ADAPTATION TO CLIMATE RELATED RISKS IN MANAGED RIVER BASINS

Diversifying land use and water management activities to adapt to climate related risks in the Netherlands and Hungary

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Thesis

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Abstract

The focal question of this thesis is: *how to adapt to climate related risks in managed river basins?* Adaptation has gained attention as an inevitable response to the challenges posed by climate change. The increasingly uncertain climatic conditions to which actors are exposed, are becoming a constraint for their well-being. From the start, I was fascinated by the potential merits of a particular adaptation strategy: diversification. In my research, I interpret diversification as the combination of different land-use and water management activities within a region. I conceptualise and assess adaptation as the process of actors developing and implementing strategies to reach adaptation objectives. Thus, the main objective of my thesis is to study diversification as a strategy of actors to adapt to climate related risk.

Borrowing from economic theory, I assess how combining land-use and water management activities influences their expected revenue and risk. I find that, to make full use of the potential of such combinations of activities to reduce climate related risks, the performance of water and land-use management activities has to be studied over the total range of climatic conditions and across different spatial scales. This is different from the current practice where water management activities are typically tailored to perform under a specific design discharge or narrow range of extreme events. Although diversification of land-use and water management can be shown to be a promising adaptation strategy to cope with climate risks, it is not yet extensively planned for and turns out to be difficult to implement. Therefore, my work also examines constraints and opportunities for implementing water and land-use diversification.

Two complementary frameworks that I find to be particularly useful in understanding these barriers and opportunities, are i) a recent conceptualisation of governance in terms of key governance principles and challenges (such as credibility, stability, inclusiveness, adaptiveness, legitimacy and allocation), and ii) transition literature that approaches major policy change from the perspective of individual actors and their strategies.

I learn that water and land-use diversification is enhanced by pilot projects that test and debate new ideas through collaboration between recognised actors from civil society, policy and science. A challenge for the newly emergent coalitions of state actors and non-state actors is to move towards legitimate, accountable *and* adaptive governance. Another challenge is keeping the momentum after a coalition has formed around a new idea, given fragmentation of objectives, dynamics and path dependency. At present only few strategies have been analysed or tested that support a diverse set of potentially better-adapted new activities rather than compensate for climate impacts on existing activities. Typical advice includes encouraging innovation through a rich variety of experiments and transition approaches that probe possible directions. Thus the currently fragmented implementation of agriculture, nature and water policies and projects could be turned into an advantage by recognising different regionally negotiated solutions as a set of experiments, from which actors can learn.

To my grandfather,
der so gerne dabei gewesen wäre.

'In time and with water, everything changes'

Leonardo da Vinci

Faust: *Ik wil verder. Ik wil meer. De mythologie kan weer vloeibaar worden. De rivierbedding van mijn gedachte verlegt zich telkens weer. Er is wel verschil tussen de beweging van het water langs de kant, en het zich verleggen van de oeverrand, maar een scherpe scheiding is er niet. De gedachte klotst tegen haar eigen bedding die uit harde stenen en los zand bestaat. Het spoelt weg en slibt weer aan. Zo kan een nieuw verhaal ontstaan.*

uit 'FAUST twee' in de bewerking van toneelgroep 't barre land

Cover image: Tisza River at the Hungarian-Ukrainian border *(Photo: Werners, 2007)*

Preface

For years I have been fascinated by one particular adaptation strategy: diversification. Yet, how do you turn fascination into science? My work began with truth to life. I went to see many river basins, read about them, spoke to people living there, and built models of land use and water management. I hope recognisable portraits of river basin management in the Netherlands and Hungary are included in my work. For me it has always been important how people such as Péter Balogh of Nagykörű and Géza Molnár of the Bodrogköz region in Hungary feel about my results and representation of their ideas.

At the same time, I had my background in physics, environmental science and a keen interest in overarching concepts such as sustainability science, transition management and, above all, complexity and resilience. And I was not alone: colleagues shared their perspectives and we had long discussions during meetings or at home over a glass of - often Hungarian - wine. Former colleagues of the Dutch consultant firm Resource Analysis, especially Jeroen Aerts, Ruud van der Helm and Daniëlle Hirsch had become friends and were an inspiration for my work. A special thanks goes to Zsuzsanna Flachner and Jan Sendzimir, who introduced me to the Tisza River in Hungary and Ukraine. Their commitment and friendship has been stimulating and addictive.

To present challenges and opportunities for adaptation to climate related risks in managed river basins I selected two study regions: the Tisza River Basin in Hungary and the Rhine River Basin in the Netherlands. The Tisza River Basin, because I deeply respect the efforts of people in the region to work together and change water management practice. The Netherlands, because it is my home country and an international example in water management. To be internationally credible, I felt it is important to stay connected to your roots. How to bring these inspirations together in a thesis that is scientific, stimulating and constructive? Truth to life, to be sure. Yet, once research gets under way, truth to science is an equal allegiance, assumptions and motivations have to be challenged and sometimes put overboard.

What did I work on? The research is introduced in Chapter 1. Chapters 2 to 4 write about the physical reality of diversification of land use and water management activities. Participants of the IIASA Summer Program and the Santa Fe Institute's summer school have been a great help by providing critical feedback and new insights for assessing potential merits of diversification. Next, Chapters 5 to 7 look at barriers and drivers that actors perceive for realising diversification. This part of my research has been inspired by the observation that the diversified water and land use systems that actors propose turn out to be very difficult to implement. I was privileged to work together with the social and political scientists Dave Huitema, Sander Meijerink, Jeroen Warner, Dik Roth, Piotr Matczak, David Tàbara and Frank Biermann. Without them this thesis would no doubt have told a different story. Chapter 8 presents concluding insights on adaptation in managed river basins for which I am very grateful for the help of the many colleagues in the European research projects ADAM (ADaptation And Mitigation strategies) and NeWater (New approaches to adaptive water management under uncertainty), and all other wonderful people I met in the river basins I visited over the years.

I thank all interviewees and participants of regional workshops in the Tisza River Basin and in the Netherlands for sharing their experience. Research partners and anonymous reviewers provided many valuable comments and suggestions. In particular, I am grateful for the friendship and cooperation with Francesc Cots, Xingang Dai, Matina Donaldson, Klaas-jan Douben, Maria Falaleeva, Zsolt Harnos, Alex Haxeltine, Paulina Hetman, Jochen Hinkel, Paul Hofhuis, Francesca Incerti, Márton Jolánkai, Mike Hulme, Pavel Kabat, Rob Koudstaal, Istvan Láng, Joanne Linnerooth-Bayer, Louis Lebel, Elena Livia Minca, Rob Misdorp, Jörn Möltgen, Gert-Jan Nabuurs, Henry Neufeldt, Claudia Pahl Wostl, Katalin Petz, Frank Rijsberman, Maja Schlüter, Serge Stalpers, Iwan Supit, Catharien Terwisscha van Scheltinga and Jennifer West. I am greatly indebted to Rik Leemans for supervising my thesis and pragmatically navigating my ideas. A lot of credit also goes to Eddy Moors and my other colleagues in Wageningen for offering a welcoming and flexible working environment. And fortunately there are my friends and family, whose happiness goes above all. My parents who have always been proud and supportive and my grandfather who loved to see me become a doctor. Anna & Ruud, Allard & Aukje, Arnoud, Axel & Maartje, Bertine & Sytze, Cecily & Chris, Frank & Brigit, Hans, Joyce & Erwin, Jürgen & Olga, Laurence, Maria & Vincent, Naomi, Nout & Haydee, Menno & Mascha, Norbert & Marieke, Peter, Sylvia, Tirtsah, Zita & Bernd thank you for your company, patience and bringing music into my life.

My research allowed me to learn about diversification, risk and water management. The merits of diversification still fascinate me. At the same time, I have come to see that many challenges lie ahead to capitalise on these merits in managed river basins. 2009 was the year of climate and Copenhagen, 2010 will be the year of biodiversity. Together with you, I hope we can forward the science of sustainability and adaptiveness, along with the diversity of managed river basins and -more in general- the diversity of the amazing world we live in. May this thesis be a start.

