change predominantly in the direction of the research results, but in the opposite direction. This supports the hypothesis that individuals learn less from research results when they perceive the quality of the research or the presentation of its results as insufficient. Although all participants indicated that they considered the workshops and the research results to be relevant, the final interviews in the Lower Rhine case indicated that the presented research results were only a small addition to the large existing body of knowledge, and that this limited learning from the research results.

Table 7.5. Individual perceptions of the research

	Case Lower Rhine	Case Delft	
	Participants workshops	Participants steering group meetings	Participants workshops
Perceived relevance workshop and/or research results [†]	3.7	4.0	3.8
Perceived research quality [†]	3.5	3.8	3.7
Perceived quality presentations [†]	3.5	3.6	3.6

[†] Average score based on participants' workshop evaluations, on a scale between 1 (very poor) and 5 (very good).
[‡] As stated by the respondents after their ex post Q sorting.

The influence of the policy process on cognitive learning
A large difference between the two cases was the way in which the collaborative research process was embedded in the policy process. In the Delft case, the research results were directly needed for decision-making, whereas in the Lower Rhine case the results supported the exploration of the long term future. This had two obvious implications. The first implication was that the research results in the Delft case were perceived as more relevant than the research results in the Lower Rhine case. The lack of a pressing policy issue in the Lower Rhine case limited the intensity of collaboration, which may have reduced learning from the research results. The second implication was that political negotiations and individual and organizational interests had a more pronounced influence on learning in the Delft case. One participant stated that a rational process was not possible due to the strong political pressure. Although we dispute that the respondents' perspectives and changes therein were fully irrational, the case study results suggest that learning from the research results was in many cases biased by individual interests, e.g., related to individual tasks and responsibilities. Although to a lesser extent, strategic considerations and individual interests also appear to have influenced collaboration and learning in the Lower Rhine case. First, transboundary politics were mentioned as one of the main reasons for the limited participation of the Working Group in the collaborative process. Second, the results suggest that some participants learned less from the research results as a consequence of their individual interests.

The interview results suggest that the individual prior technical knowledge of the policymakers and societal stakeholders influences learning from research results in two opposite ways. On the one hand, strong technical knowledge increases the individual's ability to understand the presented expert knowledge. On the other hand, strong technical knowledge increases the ability to be critical about research results. This may explain why we did not find a clear relation between individual levels of technical knowledge and individual learning from research results.

The influence of other processes on cognitive learning
Finally, we found evidence for the influence of other research, the media, other meetings and self-reflection on learning in the cases. We did not find an influence of natural events on learning, probably because no major relevant events occurred.

In the Lower Rhine case, external influences appeared to have a stronger influence on learning from the research results than the collaborative research process itself. This insight was derived from the comparison of learning in the participant group and the control group and from the final interviews. Many of the involved participants were flood management professionals who were confronted with new (technical) knowledge concerning flood management on a daily basis. Consequently, the technical knowledge presented during the workshops was only a small part of all knowledge with which they were

confronted between the ex ante and ex post Q sorting. Furthermore, the media paid a lot of attention to the potential strong effects of climate change. The specific research finding that climate change would increase peak discharges of the Rhine was in line with the more generic messages in the media.

In the Delft case, a very specific issue was at stake, which limited the influence of external factors. All participants in the steering group meetings stated to have obtained most technical knowledge about the issue at stake during the steering group meetings. Many workshop participants stated to have obtained most technical knowledge during the workshops. A few workshop participants stated to have learned from their own reflections or during other meetings, e,g., within the organization. Furthermore, some stated that other studies had a strong influence on their learning process. Some of these studies formed an addition to the research that we analyzed, focusing on different questions, and other studies could be considered as "second opinions", addressing similar questions but answering them in a different ways.

7.2. Discussion of methodology

In this section, we discuss the applied methodology for assessing cognitive learning (research question 2a), collaborative processes (research question 2b), other factors that may influence cognitive learning (research question 2c) and the relation between cognitive learning, the collaborative process and other factors (research question 2d).

Assessing cognitive learning
There are many ways to assess cognitive learning. Most existing methods assess only the learners' perceptions about the extent and content of their own learning, e.g., through interviews, workshop evaluations and ex post surveys (e.g., Halvorsen 2001; Leach et al. 2002). These methods do not take into account that cognitive learning is a largely unconscious process (Beratan 2007; Weiss 1977) and that the learner's perception of his own learning may be biased. Other existing methods analyze the content of the observed discussions, which reflect only fragments of the perspectives of the involved stakeholders and changes therein. In order to overcome these problems, we developed a methodology to measure individual perspectives before and after a collaborative process and to assess changes over time.

From the many methods to assess perspectives, we selected Q sorting as most appropriate. An advantage of Q sorting and other surveys (or questionnaires) over other methods that can be used to elicit perspectives, such as interviewing (e.g., Denzin and Lincoln, 2000) and cognitive mapping (e.g., Eden, 1988; Ridder et al., 2005), is that the elicited perspectives are more comprehensive (see Textbox 7.1). Furthermore, the perspectives can be more easily compared, because they are expressed in a quantitative form, as sets of scores. This

supports comparison and grouping of individual perspectives, as well as analysis of changes over time, using statistical techniques. An advantage of Q sorting over other types of surveys is that the respondents are forced to distribute statements over score categories according to a fixed distribution (see for example Table 4.2), which forces respondents to carefully compare all statements relatively to each other. This is assumed to decrease the risk of arbitrary or biased sorting and to increase the repeatability of the sort.

> **Textbox 7.1. Comparison of the perspectives that were elicited with different elicitation methods in the Lower Rhine case**
>
> In order to get an impression of the validity of the elicited perspectives in the Lower Rhine case, individual Q sorts were compared to individual perspectives that were obtained using interviews and cognitive mapping. Based on the results of interviews, we developed individual cognitive maps in preparation of the first workshop. During the workshop, participants elaborated the perspectives captured in the cognitive maps. In total eight Q sorting respondents were interviewed and four of them participated in the cognitive mapping exercise. For each individual it was assessed how many of the statements that received the scores "-3" or "-2" (strongly disagree) or "+2" or "+3" (strongly agree) in the Q sort were also reflected in the interview and cognitive map. On average, 30 % of these statements were reflected in the interviews and 40 % in the cognitive maps and about 50% were not reflected in either of them. Thus, Q sorting identifies much more aspects as relevant than the aspects respondents come up with themselves. This points to the fact that Q methodology is not only an elicitation technique. It forces respondents to reflect on a broad range of aspects, including aspects that the respondent may not have considered before but that are relevant to other stakeholders. The remaining 10-20% of the most relevant Q sorting statements seemed to be contradicted in the interviews and cognitive maps. Possible explanations for this are that individual perspectives changed between different elicitation moments or that the analyst interpreted statements in a different way than the interviewee. In addition, the interviews and cognitive maps included some claims that were not evident in the Q sorts, in particular some detailed explanations.

In order to assess the changes in their individual perspectives over time, we asked the stakeholders who were involved in the cases to fill out a Q sorting questionnaire both before and after the collaborative process. We analyzed the changes in Q sorts over time using common statistical analysis. This way, we were able to analyze whether overall perspectives changed, whether overall consensus increased and whether the scores on specific statements changed with statistical significance. We did not analyze changes in terms of shared perspectives or factors (like Niemeyer 2004; Pelletier et al. 1999), which is in our opinion particularly useful for summarizing cognitive changes in larger groups. Yet, analyzing changes in individual factors loadings could result in some useful insights into the degree and direction of individual learning as well.

In order to make the notion "learning from research results" operational and measurable, we had to make multiple choices that influenced our findings. We chose to focus on the Q sorting statements that were clearly rejected or clearly supported by the presented and discussed research results. In order to judge for each statement whether this was the case, we interpreted the related presentations and discussions. Concerning some statements, however, different arguments came up in different presentations and discussions. We could partly take this ambiguity into account, by considering only the research results that were presented or discussed during workshop activities that were attended by a specific participant, for determining the expected learning from the research results by that participant. Our final measure of learning from research results considers what part of the changes that would be expected - based on the difference between the individual's ex ante scores on the selected statements and the scores that reflect the research results – did really occur. We could not determine whether these changes were statically significant and had to make an assumption about whether specific changes could be considered to be predominantly in the direction of the research results or not. We also had to take into account that changes in the scores on the selected statements could be influenced by changes in the scores on other statements. Therefore, we analyzed changes in statements concerning the research results in the context of others changes. A final remark is that we could only assess the main lines of learning from the research results using repeated Q sorting. That is, the level of technical details that can be expressed in a small number of statements is low.

After analyzing the changes that occurred, we confronted a selection of respondents with those changes during (ex post) interviews. This helped us to explain the learning that occurred and to filter out measuring errors resulting from the sorting task. In most cases, the scores and changes therein were recognized, but in some cases they were not. Further questioning revealed some limitations to the sorting technique. First, the long time and strong effort required to perform the Q sorting may have decreased the response rate and biased the results (cf. Rugg and McGeorge 1997). A number of interviewees stated their dissatisfaction about the time and effort required to perform the sorting. One interviewee even stated that he got so frustrated with the (ex post) sorting task, that he completed the sorting rather inaccurately. Furthermore, we speculate that respondents may have given up while performing the sorting task, so that only the more motivated stakeholders completed the Q sorting. Second, the limited possibility to express a perspective correctly using the given distribution may have decreased the response rate and biased the results (cf. Rugg and McGeorge 1997). For example, due to the fixed distribution of statements respondents could only express their strong agreement and their strong disagreement with a small number of statements. Therefore, in particular in the Delft case, extreme scores were often assigned to statements that reflected individual values and interests, and not so much to statements that reflected research results. This reduced the degree of learning from research results

according to our measurement. Third, a number of interviewees stated that a Q sort depends very much on the interpretation of the statements and on the emphasis that the individual wants to make, which are both dependent on the moment of sorting. Finally, one interviewee suggested that respondents may learn how to sort during the ex ante Q sorting, which enables them to perform the ex post sorting more strategically.

These findings emphasize the need to 1) keep the number of Q sorting statements low[68], 2) keep the statements simple, e.g., by avoiding mentioning two statements in one, 3) test the Q sorting intensively before conducting it and 4) perform methodological triangulation. We did the latter by assessing the participants' perceptions of their own cognitive learning using workshop evaluation forms and interviews. Another idea that arose during one of the interviews was to let the respondents practice with Q sorting in a try-out exercise. Such an exercise can, however, only take place when the respondents are willing to spend the additionally required time.

In order to find out whether the participants' perceptions of the extent of learning were similar to the results of the repeated Q sorting, we compared the latter with the results of the workshop evaluations. We performed the analysis at the group level (see Tables 7.1, 7.3 and 7.4) and at the individual level. It appeared that the perceived and the measured changes in overall perspectives were rather consistent in the Delft case, whereas many participants in the Lower Rhine case overestimated their overall learning. In contrast, the perceived and the measured learning from research results were rather consistent in the Lower Rhine case, whereas many participants in the Delft case overestimated their learning from research results. Most participants in both cases overestimated the developed consensus.

The participants' overestimation of learning in the workshop evaluations was in line with our expectations that participants may be too positive about the process and its outcomes, as they want to have the feeling that they spent their time well. Another explanation may be that the participants interpreted cognitive learning in another way than we did in this research, and consequently had another impression of the degree to which they learned. For example, they may have included learning to understand others' perspectives, without changing their own perspective, in their conception of cognitive learning[69]. Interestingly, some participants in the Lower Rhine case were more critical about their learning in the final interviews than in the workshop evaluations. This may be because the participants did not feel the need to justify the time spent on the workshop anymore and had the time to put the workshops and their results into perspective.

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[68] As a rule of thumb, we would advise a maximum number of statements of ca. 35.
[69] We asked the participants in the workshop evaluations whether they learned something from others' perspectives, which leaves room for different interpretations of the effect of the learning.

Assessing the collaborative process and other factors that may influence cognitive learning
In order to assess the factors related to the collaborative process, the research process, the policy process and other processes, we collected and analyzed data in many different ways. We did this, because we were uncertain at the start or the research which data would provide interesting insights in the mechanisms that influence cognitive learning. We assessed the factors related to the collaborative process and the research process in detail, by observing the workshops, recording and transcribing workshop discussions, analyzing the interactions and the content of the discussions, conducting workshop evaluations and interviewing participants.

First, the audio recordings of the workshops and transcripts of the audio recordings proved to be useful input for analyzing the content of the plenary and sub group discussions, e.g., about the research results and the factors that influenced cognitive learning. Without recording the discussions in the sub groups, we would have missed important information about the content of the discussions concerning the research results. Second, interaction analysis proved to be useful for assessing the distribution of speech acts over participants and for attributing specific speech acts from the transcripts to specific persons. An estimation of the intensity of the collaboration and the distribution of speech acts over participants can, however, also be made by observing the process without categorizing every speech act. Third, the content analysis of the transcripts proved mainly useful to improve the interaction coding and to analyze exactly what was said about the research results. The discussion content, however, included little information concerning the factors that may have influenced learning.