Work on this thesis was kindly supported by a grant from the Dutch Science Foundation NWO, from the European Commission through the European research projects ADAM (ADaptation And Mitigation strategies supporting European climate policy, Contract No 018476-GOCE, www.adamproject.eu) and NeWater (New approaches to adaptive water management under uncertainty, Contract No 511179-GOCE, www.newater.info) and from the strategic research programs "Sustainable spatial development of ecosystems, landscapes, seas and regions" and "Climate Change" of Wageningen University and Research Centre funded by the Dutch Ministry of Agriculture, Nature Conservation and Food Quality. I thank Edward Elgar Publishing for giving permission for the use of material from Huitema and Meijerink (eds), *Water Policy Entrepreneurs: A Research Companion to Water Transitions around the Globe*, Cheltenham, UK: Edward Elgar Publishing, 2009.

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Chapter 1

General Introduction

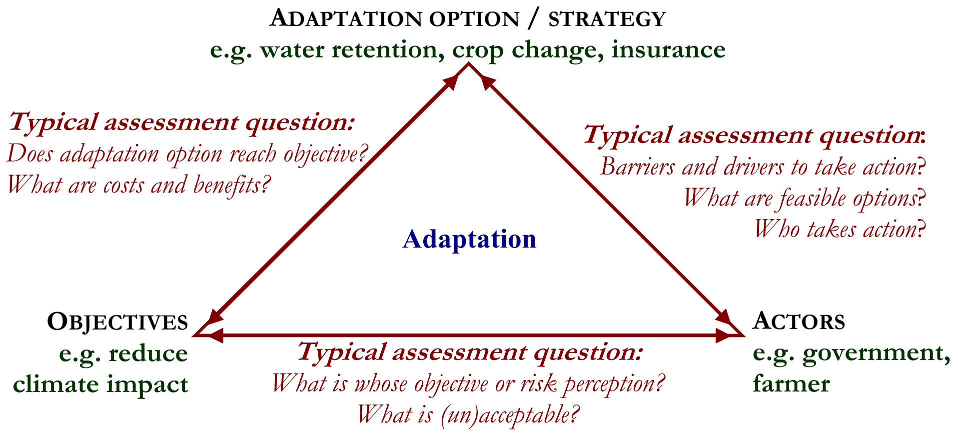
Since the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001) demonstrated that adaptation to climate change is both important and complex, there has been growing attention to appraising adaptation strategies and explaining the processes by which adaptation can occur (e.g. Adger *et al.*, 2005b; Adger *et al.*, 2007). Whereas the scientific literature on adaptation is rich in detail on impacts, vulnerability and constraints to adaptation (e.g. Smit and Pilifosova, 2001; Adger *et al.*, 2007; Adger *et al.*, 2009), little is known about the conditions that facilitate adaptation in practice. The latter are, however, of paramount importance for realising adaptation to climate related risk in the long term (Werners *et al.*, 2010b).

Adaptation to climate change takes place through adjustments in human and natural systems in response to observed or expected climate change, including extreme weather events and climate variability. Adaptation involves changes in perceptions of climate risk, in social practices and in environmental functions to reduce potential damages or to take advantage of new opportunities. Further, it includes anticipatory and reactive actions, as well as private and public initiatives. In practice, adaptation is an on-going process, reflecting many stresses and cross-sectoral concerns, and including discrete actions to address climate change specifically. Human adaptation occurs mainly at sub-national and local levels but involves many other levels of decision making from municipalities to international organisations (Isoard and Swart, 2008). Adaptation is thus a cross-sectoral, multi-scale and often transboundary undertaking that requires comprehensive and integrated responses (Adger *et al.*, 2007).

Societies have always had to respond to climate variability and extreme weather events. Many have developed ways of coping with floods, fires and droughts. Recent experience of weather extremes has given these efforts a new impetus within individual countries and at the European level. Whilst projected climate change is a new driver for action, government actors will in many cases instigate adaptation by regulatory modification of the existing policy frameworks for floods, droughts and the management of water quality. Step-wise advances in action, coordination and engagement of actors at the local and regional level will be needed to handle the expected level of accumulated incremental change over time, and to address the increased possibility of new extreme events (Footitt and McKenzie Hedger, 2007).

Adaptation can be conceptualised and assessed as the process of *actors* developing and implementing adaptation *strategies* to reach adaptation *objectives* (Werners *et al.*, 2010a). Figure 1.1 illustrates the interrelationship of these three main elements of adaptation: actors, objectives and strategies. Adaptation assessments often focus on the interrelationship of two of these elements. Figure 1.1 offers typical assessment questions addressed in adaptation assessments. At present most adaptation assessments concentrate on the potential of adaptation strategies to reduce climate impacts (e.g. Loe *et al.*, 2001; Parry, 2002; Kahn, 2003; Callaway, 2004; Rosenzweig *et al.*, 2004; Dessai and Hulme, 2007; Yang *et al.*, 2007). These assessments aim to determine the relative merit or utility of alternative adaptation options. These possible adaptations are usually considered to be distinct and discrete, in order that they can be subjected to evaluation according to some common principles or criteria (e.g. Adger *et al.*, 2005a; de Bruin *et al.*, 2009). Such analyses assume that there is, in practice, a process through which adaptations are selected and implemented, and that the relative evaluation analysis fits into this process (Smit and Wandel, 2006).

Other studies investigate the (learning) processes through which actors undertake adaptation, either in light of climatic change specifically or as part of policy and decision-making processes to which adaptations to climate change might relate (Berkhout *et al.*, 2006; McEvoy *et al.*, 2008). A third group of studies, mostly from the social sciences and the disaster preparedness community, assesses adaptation in the light of risks that are already problematic and aims to identify how acting on climate is considered together with other environmental and social objectives that actors may perceive (e.g. Demeritt and Langdon, 2004; Grothmann and Patt, 2005; van Aalst *et al.*, 2008; Patt and Schröter, 2008; Adger *et al.*, 2009). Only recently have authors started to bring these elements of adaptation together. For example, by integrating or mainstreaming adaptation strategies into other resource management, disaster preparedness and sustainable development programs (e.g. Arvai *et al.*, 2006; Smit and Wandel, 2006; Pahl-Wostl *et al.*, 2009; Werners *et al.*, 2010b).



Source: modified from Grothmann et al. (2009)

Figure 1.1: Elements of adaptation

The complexity of actors, objectives and adaptation strategies is particularly strong in the sustainable management of land and water resources that determine the resilience of the Earth's life-support system (Kates *et al.*, 2001; Clark *et al.*, 2005; Folke *et al.*, 2005; Young *et al.*, 2006). Land and water resources are directly impacted by climate change and decisions regarding these resources affect ecosystems that regulate climate impacts and human vulnerability (Reid *et al.*, 2005). As such, water and land-use planning are expected to play an increasingly central role in adaptation (e.g. Stern, 2007). Although changing land-use planning is a promising adaptation strategy to cope with climate change impacts, this strategy is not practised extensively (Footitt and McKenzie Hedger, 2007). The multitude of land uses and stakeholders means that water and land-use planning are complex sectors in the climate change arena that deserve special attention. So far, climate change analyses and climate policy formulations have not adequately addressed the integration of water resource issues and climate change response options, including associated synergies and trade-offs between different policy domains and scales of action (Bates *et al.*, 2008).