Fourth, the workshop evaluations were useful to elicit the participants' perceptions of the collaborative process and the research process. In addition, the workshops evaluations were useful for other purposes, such as monitoring and improving the ongoing collaboration process and assessing the process results. A problem that we encountered was that some participants completed the evaluation forms anonymously and some did not complete them at all. A solution to these problems may be to send the questionnaires around by email after the workshop. We did this once in the Delft case. It resulted in a high response rate (after repeated emails) and insight in who sent us which completed form. Fifth, ex ante interviews were useful to prepare the Q sorting questionnaire and to learn about the stakeholders' willingness and ability to collaborate and learn. The ex post interviews were useful to check our assessment of the collaborative process and the research process. Furthermore, the final interviews, and the questions we added to the ex post Q sorting questionnaire, were useful to get an impression of what happened in the policy process and other processes. In addition, analysis of the ex ante perspectives provided useful information about the values and interests of the participants.

Finally, writing a qualitative process description appeared to be useful to integrate the results from formal assessment methods and informal observations.

Assessing the relation between cognitive learning, the collaborative process and other processes
We explored the relation between cognitive learning and participation in collaborative research processes by analyzing differences in the degree and content of cognitive learning between 1) stakeholders that were involved in the collaborative process and stakeholders that were not and 2) individual participants that were influenced in different ways by the collaborative process, the research process, the policy process and other processes.

Analysis of differences in learning between participants and non-participants provided good insight in the overall influence of collaboration on cognitive learning. Furthermore, the assessment of the collaborative process and other processes provided a rich picture of the factors that influenced individual learning. First, the results of the initial interviews, interaction and content analysis provided a good overview of the influence of the collaborative process on learning. Second, the workshop evaluations proved to be useful input to explain limitations in the cognitive learning of a few participants, who stated that the quality of the research or the quality of the presentations was low. Third, the results of the final interviews were particularly useful for assessing the influence of specific factors related to the policy process and other processes on learning. The relative influence of the policy process appeared particularly large in the Delft case and the relative influence of other processes appeared particularly large in the Lower Rhine case.

Finding strong evidence for the influence of specific factors related to the collaborative process and other processes on cognitive learning, however, proved to be difficult. There are so many interrelated factors that it is impossible to be sure about cause and effect. Because specific factors related to the collaborative process appeared to have only a small influence on cognitive learning, we think it is of limited use to study them in much more detail than the other factors (like we did). Similar insights in these factors could be obtained with less formal and less intensive assessment methods, e.g., by making notes of the interaction and content of the workshop discussions, without conducting interaction analysis and without recording and transcribing the discussions. Such an informal methodology would, however, limit the opportunity to perform additional analysis of the data, e.g., in a case study survey.

A final important point of discussion is the representativeness of our findings, which were based on a relatively small number of individuals in only two cases. Many participants in the collaborative research processes in the cases did not respond to the repeated Q sorting. Consequently, the obtained insights concerning cognitive learning and the factors that influenced it may be biased. For example, the smaller, rural municipalities in the Delft case were

underrepresented. Policymakers from these municipalities may have learned relatively little because the expected effects in their municipalities were relatively small and consequently their motivation to collaborate and learn may have been low. Furthermore, differences in the composition of the participant group and the control group in the Lower Rhine case may have caused differences in the factors that influenced learning by these groups. Moreover, we studied only two cases in the broad field of water management, or the even broader field of natural resources management. The results provide insufficient ground to predict which factors will most strongly influence cognitive learning in other situations.

7.3. Conclusions

Different parts of this thesis provided an answer to different research questions (see Section 1.2). The first research question was addressed in Chapter 2. The second research question was addressed in Chapter 4 and Section 7.2. The larger part of this thesis, Chapter 3, 5 and 6 and Section 7.1, was devoted to addressing the third research question. In this section we summarize our final conclusions concerning each question.

1. *To what extent do current river basin management regimes support adaptive management?*

A river basin management regime can be defined as consisting of actor networks, a legal framework, policy, information management and financing. Based on literature, we developed a normative framework of a regime that is assumed to support adaptive management. We applied the framework to assess the transboundary river basin management regimes in the Rhine basin and six other basins in Europe, Central Asia and Africa. The regime in the Rhine basin was most similar to the normative framework and can thus be assumed to offer most support to adaptive management. Since stakeholder collaboration and continuous learning are "key elements" in adaptive management, the Rhine regime can also be assumed to offer good support to collaboration and learning. This was confirmed by our case studies in the Lower Rhine basin and Delft[70].

In other basins it may be much more difficult to organize a collaborative research process, for example due to limited finances, limited experience with collaboration and limited background knowledge of the involved stakeholders. In order to explore to what extent collaboration is possible and to what extent collaboration enhances learning in other basins than the Rhine basin, we recommend performing additional case studies in those basins.

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[70] Furthermore, the case study findings identify differences in the institutional support for collaboration and learning within the Rhine basin, i.e., the regime in the Delft case was more supportive than the regime in the Lower Rhine case.

2.   How can collaboration and cognitive learning be assessed?

In Chapter 4 we developed a methodology to assess cognitive learning, collaboration and other factors that may influence cognitive learning. We applied the methodology in the two case studies, as described in Chapter 5 en 6. Below we discuss how we assessed a) cognitive learning, b) collaboration and other factors and c) the relationship between cognitive learning, collaboration and other factors. In addition, we give methodological recommendations for further research.

Assessing cognitive learning
We defined cognitive learning as the changes in an individual's perspective on the issue at stake over time. We assessed cognitive learning using a combination of repeated Q sorting, evaluation forms and interviews. The repeated Q sorting enabled us to analyze cognitive learning in a standardized and detailed way and to focus our analysis on changes concerning the discussed research results. The evaluation forms and interviews enabled us to assess the stakeholders' perceptions of their learning. Furthermore, the interviews enabled us to confront the stakeholders with detailed findings from the repeated Q sorting.

Therefore, we recommend researchers who intend to assess cognitive learning in natural resources management practice to adopt a methodology that includes a standardized ex ante and ex post assessment of perspectives, e.g., using Q sorting. In addition, we recommend using ex post interviews to elicit the stakeholders' perceptions of the learning that occurred. Such an approach can be used to assess cognitive learning of (groups of) individuals during specific events or processes or to assess cognitive learning over longer periods of time.

Assessing the collaborative process and other processes
According to our conceptual framework, cognitive learning is influenced both by exposure to explicit knowledge, e.g., from others' perspectives, and by selective and interpretative framing. In the cases we assessed how the collaborative process, the research process, the policy process and other processes influenced individual exposure to knowledge and individual framing.

We assessed the collaborative process and the research process in much detail, by observing the workshops, recording and transcribing workshop discussions, analyzing the interactions and the content of the discussions, conducting workshop evaluations and interviewing participants. This assessment provided useful insights in:

1)   the participants' willingness and ability to collaborate;
2)   the intensity of the discussion of perspectives and participation in each others' activities;
3)   the fairness of the discussion and collaboration;
4)   the participants' perceptions of the research process and its results.

When strongly pressed for time, however, we would recommend researchers to make notes about the intensity and fairness of the interaction and the content of the discussion, instead of performing formal interaction analysis and recording and transcribing the workshop discussion as we did.

We assessed the policy process and other processes in less detail. In order to assess the factors related to the policy process, we determined individual values and interests concerning the issue at stake based on the ex ante Q sorts. Second, we asked the participants about their background and level of technical knowledge, after the ex ante Q sorting and during the ex ante and ex post interviews. During the ex post interviews, we also asked the participants which strategic considerations influenced their (inter)actions. Finally, at the end of the ex post Q sorting and during the ex post interviews, we asked the participants which other processes influenced their learning.

Assessing the relation between cognitive learning, collaboration and other factors
We first explored the relation between cognitive learning and collaboration by analyzing differences in cognitive learning between stakeholders that were involved to different degrees in the collaborative process. Second, we analyzed whether learning by individual participants was influenced by other factors related to the collaborative process, the research process, the policy process and other processes. We learned that it is difficult to distinguish between the influence of factors related to the collaborative process and factors related to other processes, in particular when cognitive learning is assessed over longer periods of up to two years.

Therefore, we recommend researchers who want to improve their insight into collaborative learning to focus either on the influence of specific collaborative events on cognitive learning or on the broader range of factors that influence cognitive learning over longer periods of time[71]. The first approach may be taken in order to assess the effectiveness of specific collaborative activities in specific situations. In this approach, the perspectives of the participants in the collaborative event can be measured shortly before and shortly after the event (such as in Pelletier et al. 1999). This way, the influence of other processes than the collaborative process is limited. Yet, individual values, interests, technical knowledge and perceptions of the discussed knowledge, as well as strategic considerations related to the policy process, may still be of influence.

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[71] A third approach may be to try to gain more control over the factors that may influence learning by organizing and analyzing role playing games instead of real management situations. A problem with such an approach would be, however, that individual framing of explicit knowledge is a highly individual, largely unconscious and complex process. Therefore, cognitive learning of specific stakeholders can, in our opinion, not be simulated well by role players.

Taking the second approach, more insight could be obtained in the variety of factors that influence cognitive learning over longer periods of time. More in-depth insights could be obtained by analyzing a limited number of individuals, including their interests, knowledge, motivations, preferences and actions in detail. An interesting question would be whether the phase of the collaboration influences which goals are strived for, how motivated the participants are, which activities they undertake and with what results. To obtain such insights, the individuals should be interviewed repeatedly and observed during all relevant professional (inter)actions in which they are exposed to explicit knowledge or which influence their frames. It may, however, be a challenge to find stakeholders who agree to such detailed analysis of their motivations, behavior, etc.

We focused our analysis on cognitive learning and collaborative research processes. In order to obtain more comprehensive insights into collaborative learning in natural resources management, we recommend analyzing other aspects as well. It may be interesting to perform case studies in which cognitive learning by researchers is measured as well, or in which collaboration with societal actors plays a larger role, e.g., public participation processes. Furthermore, we recommend looking beyond cognitive learning and analyzing whether it leads to new policies and practices. However, this would be a quite different type of research, requiring other methods than Q methodology.

Finally, we recommend to perform integral case surveys concerning collaborative learning in natural resources management (cf. Mostert et al. 2007; Muro and Jeffrey 2008). Such surveys could be conducted every time a substantial number of new case studies has been finalized. This way, empirical findings of several cases could be compared, covering different types of collaborative processes and different types of learning.

3.   To what extent and how does collaboration influence cognitive learning?

We answered the third research question by literature study (Chapter 3) and two case studies (Chapter 5 and 6). Below we address a) whether cognitive learning occurred, b) the influence of collaboration on cognitive learning and c) the influence of other factors on cognitive learning.

Cognitive learning
According to literature, the perspectives of stakeholder may change in different ways. For example, stakeholders may learn about the effectiveness of a certain measure or about the goals to be achieved. Whereas instrumental learning may happen on a daily basis, learning about the goals to be achieved may take decades (cf. Sabatier 1998). Our case study findings confirm that substantial changes in stakeholder perspectives on the issue at stake occur in water management practice. The observed changes concerned problems, management

strategies and the goals to be achieved, and occurred on timescales of one month up to two years. In order to explore to what extent cognitive learning is durable and to what extent perspectives fluctuate, it would be interesting to repeat a specific Q sorting questionnaire more than twice, e.g., every two years over a period of a decade. Such analysis would only be useful when the issue at stake and the selected statements remain relevant during the entire period.

The influence of collaboration on cognitive learning
The most interesting and at the same time most speculative part of the research findings concerns the relation between collaboration and learning. According to the literature, collaboration may enhance reflection on each others' perspectives and mutual learning between the collaborating stakeholders. In turn, this may increase consensus between the collaborating stakeholders. More specifically, collaborative research may 1) increase mutual understanding between researchers, policymakers and societal stakeholders, 2) result in the production of research results that are both of high (scientific) quality and relevant for policymakers and societal stakeholders and 3) result in learning by policymakers and societal stakeholders from the research results. Other literature, however, suggests that cognitive learning is influenced by a complex mix of factors that influence individual exposure to others' perspectives and individual framing, and can be related to collaborative processes, research processes, policy processes and other processes.