A particular challenge is the combination of water and land-use adaptation options into robust adaptation strategies. Agricultural and ecological research has provided arguments that diverse systems are more robust and better able to cope with risks. For instance, agricultural research has illustrated the importance of crop diversity to improve the stability of agricultural yields (Vandermeer, 1989; Altieri, 1994). Tonhasca and Byrne (1994) investigated the effect of crop diversification on mitigating pests, whereas others have assessed the influence of the diversity of farming systems and landscape structures in agriculture on vulnerability of yields and biodiversity (e.g. Sendzimir and Flachner, 2007; Reidsma and Ewert, 2008). Stirling (2007) offers an excellent overview of the application and analysis of diversity in science, technology and society. His paper offers a framework for systematic exploration of diversity, including trade-offs between diversity and other aspects of interest, notably portfolio interactions. The benefits of portfolio building and diversification are widely recognised by financial economists for planning and investing under uncertainty. Investors rarely hold a single financial asset; instead they hold portfolios of financial assets. This way, investors diversify risks and become less sensitive to losses on individual assets. Modern Portfolio Theory (Markowitz, 1952) has been developed to comprehensively evaluate whether different investments can be combined in a portfolio with a lower risk than the risk of the individual investments.

Although diversification is commonly studied in agricultural and economic research to meet growth and market fluctuations (Isik and Devadoss, 2006), few attempts are made to quantify the benefits of diversification in the context of climate variability and climate change (Chapter 2). In water management in particular the relationship between diversity and the ability to cope with extreme events and unexpected stresses has been a neglected research area. For a long time, water management has focussed on selecting the most cost effective measure to cope with a specific quantified stress. The underlying structure of how diverse water and land-use systems interact with the full range of climatic conditions has rarely been addressed. The relationship between diversification of water and land use and adapting to climate risks is still largely unexplored (Chapter 2). This has been the main inspiration for my thesis.

The focal question of this thesis is how to adapt to climate related risks in managed river basins. From the start, I was fascinated by the potential merits of a particular adaptation strategy: diversification of land use and water management activities. Here, I interpret diversification as the combination of different land-use activities and water management options within a region. In line with the framing of adaptation in Figure 1.1, my thesis aims to study diversification as an adaptation strategy in relation to adaptation objectives and actors.

The focal question for my thesis is:

How to adapt to climate related risks in managed river basins?

Within the context of the focal question, the research questions for my thesis are:

1. *Can diversification of land use and water management activities reduce climate related risks in managed river basins? (Chapter 2 - 4)*
2. *Can Modern Portfolio Theory be used to assess the reduction of climate related risks by diversification of land use and water management activities at different scales in managed river basins? (Chapter 2 - 4)*
3. *What governance systems enable diversification of land use and water management activities? (Chapter 5)*
4. *What is the role of individuals in diversifying land use and water management activities? (Chapter 6 - 7)*

Figure 1.2 illustrates the main research questions of this thesis and how they relate to adapting to climate related risks in managed river basin. It shows how this thesis studies diversification as an adaptation strategy in relation to adaptation objectives and adaptation actors. Although this thesis touches upon risk perception and risk allocation among actors, it does not aim to study the relationship between adaptation actors and objectives in full detail. Other work that I was fortunate to participate in reports more comprehensively on this relationship (e.g. Tàbara *et al.*, 2009; Matczak *et al.*, 2010; Veraart *et al.*, 2010; Werners *et al.*, 2010b).

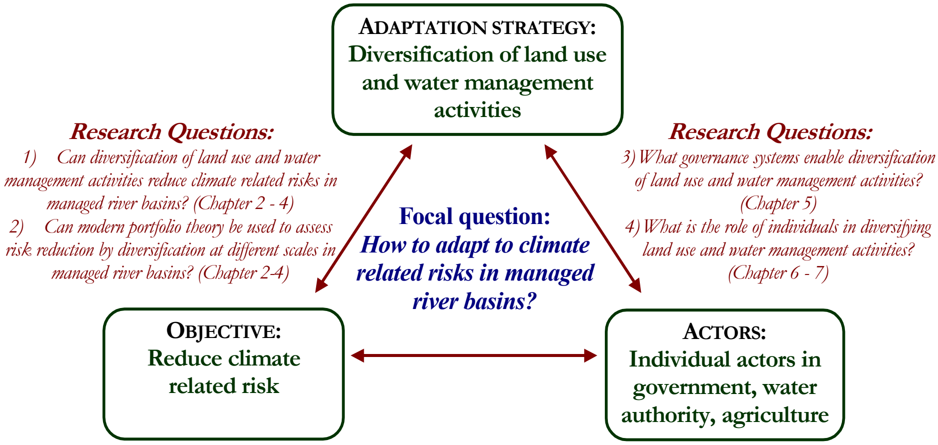


Figure 1.2: Main elements of this thesis

To examine the challenges and opportunities for adaptation to climate related risks in management river basins I selected two study regions: the Tisza River Basin in Hungary and the Rhine River Basin in the Netherlands. These study regions have in common that, in response to flood events and climate change projections, water policy was reoriented towards strategies that combine creating space for rivers, water retention and emergency storage reservoirs (Chapter 2 - 6). The cases differ in institutional context and governance traditions upon which river basin management has developed (Chapter 7). In the different chapters of this thesis I discuss adaptation in the study regions from a quantitative, empirical and analytical perspective, presenting model results, measured data and results from stakeholder interviews and workshops.

This thesis is organised as follows. Chapter 2 frames diversification and Portfolio Theory in the context of adaptation to climate related risks and the quest for robust water management strategies. The chapter provides the main argumentation underlying the study. Chapters 3 and 4 explore the use of Portfolio Theory to assess potential merits of diversification at different spatial scales in the case studies of Hungary and the Netherlands. Approaching adaptation in managed river basins from the concept of diversification, Chapters 2 - 4 seek to examine the conditions under which diversification can reduce risks and those under which it would increase risks. Thus diversification is not seen as a magic bullet that necessarily reduces risk. Rather, it is studied as an attribute of managed river basins with consequences for the way the river system performs.

Next, Chapters 5 - 7 look at barriers and drivers perceived by actors for realising diversification. These chapters aim to add to our understanding of the conditions that limit or facilitate adaptation in practice and its integration into ongoing sectoral planning to reduce climate risks. For this part of my research, I was privileged to work together with social and political scientists. This allowed me to discuss a suite of governance concepts, including new institutional economics (Matczak *et al.*, 2008), social learning (McEvoy *et al.*, 2007; Tàbara *et al.*, 2009), adaptive water management (Pahl-Wostl *et al.*, 2005), adaptation mainstreaming (Werners *et al.*, 2010b) and transboundary cooperation (Cots *et al.*, 2009). Two complementary frameworks that I found to be particularly useful in understanding the barriers and drivers for implementing diversification, were a recent conceptualisation of governance in terms of key governance principles and challenges (such as credibility, stability, inclusiveness, adaptiveness, legitimacy and allocation (Biermann, 2007)), and transition literature that approaches major policy change from the perspective of individual actors and their strategies (Huitema and Meijerink, 2009). Thus, Chapter 5 reports on barriers and bridges for implementing water and land-use diversification from the perspective of earth system governance. Chapters 6 and 7 analyse the case studies from the perspective of individual actors. Chapter 7 also compares the Dutch and Hungarian case. Chapter 8 presents conclusions and recommendations.

My research shows that combining water and land-use management activities offers opportunities to reduce climate related risks that would be missed if these activities were studied in isolation. Activities can be combined into a portfolio that has a lower risk than the risk of the individual activities. To make full use of the potential of such combinations of activities to reduce climate related risks, the performance of water and land-use management activities has to be studied over the total range of climatic conditions and across different spatial scales. Borrowing from economic theory, Modern Portfolio Theory offers a promising method that helps to combine activities into a robust risk reduction strategy and encourages the systematic evaluation of the performance of activities. Earth system governance offers a comprehensive framework to assess drivers, barriers and opportunities for adapting river basin management. The analysis of the strategies of supports and opponents of policy change uncovers collectives of individuals and the complementary roles they play in furthering or blocking the adaptation of river basin management. Crucial for adapting water management are recognition of an adaptation strategy at an abstract level by responsible civil servants, and their engagement with a credible regional coalition that can contextualise and advocate the strategy regionally. Opponents and supporters of policy change use similar tactics. Opposition is inherent to policy change and managing conflict, information and expectations is an important activity for those aiming to manage climate risks in river basins.