Because there are so many interrelated factors that may influence learning and because we performed only two case studies, we can only make well-founded speculations about the relation between collaboration and learning in natural resources management. First, our case study findings suggest that collaboration may be difficult. The Lower Rhine case showed that if some stakeholders are not sufficiently motivated to collaborate, this may limit the collaborative process and its results and frustrate the more motivated stakeholders. In addition, not all stakeholders may be sufficiently able to collaborate, e.g., because of limited experience with collaboration and limited trust. Second, our case study findings suggest that only intensive collaboration enhances cognitive learning. In the Lower Rhine case, we found only minor differences in learning between participants and non-participants. Furthermore, in neither case did we find clear differences in learning between workshop participants who were involved to different degrees in the collaborative process. Only the members of the steering group in the Delft case increased their mutual consensus. They also learned relatively a lot from the research results. This can be explained by their intensive discussion of perspectives and their active participation in the technical research. Finally, the perspectives of the participants in the Delft case changed on average more strongly those of the participants in the Lower Rhine case. This can be related to the stronger urgency of the issue at stake in the Delft case, which may have increased the willingness to collaborate and learn.

The influence of other factors on cognitive learning

Focusing on learning from the research results, the cases revealed a strong influence of other processes than the collaborative process as well. Some participants stated to have learned little because they did not perceive the research results or their presentation to be of sufficient quality. Their criticism was related to their strong technical knowledge and the lack of reflection by the researchers on the line of thinking and the assumptions of the research. The latter could possibly have been prevented by involving the critical participants more intensively in the research.

The learning of others appeared to be influenced by their individual values and interests and strategic considerations emerging from the policy process. In particular in the Delft case the stakes were high. Many stakeholders used the research results strategically, in order to defending their position in the political negotiations. Others learned only about the problems that would directly affect them. Furthermore, in particular in the Lower Rhine case, a large part of the observed learning appeared to be caused by sources of knowledge external to the collaborative process, research process and policy process. Flood management is of interest to a broad range of stakeholders in the Lower Rhine basin. Consequently, relevant technical knowledge was produced in several other projects and studies and appeared also in the media.

A final observation is that the urgency of the issue at stake appears to influence many factors in the conceptual framework. In case of an urgent issue, such as in the Delft case, the motivation to collaborate, learn and agree on a solution appears to be stronger than in case of a less urgent issue, such as in the Lower Rhine case. Consequently, in case of an urgent issue the collaborative process and the research process, as well as their results, are considered to be of more (direct) relevance. At the same time, however, values, interests and strategic considerations play a larger role, which increases the risk of conflict.

7.4. Recommendations

In this section, we formulate our recommendations for researchers, policymakers and societal stakeholders who are involved in collaborative research processes with the intention to learn from each other about the issue at stake[72]. Based on literature, we formulated seven lessons for such collaborative research (see also Textbox 3.1[73]):

1) Know each other;
2) Formulate research together;

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[72] Recommendations for research on collaboration and learning have already been incorporated in our conclusions concerning research question 2 in Section 7.3.

[73] In addition, we refer researchers who are interested in influencing the policy process to another paper (Mostert and Raadgever 2008).

3) Produce knowledge iteratively;
4) Present results in an attractive and clear way;
5) Reflect on knowledge critically;
6) Use appropriate tools and methods;
7) Use intermediaries in case of large differences.

By putting these lessons into practice, the collaborating stakeholders may enhance mutual cognitive learning[74]. The case studies, however, revealed that this is not easy. Although most of the lessons were applied, at least to some extent, the resulting cognitive learning was limited. It appeared that putting the lessons into practice required a great investment of time, money and creativity of the involved stakeholders. Because stakeholders have a limited amount of resources, they often have to choose which lessons they give priority.

Based on literature we also formulated specific factors that may influence cognitive learning, related to the collaborative process, research process, policy process and other processes. These factors are (Figure 3.3):

- willingness and ability to collaborate and learn;
- intensity of discussion and collaboration;
- fairness of discussion and collaboration;
- relevance and quality of research results;
- attractiveness and clearness of their presentation;
- strategic considerations;
- individual values and interests;
- individual technical knowledge;
- other processes (e.g., media and natural events).

In the cases, all factors appeared to have influenced cognitive learning to some extent. Whereas some factors were dominant in the one case, others were dominant in the other case. Therefore, we recommend researchers, policymakers and societal stakeholders who intend to collaborate and learn from each other, to consider the potential influence of each factor in their specific situation at the beginning of the collaborative process. We recommend analyzing the other involved stakeholders, their perspectives on the issue at stake and their motivation to collaborate. In addition, we recommend analyzing how the collaborative process, research process, policy process and other process may unfold and interfere with each other[75]. It may be useful to perform the analysis jointly and to use the result to jointly prepare the collaborative process.

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[74] At the same time following the lessons may be useful for achieving other possible goals of collaborative processes, such as developing relations, skills and legitimate plans.
[75] When the influence of external processes on cognitive learning is expected to be strong, we recommend considering the external sources of knowledge within the collaborative process. This may facilitate an explicit discussion of a broad range of perspectives and may prevent strategic knowledge use.

Such analysis would point to the factors that can be expected to have a strong influence on learning, as well as the related lessons for collaboration. Based on the obtained information about the factors that may support or hinder collaborative learning, the involved stakeholders can decide whether and how they will participate in (the remainder of) the collaborative process. We recommend collaboration between researchers and other stakeholders only when the following five conditions have been fulfilled:

1)   the issue at stake is perceived as important;
2)   there is a lack of knowledge about this issue;
3)   additional research could potentially provide useful knowledge;
4)   all stakeholders are highly motivated to collaborate intensively and learn;
5)   the stakeholders have sufficient time and other resources to collaborate intensively.

When these conditions are fulfilled, there should be sufficient opportunity to put our main recommendation into practice: collaborate intensively! This recommendation may also be relevant for collaborative processes with other goals than cognitive learning (cf. Huxham and Vangen 2005; Ridder et al. 2005). Many obstacles to effective collaboration can only be removed from the path by intensive collaboration. Even getting through the first steps of a collaborative process - getting to know each other and agreeing on the goals and the design of the collaborative process – may cost a lot of time and effort.

Last but not least, we would like to stress that collaborative processes often have to be built up in several phases. The goals to be achieved and the activities to achieve them may vary between different phases of the process (cf. Gray 1989). It may not be a good idea to start a critical discussion of perspectives on the issue at stake before the participants know and trust each other and before they have reached agreement on basic process rules. Sufficient willingness and ability to collaborate have to be developed first. Thus, we recommend not only to collaborate intensively, but also to design the collaborative process in a smart way. The challenge that remains is to involve the right stakeholders at the right time in the right way.

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Appendices

Appendix A. Framework for adaptive management regimes [76]

Criteria	Indicators
A. Actor networks	
1. Cross-sectoral co-operation	- Sectoral governments actively involve other government sectors - Co-operation structures include government bodies from different sectors; many contacts generally - Conflicts are dealt with constructively, resulting in inclusive agreements to which the parties are committed
2. Co-operation between administration levels	- Lower level governments are involved in decision-making by higher level governments - Co-operation structures include government bodies from different hierarchical levels; many contacts generally - Conflicts are dealt with constructively, resulting in inclusive agreements to which the parties are committed
3. Co-operation across administrative boundaries	- Downstream governments are involved in decision-making by upstream governments - International/ transboundary co-operation structures exist (e.g. river basin commissions); many contacts generally - Conflicts are dealt with constructively, resulting in inclusive agreements to which the parties are committed
4. Broad stakeholder participation	- Legal provisions concerning access to information, participation in decision-making (e.g. consultation requirements) and access to courts - Co-operation structures include non-governmental stakeholders - Non-governmental stakeholders actually contribute to agenda setting, analysing problems, developing solutions and taking decisions ("co-production") - Non-governmental stakeholders undertake parts of river basin management themselves, e.g. though water users' associations - Governments take stakeholder input seriously
B. Legal framework	
5. Appropriate legal framework	- A complete and clear legal framework for water management exists (with sufficient detail) - Policies have to be reviewed and changed periodically
6. Adaptable legislation	- Laws and regulation can easily be changed - Water (use) rights can easily be changed / are not permanent

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[76] The framework was also presented in two earlier publications (Raadgever, Mostert, Kranz et al. 2008; Raadgever et al. 2006).

Criteria	Indicators
C. Policy	
7. Long time horizon	- Solutions for short term problems do not cause more problems in the (far) future (20 years or more)
	- Already now preparations are taken for the (far) future (20 years or more)
8. Flexible measures, keeping options open	- Measures taken now or proposed for the near future do not limit the range of possible measures that can be taken in the far future and are preferably reversible
9. Experimentation	- Small-scale policy experiments take place/ are financially supported.
10. Full consideration of possible measures	- Several alternatives and scenario's are discussed
	- Alternatives include small and large-scale and structural and non-structural measures
11. Actual implementation of policies	- Plans and policies are actually implemented
	- Policies are not dogmatically stuck to when there are good reasons not to implement policies, such as new and unforeseen circumstances and new insights
D. Information management	
12. Joint/ participative information production	- Different government bodies are involved in setting the terms of reference and supervising the search, or at least consulted (interviews, surveys etc.)
	- Idem for non-governmental stakeholders
13. Interdisciplinarity	- Different disciplines are involved in defining and executing the research: in addition to technical and engineering sciences also for instance ecology and the social sciences
14. Critical reflection on assumptions	- Researchers allow their research to be challenged by stakeholders and present their own assumption in as far as they are aware of them
	- Research results are not presented in a an authoritative way, but in a facilitative way, to stimulate reflection by the stakeholders about what is possible and what it is they want
15. Explicit consideration of uncertainty	- Uncertainties are not glossed over but communicated (in final reports, orally)
16. Broad communication	- Governments exchange information and data with other governments
	- Governments actively disseminate information and data to the public: on the Internet, but also by producing leaflets, though the media, etc.
17. Utilization of information	- New information is used in public debates (and is not distorted)
	- New information influences policy
As to the issues on which information should be produced, communicated and utilized: see under C.	
E. Financing	
18. Appropriate financing system	- Sufficient (public and private) resources are available
	- Costs are recovered from the "users" by public and private financial instruments (charges, prices, insurance etc.)
	- Decision-making and financing in one hand
	- Authorities can take loans and depreciate their assets, to facilitate efficient use of resources and replacement of assets

Appendix B. Q set and initial factor Q sort values Lower Rhine case

No.	Statement	Factor values		
		A	B	C
Current / general situation (1-14)				
1	The priority of flood management on the political agenda is currently too low.	1[†]	-1	1
2	The ICPR Flood Action Plan is useful because it stimulates countries to put additional effort in flood management.	0	2	1
3	Agriculture and other economic activities are not valued high enough in current flood management.	0	-2	-1
4	Current safety standards in the Netherlands and Northrhine-Westphalia are adequate.	-1	0	0
5	Informal cooperation is essential for success in transboundary flood management.	0	3	1
6	Spatial quality is as important as safety against flooding.	0	1	-2
7	It is necessary to develop a clearer perspective on the desired state of "nature", e.g., clearer ecological goals.	0	2	0
8	Looking 10 years ahead in the development of flood management policies is sufficient.	-3	-1	-3
9	The Dutch five-yearly review of the design discharge guarantees that flood prevention stays up to date in an efficient way.	-1	1	-1
10	Because the range of possible flood management measures is decreasing due to increasing spatial pressure, it is important to take action fast.	3	2	1
11	It is more important that citizens and businesses feel safe than that they are aware of and prepared for possible flooding.	-2	-3	-3
12	A simple governance structure, with clear and little overlapping tasks and responsibilities, is beneficial for flood management.	3	2	1
13	Scientific and expert knowledge are currently not well enough adopted in policy formulation and decision-making.	0	-1	2
14	It is important to pay more attention to smaller floods and local issues, instead of extreme floods.	-1	0	-1
Expected autonomous developments (15-23)				
15	Climate change will significantly increase peak discharges at the Lower Rhine between now and 2050.	2	1	0
16	Floodings in Germany will prevent the occurrence of Rhine discharges larger than 17 000 m^3/s at Lobith until 2050.	2	1	2
17	Because the effects of climate change on peak discharges are still unclear and contradictory, it is better to wait than to take action now.	-3	-1	0
18	The potential damage in the flood prone areas in Northrhine-Westphalia and the Netherlands will not significantly increase until 2050.	-2	-1	-1
19	Spatial pressure along the river will decrease between now and 2050, as agricultural land use decreases.	-1	-3	0
20	There will be large changes in the administrative structure of flood management until 2050.	0	-1	-1