My analysis illustrates that adaptation to climate risks in managed river basins can be meaningfully analysed in its relation to adaptation options, objectives and actors. At present, most adaptation assessments concentrate on climate impacts and the potential of adaptation strategies. The conditions that enable people to act on adaptation are studied less frequently. Yet these have been identified as particularly important for successful planning and implementation of adaptation. My research conveys that consideration of actors and the activities they call for, reveals opportunities for realisation of adaptation objectives. Furthermore, my analysis suggests that, next to advancing adaptation through isolated sectoral adaptation options, there is a need for a comprehensive and systemically compiled adaptation portfolio, reaching across non-climate policies and actor groups where risk sharing and complementarity are guiding principles.

Chapter 2

Diversification and adaptation portfolios in water management

Abstract

This chapter explores how Modern Portfolio Theory can be applied to reduce climate related risks in managed river basins. Integrated water management is widely recognised for its river basin approach and for promoting multi-stakeholder involvement. It lacks, however, systematic ways of handling uncertainty about the future, stemming from, for example, climate change. Portfolio Theory addresses risks associated with the probabilistic part of uncertainty by systematically assessing investment options and generating diverse sets of investment portfolios. In Portfolio Theory, diversification is used to handle trade-offs between reducing risk and increasing the expected return of investments. Portfolio Theory can be applied when four preconditions are met: (1) there is more than one possible investment at any given time, (2) investments are subject to risk, (3) there is information about the historical and / or expected return of investments and (4) external conditions do not affect all investments equally. The chapter discusses how these preconditions apply in managed river basins and what opportunities Portfolio Theory offers for finding robust water management strategies. The chapter also explains how Portfolio Theory encourages systematically discussing the relationship between the risk and return of individual water management options and the risk and return of complete portfolios. In particular Portfolio Theory calls for risks to be evaluated in relation to the full range of options that actors have at their disposal and the full range of external conditions these options may be exposed to, now and in the future. This has so far been neglected in Dutch water management.

Keywords: Water management, risk assessment, modern portfolio theory

Chapter based on:

Werners, S.E. and J. Aerts (under review) Adaptation portfolios in water management. Climatic Change.

2.1 Introduction

Adaptation is increasingly seen as an inevitable answer to the challenges posed by climate change (Smit *et al.*, 2000; IPCC, 2001; IPCC, 2007). Since water resources will be impacted in particular, questions are posed as to whether current water management practices and regimes are able to cope with climate change and increased climate variability (Aerts and Droogers, 2004; Bates *et al.*, 2008). Furthermore, projected trends in climate change and variability are highly uncertain; hence a challenge for water managers is to develop adaptation strategies that are robust in terms of their performance under a range of possible future conditions (e.g. Gleick, 2003; Dessai *et al.*, 2009).

Much of the current water management practices are rooted within the concept of integrated water management (GWP, 2000). The introduction of integrated water management in the 1980s has been a step forward as it facilitates an integrated approach addressing both multi-stakeholder issues in water resources management, and sustainable development (e.g. Biswas, 2004). Problems arise when using integrated water management approaches for long-term planning such as planning for adaptation under climate change (Brown *et al.*, 2005). In this context the goal based approach of integrated water management that aims, for example, at achieving a positive cost/benefit ratio of water management investments, may break down because it needs reliable probabilistic information about the future (e.g. New and Hulme, 2000). The latter is often not available.

Uncertainty in climate and water management arises, amongst other ways, from the variation across climate scenarios produced by a number of different climate models (Mearns *et al.*, 1998). It also has its origin in the unpredictability of future societies, institutional settings and water management practices (Dessai *et al.*, 2007). Thus, acknowledging that the future is inherently uncertain, it is difficult to assess which water management activities will be most effective for handling future conditions (Pahl-Wostl *et al.*, 2007b).

Approaches for dealing with uncertainties in water management have been introduced during the last decades. Two types of uncertainty can be distinguished. Firstly, there are the quantifiable uncertainties with knowable probability. Secondly, there are the non-probabilistic uncertainties associated with, amongst others, knowledge uncertainties (both socio-economic and hydrological), model uncertainties and unexpected events. Risk management approaches specifically address the probabilistic part of uncertainty. These approaches are common in spatial planning and have gained attention in water management and climate research (Burby *et al.*, 1999; Downing *et al.*, 1999; Jones, 2001). In climate and vulnerability sciences, scholars have argued that determining future vulnerability holds too many uncertainties and that research on vulnerability should focus on reducing current vulnerability (O'Brien *et al.*, 2004b). Adaptive (water) management approaches have been developed in recognition of the inherent uncertainty involved in complex decision making. In contrast to conventional water management that typically optimises decision making for one or a limited set of future conditions, adaptive management aims to find robust management strategies that perform well under an envelope of future conditions or that can be modified once more information becomes available. Adaptive management also addresses uncertainty through institutional flexibility and puts stakeholder interests central to an iterative social learning process (Folke *et al.*, 2002; Pahl-Wostl *et al.*, 2007c).

In research domains other than water management, literature has provided arguments that diverse systems are better able to cope with risk. For example in agriculture, Tonhasca and Byrne (1994) investigated the effect of crop diversification on mitigating pests, whereas others have assessed the influence of the diversity of landscape structures on sustainability of yields and biodiversity (e.g. Thies and Tscharntke, 1999). Furthermore, crop diversity has been used as an indicator of both ecosystem resilience and a strategy for food security (Unruh, 1994; Blocka and Webb, 2001). Stirling (2007) offers a framework for systematic exploration of diversity in science, technology and society, including trade-offs between diversity and other aspects of interest, notably portfolio interactions. The benefits of portfolio building and diversification are well recognised by financial economists for planning and investing under uncertainty. In economic research, Frenken *et al.* (2007) show that unrelated variety in regional knowledge across economic sectors dampens unemployment growth. Costanza *et al.* (2000) make reference to the portfolio concept for environmental assets.

The question remains of how to develop a robust set of water management measures that handles a variety of possible futures at an acceptable (i.e. 'affordable') initial investment. Research on financial economics has a track record in dealing with this question and for decades investors have planned long-term investment strategies under uncertainty (e.g. Carruth *et al.*, 2000). An approach that is frequently used to facilitate the development of investment strategies under uncertainty is Modern Portfolio Theory (Markowitz, 1952). This theory aims at finding sets - or portfolios - of investments with an overall portfolio risk that is lower than the risk of the individual investments (risk is here defined as standard deviation or variance). As such, Modern Portfolio Theory does not aim to identify the 'best solution' but to inform portfolio managers with the best available knowledge on the revenue of activities together with the associated risk. Portfolio managers will combine this knowledge with information from other sources (e.g. on company or market development) to decide on the portfolio composition and trade-offs between portfolio risk and return.

This chapter frames how Modern Portfolio Theory can contribute to the concept of integrated water management by serving as an inspiration for developing water management strategies under uncertainty. The objectives of this chapter are to:

- Explain the concept of diversification to reduce risk as formulated in Modern Portfolio Theory
- Compare the current practice of risk assessment in water management to Modern Portfolio Theory
- Discuss the preconditions for applying Modern Portfolio Theory in water management
- Discuss the pros and cons of Modern Portfolio Theory in water management

The chapter has three main parts. First, Modern Portfolio Theory is introduced. Next, current risk assessment practices are compared to the application of Portfolio Theory in water management. Finally, conclusions are presented with respect to the use of Modern Portfolio Theory in integrated water management. The chapter shows how Portfolio Theory encourages exploring trade-offs between the risk and return of individual water management options and of complete portfolios. In particular, Portfolio Theory calls for risks to be evaluated in relation to different options that actors have at their disposal under the full range of external conditions to which these options may be exposed.