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No.	Statement	Factor values		
		A	B	C
21	The European Union Flood Directive will significantly increase the influence of downstream countries on flood management in upstream countries.	-1	-1	0
22	Improvement of computer technology and models between now and 2050 will lead to new, valuable insights in the behaviour of the river system.	0	1	3
23	The water sector will gain in importance relatively to other sectors (e.g., agriculture, spatial planning) between now and 2050.	1	0	1
Management strategies (24-39)				
24	Creating space for the river by removal of obstacles, floodplain excavation and dike relocation is a sufficient strategy for flood management until 2050.	-1	-1	-1
25	In the next decades, bypasses (e.g., "green rivers") have to be realised to safely accommodate increasing peak discharges.	0	0	-1
26	It is not useful to involve non-governmental organisations and the public more actively in flood management decision-making.	-3	-2	-2
27	Flood management should become more decentralised and controlled by local government bodies.	-2	-2	-2
28	Holding back the water through land use changes and local infiltration upstream in the Rhine basin is useful to decrease peak discharges on the Niederrhein.	2	-3	1
29	Adjusting the timing of peak flows from the main tributaries can hardly contribute to preventing peak flows on the Lower Rhine.	-2	0	0
30	A better integration of water management and spatial planning is essential to solve future flood management problems.	3	1	2
31	Downstream countries should search for and finance measures in upstream countries, when this provides more effective or efficient solutions.	1	1	0
32	Existing dikes, rivers and floodplains should be better maintained.	0	0	2
33	The Rhine countries should develop more controlled retention polders and optimise their use for the whole Rhine basin.	1	0	-1
34	It is important to develop better disaster management plans that thoroughly consider the logistics of potential evacuations.	2	3	2
35	Soft measures like offering compensation or options for insurance are good possibilities to cover residual potential flood damage.	-1	0	0
36	Socio-economic developments in flood prone areas should not be mitigated through spatial planning and construction regulation.	-1	-3	-2
37	Dike heightening is an effective and efficient strategy for future flood management.	-2	-2	3
38	Residual flood risk should be reduced by controlled flooding (e.g., emergency flood detention areas) and compartmentalisation.	1	3	-2
39	At locations where technical flood prevention measures are difficult to establish, flooding should be accepted.	-1	1	0

Table continues on next page

No.	Statement	Factor values		
		A	B	C
Desired future situation / Goals (40-46)				
40	A harmonised approach to determine design discharges and safety standards in the Netherlands and Germany should be operational in 2050.	3	0	1
41	In 2050 ideally a strong river basin authority has been established.	2	-1	-1
42	In 2050 safety standards should be differentiated, based on the values to be protected in a certain area.	1	0	3
43	In 2050 the Rhine should still offer plenty of opportunities to a broad range of (user) functions.	1	3	3
44	In 2050 the dikes should have been retreated, and the river should be revitalised and meandering.	1	1	-3
45	In 2050 the river landscape should be open and enjoyable to live and recreate in.	1	2	1
46	It would be acceptable when in 2050 the current high safety levels could not be guaranteed anymore.	-3	-2	-3

[†] The score range from "-3" (strongly disagree with statement) to "3" (strongly agree with statement).

Appendix C. Q set and initial factor Q sort values Delft case

No.	Statement	Factor values			
		A	B	C	D
Strategies / financing (1-16 and 37)					
1	The involved governments should promote alternative utilization of the abstraction by market parties.	0[+]	0	0	3
2	When there are no possibilities for alternative utilization, the involved governments need to continue the abstraction themselves.	0	2	-1	-2
3	The abstraction should be reduced in a few steps.	-1	2	1	2
4	Negative impacts of ending the central abstraction should be prevented by strategically located small abstractions.	-1	0	-2	-1
5	Additional drainage is needed, in order to prevent groundwater nuisance.	1	1	1	2
6	Municipalities need to inform citizens and companies about the expected effects of ending the abstraction and about how to manage these effects.	1	-1	2	1
7	When the abstraction is ended, additional infrastructure for flushing the "boezems" (main drainage canals) is needed.	-2	-1	0	-1
8	An intensive monitoring network is needed to monitor the different effects of ending the abstraction.	1	-2	2	3
9	Surface water levels in the polders need to be adjusted in order to prevent nuisance from ending the abstraction.	-1	0	-1	-3
10	When the abstraction is ended, constructional measures need to be taken to prevent damage and nuisance.	1	0	3	0
11	When searching for a solution for (ending) the abstraction, the construction of the train tunnel needs to be considered.	0	0	-2	1
12	Real estate owners have to take their own measures to prevent nuisance and damage due to ending the abstraction.	-2	-2	-3	-1
13	When the abstraction is continued, current taxes concerning the abstraction of groundwater and its discharge into the sea need to be reduced as much as possible.	0	1	-1	1
14	Utilizing the abstraction for drinking water, agriculture / horticulture (glass houses) or industry can cover the cost of the abstraction.	-2	0	-1	-2
15	Significant cost reductions can be realized by implementing the required measures in phases.	2	2	3	0
16	Strategically located small abstractions are only (cost) efficient when local users can be found.	-1	1	-1	1
37	All involved governments should contribute to financing management solutions, in order to keep the costs low for all of them.	0	-3	-2	1

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No.	Statement	Factor values			
		A	B	C	D
Effects of ending the abstraction (17-30, and 35-36)					
17	On the long term abstracting deep groundwater will lead to significant salinization of the shallow and the deep groundwater.	0	-1	2	0
18	Ending the abstraction will result in a recovery of natural dynamics and a larger biodiversity.	1	0	0	-1
19	When the abstraction is ended, the ground level in and around Delft will rise again.	-3	-3	0	0
20	When the abstraction is ended, downward groundwater flow will decrease or turn into upward groundwater flow in an area of 50 km^2 around the abstraction.	3	1	1	0
21	When the abstraction is ended, the stability of a number of levees will be endangered so much that measures for strengthening the levees are required.	-1	1	-2	-1
22	When the abstraction is ended, old buildings and monuments will be damaged significantly due to swelling and settling of the ground.	-3	1	1	-1
23	When the abstraction is ended, this will result in nuisance due to wet cellars and rising damp.	2	2	1	0
24	The probability of drifting or bursting of deep underground constructions increases due to an increase in the groundwater head.	0	2	0	0
25	The cumulative effects of more rain, sea level rise and ending multiple groundwater abstractions need to be accounted for.	2	0	0	0
26	When the abstraction is ended, salinization and eutrophication will significantly threaten the quality of swimming water and nature in and around Delft.	-1	0	0	-3
27	When the abstraction is ended, salinization and wetter farmland will result in significant damage for agriculture and horticulture.	0	0	1	-2
28	When the abstraction is ended, a number of drinking water wells will become too salty.	-2	0	0	-1
29	When the abstraction is ended, many of the current soil sanitation programs and installations for seasonal thermal storage need to be adjusted.	0	-1	-3	0
30	When the abstraction is ended, the accessibility of nature and agricultural areas will deteriorate.	1	-1	0	0
35	The current abstraction influences an area covering Leiden, Gouda and Rotterdam.	-1	-1	2	-2
36	The abstraction can be reduced by 50% without causing any problems.	0	-2	-1	1
Goals (31-34)					
31	It is important that solutions contribute to the sustainability of the natural system.	3	1	1	0
32	It is important that solutions are realized at the lowest possible societal costs.	0	3	0	1
33	It is important to distribute the costs among all stakeholders in a fair way.	2	-1	-1	2
34	Maintaining good relations between the involved stakeholders is of major importance.	1	-2	0	2

[†] The scores range from "-3" (strongly disagree with statement) to "3" (strongly agree with statement).

Glossary [77]

Adaptive management
Adaptive management emphasizes the limitations of our knowledge and sees policies as hypotheses that have to be tested, e.g., through modelling or policy implementation, and continuously revised.

Autonomous development
Possible future development that cannot be directly influenced by management strategies.

Boezem
Main drainage canal of a polder.

Cognitive learning
The process of change of individual perspectives, as well as the resulting changes in individual perspectives.

Collaboration
Interactive process in which two or more persons work together to achieve common goals.

Collaborative research
Process in which researchers, policymakers and/or societal stakeholders interact and jointly contribute to research and/or policymaking activities.

Conceptual knowledge use
Knowledge use in which knowledge has an indirect and abstract impact (on policymaking).

Concourse (in Q methodology)
Collection of all possible statements about the issue at stake.

Consensus
Correlation between the perspectives of multiple stakeholders.

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[77] This glossary describes the meaning of the central concepts in this thesis, as we used them in this thesis. Furthermore, it explains the abbreviations we used.

Expert knowledge
Knowledge that 1) has a specialized and abstract character, 2) is produced using formal, scientific methods that can be characterized by the aim for inter-subjective reproducibility and 3) has a high social status.

Explicit knowledge
Knowledge that is external to the human brain, e.g., reports, models, spoken word.

Externalization of knowledge
Process in which perspectives are made explicit, e.g., through speech or writing.

Factor (in Q methodology), Shared perspective
The weighted average perspective of a group of stakeholders with similar perspectives (or: unobserved scoring pattern obtained through factor analysis).

Factor analysis (in Q methodology)
Statistical data reduction technique used to explain as much of the variability among the observed Q sorts as possible in terms of a few unobserved scoring patterns (or factors).

Factor loading (in Q methodology)
Correlation between an individual Q sort and a factor.

Frames
Selective and interpretative processing rules (cf. 'filter' or 'lens') that individuals use to externalize their perspective and to internalize explicit knowledge.

ICPR (or IKSR in German)
International Commission for the Protection of the Rhine.

Institutions, Institutional setting, Regime
Principles, norms, rules and decision-making procedures around which actors' expectations in a given area converge, including actor networks, law, policy, information management and financing systems.

Instrumental knowledge use
Knowledge use in which knowledge has a direct and concrete impact (on policymaking).

Intermediary
Stakeholder who is able to enhance collaboration between policymakers, researchers and/or societal stakeholders, by forming a bridge between the different communities.

Internalization of knowledge
Process in which explicit knowledge is selected, interpreted and embedded in the perspective of an individual.

IWRM
Integrated Water Resources Management.

Knowledge
Selective and interpretative representation of an objective, external reality.

Lay knowledge
Concrete knowledge that is obtained through unstructured observations and experiences and often has a low social status (in contrast to expert knowledge).

Learning
Process in which individuals relate to the social and physical environment, e.g., through interacting, and adapt to it, e.g., by changing their perspectives.

NGO
Non-governmental organization.

P set (in Q methodology)
Structured sample of relevant stakeholders who may be expected to have clear and distinct viewpoints.

Perspective
More or less consistent and enduring cognitive representation of a specific issue and the position of the individual related to this issue, as seen by this individual.

Polder
Artificially drained low-lying land.

Policymaker
Government official with a responsibility for, task in or influence on water management.

Q methodology
Knowledge elicitation method that can be used to systematically elicit individual perspectives and to group them into shared perspectives using factor analysis.

Q set (in Q methodology)
Selection of the most relevant statements from the concourse.

Q sort (in Q methodology)
A set of interrelated scores for all statements in a Q set, resulting from individual Q sorting (or: quantitative representation of an individual perspective).

Q sorting (in Q methodology)
Assigning the statements in a Q set to a number of score categories, according to some rule or question, e.g., the level of agreement with each statement.

Regime, Institutions, Institutional setting
Principles, norms, rules and decision-making procedures around which actors'
expectations in a given area converge, including actor networks, law, policy,
information management and financing systems.

Researcher
Stakeholders that work at universities or research institutes and perform
research.

Scenario
Plausible and consistent picture of how the future might unfold.

Shared perspective, Factor
The weighted average perspective of a group of stakeholders with similar
perspectives (or: unobserved scoring pattern obtained through factor analysis).

Societal stakeholder
Citizen, NGO or business with an interest in a specific policy issue.

Stakeholder
Any person, group or organisation with an interest in a specific policy issue,
either because he/she is affected by the problem or possible solutions or because
he/she can influence possible solutions, e.g., by knowledge, power or financing.

Strategic knowledge use, Symbolic knowledge use
Knowledge use in which stakeholders use knowledge only to confirm the
programs or position that they wish to promote (Beyer 1997; Pelz 1978).

Technical knowledge
Knowledge concerning physical or economic processes.

Curriculum vitae

Tom Raadgever was born in Utrecht, The Netherlands, on the 9th of March 1981. In 1999 he finished his secondary education at the Christian Grammar School in Utrecht. Between 1999 and 2004 he studied Civil Engineering at Twente University. He did a master in Water Engineering and Management and a minor in Philosophy. During his studies, Tom Raadgever did an internship at Posford Haskoning in Peterborough (UK). He developed a tool for assessing the costs of constructing water management infrastructure, including the uncertainty in the costs. His master thesis was about low flows of the river Meuse in Flanders and The Netherlands. In collaboration with Royal Haskoning and Rijkswaterstaat, he assessed the damage that the river users suffer in various low flow scenarios.

From 2005 until 2009, Tom Raadgever performed a PhD research at the Water Management department of Delft University of Technology. He participated in the European NeWater project concerning "New approaches to adaptive water management under uncertainty". During his research, he worked for two months at Seecon in Osnabrück, Germany. Seecon is a consultancy specialized in facilitating participatory water management processes. Tom Raadgever also attended several courses and a summer school concerning stakeholder participation, cognitive mapping and group model building. In addition, he co-organized two symposia on behalf of the Netherlands Centre for River Studies and the Water Research Centre Delft.