2.2 Modern Portfolio Theory

The Modern Portfolio Theory (MPT) originates from Markowitz (1952). While investors knew intuitively that it was smart to diversify (i.e. don't "put all your eggs in one basket"), Markowitz (1952) was among the first to quantify risk related to investments and demonstrate quantitatively why and how portfolio diversification works to reduce risk for investors. Investments are described statistically, in terms of their expected long-term *return* rate and their expected *risk* or *volatility*. Risk is expressed with statistical parameters such as the standard deviation. Diversification is the main strategy in MPT for reducing investment risk (Elton and Gruber, 1995). Holding assets that tend to move in concert with each other does not lower risk. According to Markowitz (1952), diversification of assets reduces risk only when assets are combined whose prices move inversely, or at different times, in relation to each other. Hence, diversification allows investors to reduce market risks by investing in a portfolio that consists of assets that are imperfectly correlated. The risk reduction is "free" for a given portfolio because the expected return of the portfolio is not affected, whereas the risk of the portfolio is lower than the weighted sum of the risk of the individual assets.

Markowitz (1952) showed that the expected return of a portfolio that is invested in multiple assets (e.g. stocks and bonds) is the weighted average of the individual assets' returns. At the same time, if the returns of the assets are uncorrelated, the portfolio risk will be less than the weighted average of the individual asset risks. As there are many combinations of both portfolio risk and return, the goal for an investor is to identify an acceptable level of risk, and then to find the portfolio with the maximum return for that level of risk. The main MPT terminology is summarised in Table 2.1.

Table 2.1: Terminology of the Modern Portfolio Theory

Terminology	Definition
Asset	Items within a portfolio, also referred to as: investment, security, instrument
Correlation	A measure of the degree to which the change in revenue of two assets is similar
Diversification	Investing in different assets that together make up a portfolio
Efficient frontier	Portfolios on the efficient frontier are preferred in offering maximal expected return for a chosen level of risk or minimal risk for a given return
Portfolio	Set of assets held by a person or an organisation
Return	Combined income and capital gain (or loss) from an investment / asset. This is usually expressed as a percentage, which may be annualised over a number of years or representing a single period
Risk	The uncertain outcome of an investment. Risk can be divided into specific and non-specific risks. Specific risk can be addressed through the combination of anti-correlated assets and diversification; non-specific risk affects the entire market. Risk is often expressed as *standard deviation* or portfolio *variance*
Volatility	See: Risk

Portfolio diversification for a two asset case is illustrated in Figure 2.1, which shows different sets of portfolios composed of two assets A and B for different correlations ρ between these two assets (ρ ∊ [1, -1]). A positive correlation between two assets A and B indicates that when the return of asset A turns out to be above (below) its expected value, then the return of asset B is likely also to be above (below) its expected value. A negative correlation suggests that when asset A's return is above its expected value, then asset B's will be below its expected value, and vice versa. An investor can develop different portfolios by varying the proportion of assets A and B in the portfolio. The curved lines in Figure 2.1 represent all possible two-asset portfolios that an investor can choose between, given the correlation between asset A and B. Points on these curves correspond to portfolios consisting of different fractions of the two assets, ranging from a portfolio with only asset A to one with only asset B. In the example in Figure 2.1, asset A has a smaller risk and expected return than asset B. Thus, more risk averse investors or people who cannot take the risk of a low return may prefer asset A over B at the cost of expecting a lower average revenue.

The straight line between the two assets represents possible risk and return characteristics of a portfolio composed of two assets (A and B) with a correlation of unity (ρ = 1). The diversification effect applies to the curved lines, where the correlation is smaller than unity. This backward bending always occurs if ρ≤0, but may or may not occur if ρ>0, depending on the relative size of the individual assets' risk. The lower the correlation between the two assets, the more bent is the curve indicating that higher returns can be earned at the same portfolio risk. Alternatively, the lower the correlation the lower the standard deviation of a portfolio is for a specific expected return. The point MinV (minimum variance) on each of these curves represents the minimum variance portfolio. The share of the assets in the minimum variance portfolio is determined by the standard deviation and correlation of the assets. To hold a portfolio with expected revenue below that of the minimum variance portfolio is considered inefficient for an investor. The part of the curve between MinV and -in this example- B represents all efficient portfolios for a given correlation. It is therefore called the efficient frontier.

When risk and return for individual assets are known as well as the correlation coefficients between these assets, the Markovitz (1952) algorithm allows for quantitatively determining portfolio return and variance and hence design efficient frontiers such as plotted in Figure 2.1 (see also Chapter 3 and 4 for quantitative examples).

In general, MPT demonstrates that diversification is useful when the following preconditions are met (Elton and Gruber, 1995; Fraser *et al.*, 2005):

1. There is more than one possible investment at any given time.
2. The investments are subject to risk.
3. There is information about the historical and / or expected return of the investments.
4. The same (economic) conditions do not affect all investments equally.

These preconditions will be explored in the next section in the context of water management.

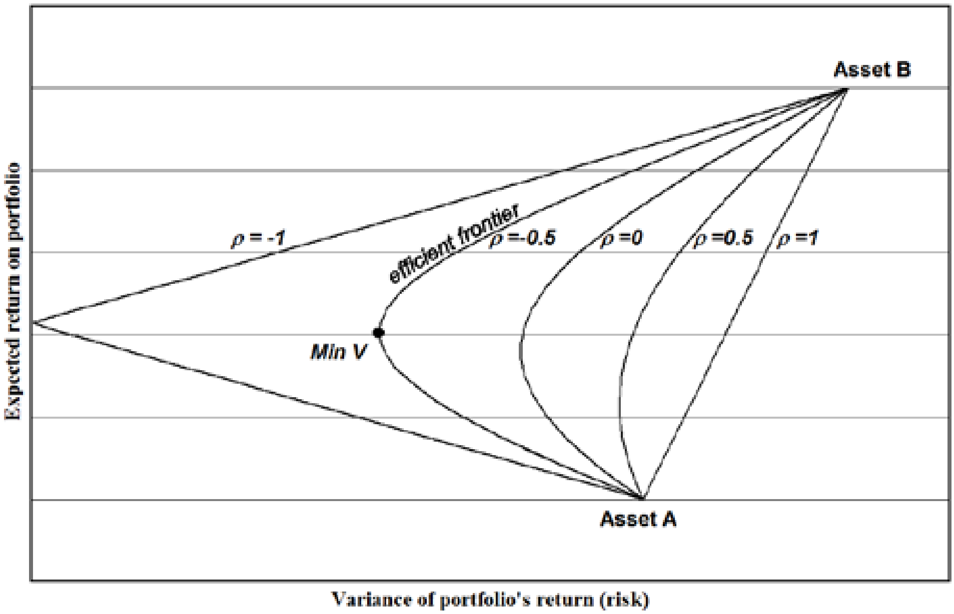


Figure 2.1: Revenue and risk of two asset portfolios for different asset correlations ρ

2.3 Comparing current risk assessment practices and the application of Portfolio Theory in water management

2.3.1 Current risk assessment practices in water management

Integrated water management practices have largely been planned and implemented by experts using technical approaches developed for designing systems that can be predicted and controlled (Pahl-Wostl *et al.*, 2009). This is not surprising, as technical innovations and control in water management have brought development and prosperity to many parts of the world (GWP, 2000). New long-term developments however, such as climate change, provide new challenges to water management and research, and call for more adaptive and flexible approaches. Climate scenarios have improved drastically over the last five years, yet will continue to contain many uncertainties especially when they are used at operational water management levels: both regional and local scales (Varis *et al.*, 2004). Furthermore, potential feedbacks from long-term trends such as climate change and socio-economic conditions are difficult to project and hence difficult to prepare for with narrow defined objectives as often used in cost benefit analyses.

In water management the relationship between diversity and the ability to cope with extreme events and unexpected stresses has been a neglected research area. For a long time water management has focussed on selecting the most cost effective measure to cope with a specific quantified stress. In the Netherlands, for example, water management is tailored to perform under a specific design discharge of 16,000 m^3/s at Lobith where the River Rhine enters the Netherlands. Flood (e.g. Ten Brinke and Bannink, 2004; Hoes, 2007) and drought (e.g. Projectgroep Droogtestudie Nederland *et al.*, 2005) strategies are elaborated independently, each with their own water management interventions and scenarios. Modelling studies focus predominantly on assessing conditions at the design discharge (e.g. Parmet *et al.*, 2001; Silva, 2002; Schielen and Gijsbers, 2003; van Schijndel, 2005; te Linde *et al.*, 2008) and models are often unsuitable for operating outside a narrow range of extreme conditions for which they were built and calibrated. The underlying structure of how diverse water and land-use systems interact with the full range of climatic conditions has rarely been addressed. Thus, the relationship between diversification of water and land use, and adaptation to climate risks is still largely unexplored.

2.3.2 Preconditions for applying MPT to water management

In view of climate risks, long-term planning in water management may seek an analogy in financial services. In financial services, portfolio managers are not primarily concerned about the valuation of individual assets but are mainly interested in which securities can be combined in a portfolio investment to minimise risk and in what quantity. Similarly, the task of a water manager could be to construct a portfolio of water management activities that generates the highest return under an acceptable risk (quantifiable uncertainty). This section discusses how MPT may support water managers by demonstrating how the four preconditions (Section 2.2) for using MPT apply to decision making in water management.

There is more than one investment

The first precondition refers to a situation where there is more than one possible investment at any given time at the disposal of a portfolio manager. This precondition is true for most water management issues as water managers can choose between many options, measures and policies to address water management problems (obviously dependent on their resources). Think of a semi arid area that is largely dependent on water for its main economic activity: agriculture. To make crop production more reliable, a water manager can choose to promote or invest in various new drought mitigation measures, such as increasing storage capacity of surface water, increasing groundwater capacity, introducing water pricing policies and changing cropping schemes with techniques or crops that use less water. The boundary conditions for choosing (combinations of) these investments depend, amongst others, on available budget, acceptance by the public and geographical conditions.

Investments are subject to risk

This precondition refers to the situation that the effects of the proposed water management measures are subject to uncertainty and risk. This is inherently true for all water management investments. For example, in the previously mentioned drought example the drought damage reducing effect of each investment cannot be predicted with certainty. The effectiveness of each individual measure will largely depend on events related to climate change or future economic conditions.

There is information about the historical and / or expected return of the investments

The application of this precondition in water management is less straightforward. For many water management policies and measures, historical data is available on both the effects of measures and the variance (risk) of the effects. For example, there is much quantitative research on the return of different irrigation measures in terms of 'crop yield' or 'cubic metres water saved'. Furthermore, in flood protection research, there is probabilistic information available for different types of flood mitigation measures (e.g. risk zoning, pumping stations, dykes, etc) and their effectiveness in terms of reducing the number of potential casualties and economic damage. However, these numbers apply to certain geographic locations and cannot simply be transferred to other areas. Furthermore, for new measures, such information is not available, and a water manager would need to estimate expected returns and risk values.

The same (economic) conditions do not affect all investments equally

This precondition warrants that when investments are combined in a portfolio, the risk of the total portfolio will be reduced. In water management, climatic or economic conditions are likely to impact investments in different ways. For example, various land use types have a different response to climatic conditions as well as a different effect on river runoff and water management objectives. In the previous drought example, increased storage capacity may run out after two consecutive dry years. Alternatively, drought resistant crops may produce less than irrigated crops but are more reliable in consecutive dry years. Also, the investment strategy to increase subsurface water storage capacity will enhance available water but its long-term success depends on the level of maintenance and user rights. Alternatively, water pricing and water saving measures, which aim at achieving the same return (e.g. 'cubic metre water saved'), depend, in differing ways, on public acceptance and government subsidies.

2.3.3 Opportunities and limitations of applying MPT in water management

This section qualitatively deliberates on opportunities and limitations for applying MPT in water management. These opportunities and limitation are summarised in Table 2.2 and will be addressed in the case studies in Chapter 3 and 4, which offer quantitative examples of how diversification of land use and water management activities can be combined to cope with climate risk that challenges the effectiveness of current water management policies.

The discussion in Section 2.3.2 revealed some potential limitations for using MPT in water management, especially for quantitative implementation of the Markovitz algorithm. In the financial sector, historical data on the return of different assets is readily available in many cases. This allows the calculation of variance and correlation of assets. In the case studies presented in Chapters 3 and 4, information and models were available to derive quantitative insight in returns, variance and the correlation of different measures. These kinds of returns and correlations are not always obvious in integrated water management. Another limitation to using Portfolio Theory in water management is that the assets depend on location and management and evidence from one location cannot easily be transferred to similar assets elsewhere. In addition, assets are often partly related and changing the share of one asset affects the other's return. This makes the combination of assets into portfolios less straightforward. For example, in a flood protection case where developing dykes is one of the options, the portfolio manager would have to carefully specify the meaning of adding 'a certain percentage of dyke developments' within a portfolio; would increasing the percentage of dyke developments in a portfolio mean building higher or more dykes?

Table 2.2: Contributions of MPT to water management divided into aspects that offer opportunities for water management and aspects that show limitations.

Opportunity	**Limitation**
Structural methodology for assessing risk, variance and returns related to sets of water management measures	Applying MPT in multi objective cases is difficult since multiple types of returns would require complex mathematical programming approaches. This could complicate the case rather than structure the decision problem
Methodology to support current planning while addressing long-term uncertainty	Historical data on variances and return related to measures is difficult to obtain
MPT reveals the correlation between pairs of potential water management measures and strategies	It is often difficult to quantitatively compare correlations in returns and variances between different locations and temporal scales
Methodology to identify robust sets of measures	Assets are related and their combination less straightforward than in financial sector
MPT provides input to the discussion on how to conceptualise vulnerability to long-term developments such as climate change	

In MPT the return of the portfolio is typically expressed in terms of one monetary unit. In water management practice, however, a water manager has to address several objectives simultaneously. For example, by using agricultural land as an area to temporarily store water, the area becomes attractive to the combination of agriculture with wetland or recreational functions. In other words, apart from evaluating the return of the portfolio in monetary terms (e.g. 'avoided damage') other return values such as 'realised wetland area' have to be considered. In order to consider multiple objectives in portfolio thinking, links to developments in operations research can be made. For example, Steuer *et al.* (2008) provide multi-objective approaches for different return types, but still focus on monetary units.

An advantage of MPT is that it encourages the description of each investment in terms of both expected return (e.g. avoided damage) and its potential to lower portfolio risk. Thus, the risk of individual measures and activities can be diversified away by combining them in a portfolio. By going through the four preconditions of MPT for a river basin, one can understand the varying conditions that cause risk (e.g. climate change, spatial developments) and describe how potential new measures would generate returns under these long-term trends. Returns can be quantified if information is available on damage and damage functions, however some water management returns might be difficult to assess (e.g. the contribution of water availability to biodiversity). Another challenge is to obtain information on the risk of individual activities. In such cases, one could use historical information on the effectiveness of water management measures such as dykes, irrigation measures, insurance and storage areas. Where this is not available, expert knowledge can serve as an alternative.

Another opportunity for using MPT is in the ongoing discussion on vulnerability to climate change (e.g. Kelly and Adger, 2000; Luers *et al.*, 2003; Adger *et al.*, 2004; O'Brien *et al.*, 2004b; Luers, 2005; Ionescu *et al.*, 2009). Figure 2.2 provides a stylised graph of the potential damage against the probability of a flood event. The surface underneath this graph or in general the 'risk-return' ratio can be perceived as the vulnerability of the system for inundations (cf. Luers, 2005). Furthermore, diversification could be linked to adaptive water management research (Pahl-Wostl *et al.*, 2007b). The concept of adaptive management focuses on (developing) more flexible governance structures across stakeholders in water management, and MPT can add information on the types of measure stakeholders may wish to develop.

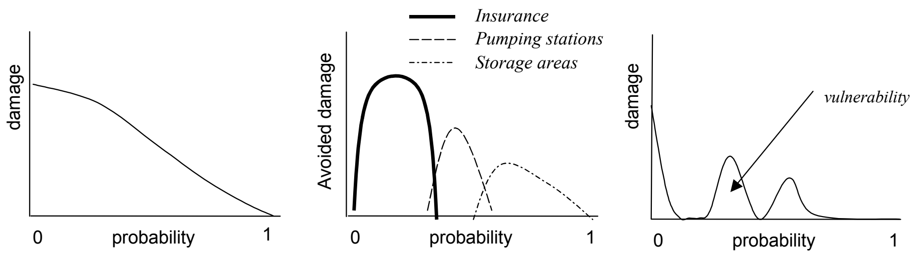


Figure 2.2: Theoretical graph showing the probability of an event against the potential damage (left), how much damage can be avoided through measures (middle) and what the residual potential damage is after implementing measures (right).

2.4 Conclusions and recommendations

Whenever decisions relate to different activities and the return on the individual investments is subjected to risk, Portfolio Theory can be used to develop robust sets of activities. These preconditions hold for developing adaptation strategies in water management aimed at coping with long-term trends such as climate change. This chapter illustrated how Modern Portfolio Theory (MPT) thinking could help current water management practices in developing more robust adaptation strategies, by discussing whether the four main MPT preconditions apply. A portfolio is interpreted as a collection of measures and policy instruments between which a water manager can select.

The method presented in this chapter could be enriched by the following topics for future research:

- Extension of this largely qualitative transfer of Portfolio Theory to a more quantitative application in water management issues. Though the transfer may not yield a full predictive model, it can support development of robust portfolios (Chapters 3 and 4). Consider using MPT to quantify indicators for adaptive water management regimes and to assess the adaptiveness of water management systems and institutions. Within this context, MPT can explicitly determine the trade-offs and merits of combining investments suggested by stakeholders. MPT provides information to address questions such as: what are remaining risks given current water management? what kind of measures can be added to current water management practice to reduce risks in new water management portfolios? and, what are the sources of future risk?

- Inclusion of values of water systems beyond the human use. This chapter adopts an anthropocentric utilitarian point of view: water systems are valuable because people expect a future benefit. This benefit is uncertain and Portfolio Theory helps to optimise the risk–return ratio by ensuring that portfolios are diversified.
- Consider multiple goals. This study uses return values related to potential damage and variance in the return. However, in practice, additional social and environmental aspects will have to be taken into account in investment decisions. This work could be combined with aspects of operational research, especially optimisation, in order to apply MPT to multiple returns. This way, for example, trade-offs can be discussed between risk reduction, reducing potential damage and increasing socio-ecological values (e.g. Penning-Rowsell *et al.*, 2006). Within this context, available budget could be a boundary condition within which portfolios are evaluated (Chapter 3).
- Investigate whether the risk-return ratio can be used as an indicator that allows water and climate researchers to identify the vulnerability of the water system and appraise potential investments in this system (Werners and Donaldson, 2006). The concept of diversification fits well in current climate change and vulnerability research (e.g. O'Brien *et al.*, 2004a; Adger, 2006), which focuses on reducing the current vulnerability, thereby expecting that future (unexpected) shocks or extreme events can be absorbed or anticipated.

This chapter showed that MPT encourages the development of robust sets of measures to reduce the risk of damage from climate related events. It appraises the risk under which current technical measures are being developed in terms of their return under current and/or future scenarios. MPT thinking promotes appraising additional measures such as insurance or the creation of storage areas in terms of their contribution to risk reduction. Although this chapter does not quantitatively demonstrate the potential success of such application, it suggests that MPT deserves more attention in water management. MPT encourages the systematic discussion of the relationship between the risk and return of individual activities and the risk and return of complete portfolios. MPT reveals that having more adaptation measures available does not necessarily reduce risks. Only when adaptation measures are non-perfectly correlated may they add to risk reduction. Furthermore, the analysis of the correlation between returns of various water management activities can provide a tool to learn and re-evaluate portfolios once more information becomes available. In particular Portfolio Theory calls for risks to be evaluated in relation to the full range of water management options that actors have at their disposal and the full range of external conditions to which these options may be exposed, now and in the future.

Chapter 3

Diversification of land use to cope with climate related risks in the Hungarian Tisza River Basin

Abstract
This chapter examines whether diversification of agricultural land use can reduce climate related risks. It explores combinations of different agricultural crops and of two different land use and water management strategies in the Hungarian Tisza River Basin: intensive agriculture protected by flood levees, and water retention areas with extensive cattle breeding and orchards. Borrowing from economic theory, the chapter assesses risks and revenues at different spatial scales as a function of land use and the climatic conditions to which the Tisza is subjected. The chapter shows that risks and revenue of land use and water management at the regional level are different from those at higher levels of aggregation taking into account downstream flood risk. The river basin perspective highlights trade-offs between flood levees and water retention that may be overlooked at the level of the micro-region and vice versa. The analysis shows that agricultural land use is well adjusted to the current climate variability. A shift from conventional intensive agriculture protected by flood levees to retention areas with extensive cattle breeding and orchards increases both the expected revenue from agriculture and the agro-economic risk. Downstream regions can benefit from investments in water retention and reduced flood risks. In the studied micro-region, the flood risk reduction does not significantly outweigh the costs of building and maintaining water retention infrastructure. For the county and the river basin however, the reduced flood risks largely exceed the costs of water retention. Along with the assessment of the costs, benefits and risks of water and land-use strategies, this chapter calls for careful evaluation of risk allocation between actors at the local, regional and national level.

Keywords: Diversification, risk, climate impacts, adaptation, crop revenue

Chapter based on:
Werners, S.E. (2010) Diversification of agricultural land use to cope with climate related risks in the Tisza River Basin in Hungary. Regional Environmental Change (under review).
And
Werners, S.E., É. Erdélyi and I. Supit (2010) Use of Modern Portfolio Theory to evaluate diversification of agricultural land use as an adaptation to climate risks in the Tisza River Basin. In Climate change adaptation in developed nations (eds Ford, J. D. and L. B. Ford). Springer, Netherlands (forthcoming).

3.1 Introduction

Land-use change is an adaptation strategy to cope with climate related risks that is perceived effective, but not practiced yet on a large scale (Footitt and McKenzie Hedger, 2007). To add to our understanding of how land-use change can reduce climate related risks, this chapter concentrates on a particular land-use change strategy. It focuses on diversification of agricultural land use, meaning the combination of different agricultural crops and land-use systems within a region.

Agricultural and ecological research has provided arguments that more diverse systems are better able to cope with risks. For example, research has illustrated the importance of crop diversity to improve the stability of agricultural yields (Vandermeer, 1989; Altieri, 1994). Tonhasca and Byrne (1994) investigated the effect of crop diversification on mitigating pests, whereas others have assessed the influence of the diversity of farming systems and landscape structures in agriculture on vulnerability of yields and biodiversity (e.g. Sendzimir and Flachner, 2007; Reidsma and Ewert, 2008). Furthermore, crop diversity has been used in a range of African settings as an indicator of both ecosystem resilience and a strategy for food security (Unruh, 1994; Blocka and Webb, 2001). Fraser *et al.* (2005) use the Panarchy concept (Gunderson and Holling, 2002) to elaborate on the importance of portfolio management and diversification for reducing vulnerability in agri-environmental systems. Figge (2004) argues that the number of species not only determines biodiversity but also the degree of diversification. In social sciences, diversity is found to relate positively to innovation and learning (Ostrom, 2005; Olsson *et al.*, 2006).

In the area of financial services, planning and investing under uncertainty has been explored widely. An approach that is frequently used to determine investment strategies under uncertainty is Modern Portfolio Theory (Markowitz, 1952). It shows whether different investments can be combined in a portfolio with a lower risk than the risk of the individual investments. Although diversification is commonly studied in agricultural and economic research to meet demand fluctuations (Isik and Devadoss, 2006), fewer attempts are made to quantify the benefits of diversification in the context of climate variability and climate change (Werners *et al.*, 2007; see also Chapter 2).

To evaluate diversification of agricultural land use in the context of climate related risk this chapter uses the Tisza River Basin in Hungary as a case study. The main climate related risk in the Tisza Basin is the frequent occurrence of floods and droughts (Láng, 2006; Bartholy *et al.*, 2007). Two agricultural production systems have dominated land use in the Tisza basin. Until the 18th century, socio-economic activities were mainly organised around the operation of a system of creeks and channels regulating the water flow between the main river bed and the floodplain (Balogh, 2002). The inundation frequency influenced agricultural practices and other determinants of land use. Mosaic floodplain production systems combined plough land, forest, floodplain orchards, meadows, fishing and cattle (Andrásfalvy, 1973; Bellon, 2004). Over the last two centuries agricultural practice has shifted to tillage. To cater for large-scale intensive agriculture and river transport the river was canalised and straightened, and the floodplains were drained. Levees were built, one third of the river length was regulated, and the floodplain was drained, decreasing the total naturally flooded area by 84 per cent (Figure 3.1). These changes put an end to the traditional water management system and the related production systems (Bellon, 2004).

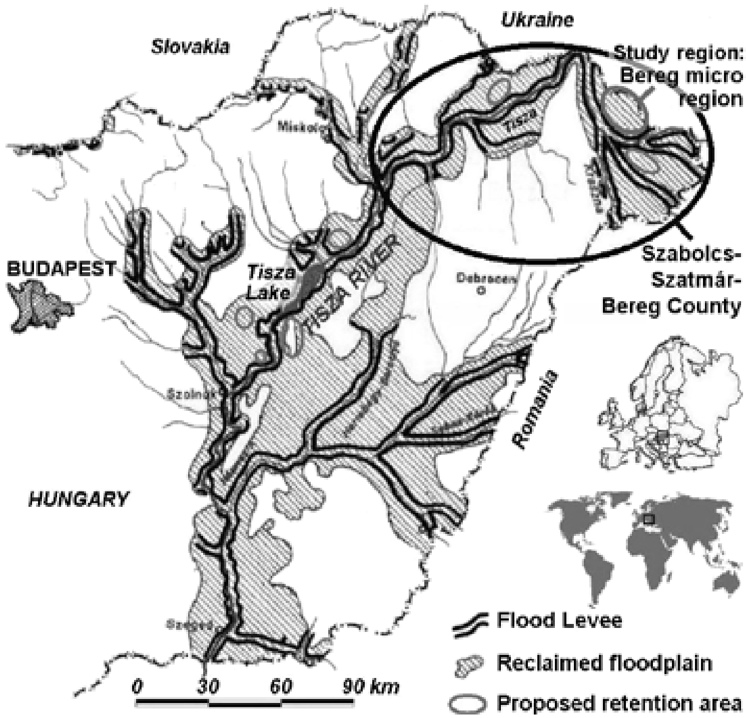


Figure 3.1: Tisza River Basin

Following major floods in the years 1998 and 2000, the Hungarian Government issued a new water management plan to cope with flood risks in the Tisza River Basin in Hungary (VITUKI, 2004). The plan marked a substantial shift in land use and water management as it promotes water retention and land-use change to replace or complement the prevailing system of flood levees and drainage on which intensive agriculture currently depends (Werners *et al.*, 2009b; Chapter 6). In terms of land-use diversification, the plan proposes to combine intensive agriculture protected by flood levees with water retention in areas containing, for example, meadows, extensive cattle breeding and orchards.

It is against this background that this chapter analyses diversification of crops and agricultural land-use systems. The chapter elaborates on three main questions in relation to land use and climate related risks:

1. What climate related risks are associated with the current agricultural land-use?
2. Can diversification of agricultural land-use reduce risks locally and in the river basin?
3. What are the tradeoffs between local reduction of agro-economic risks and regional flood risk reduction?

The chapter seeks to examine diversification not as a magic bullet that is always required, but as an attribute of agro-environmental systems with consequences for the way the system performs. Modern Portfolio Theory is used to evaluate diversification of agricultural land-use as an adaptation strategy to cope with agro-economic risks associated with direct climate impacts on crop yields. Agro-economic risk is calculated as the standard deviation of annual crop revenue over a ten-year period (1998-2007). Flood risk is assessed as flood probability multiplied by flood damage.

The chapter has three main parts. First, the approach to assess land-use diversification is introduced. Second, results of the assessment are presented for selected crops and agricultural land-use systems. Risk reduction is discussed at the local and regional scale, demonstrating trade-offs between local agro-economical risks and regional flood risks. Third, conclusions are given along with strengths, limitations and possible extensions of the approach. The chapter shows how Portfolio Theory encourages systematic discussion of the relationship between the revenue and risk of individual crops and the revenue and risk of different water and land-use systems. By focusing on climate risk, this chapter offers decision makers a tool to take climate adaptation into account along with the many non-climatic factors that influence decisions on land use and water management.

3.2 Approach for assessing land-use diversification, agro-economic risk and flood risk

3.2.1 Project area, selection of agricultural land use, yield data and the calculation of crop revenue

In response to climate change, the agricultural sector has to consider coping with: 1) the impact of climate change and variability on crop yields and 2) the shift in water management from flood levees to retention areas. For the purpose of the analysis I call the agricultural production system that relies on flood levees 'intensive agriculture'. The system relying on retention areas I call 'floodplain agriculture'. The main difference between these agricultural systems is their potential to cope with flooding. Intensively produced crops are more sensitive to water cover than cattle breeding and floodplain orchards that can withstand water cover of a certain duration, and even benefit from annual flooding. This distinction does not imply that these agricultural systems exist only under dry or wet conditions; 'Intensive agriculture' at present is practiced at locations suffering from water logging, and 'floodplain agriculture' exists outside the active floodplain in areas behind the flood levees. However, distinguishing between the two agricultural systems facilitates the analysis and interpretation of the results.

The study region is the Szabolcs-Szatmár-Bereg County (see Figure 3.1). Half of the Szabolcs-Szatmár-Bereg County is arable land, of which the three crops wheat, maize and sunflower occupy more than 50 per cent. Grasslands covers 14 per cent of the county (Dobos *et al.*, 2000). Table 3.1 lists the crops selected for the analysis. The selection of crops is based on their predominance in the region and data availability. This chapter uses annual crop yield data at the county level from the period 1998-2007. The data were obtained from the Hungarian Central Statistical Office[1]. In the analysis I use a 10-year time horizon because the results of earlier years strongly reflect the agricultural reforms after the fall of the communist regime (Erdélyi, 2008). In addition the data cover a period with both floods and droughts in the Tisza region. Within the Szabolcs-Szatmár-Bereg County lies the Bereg micro-region, an area where land-use change is planned in support of water retention and floodplain revitalisation (Molnár *et al.*, 2007). The larger cities along the Tisza under flood risk, e.g. Tokay and Szolnok, are down-stream from the Bereg micro-region. The flood reduction potential of water retention in

1 *Available from http://portal.ksh.hu*

the Bereg micro-region is most significant in the counties upstream of the Tisza Lake reservoir (Koncsos, 2006).

Table 3.1: Characteristics of the assessed agricultural land use

	Land use	Characteristics	Average yield [kg/ha][1)]	Average fraction of total area / revenue[%]	Av. Price[2)] [€/kg]
Intensive Agriculture	*Wheat*	Well adapted to different soil types and the regional climate. Predominantly winter wheat. Grown rain fed. The growth phases most sensitive to drought are shooting, flowering, and caryopsis filling. Sensitive to waterlogging.	3700	23 / 20	0.11
	Maize	Water is an important limiting factor. In Tisza region, grown rain fed.	5000	20 / 20	0.10
	Sunflower	Heat tolerant without extra maintenance. Rain fed.	2000	10 / 10	0.23
Floodplain Agriculture	*Fruit*	Fruit orchards. Fruit trees can withstand temporary inundation depending on time of the year and fruit species. For example, nut trees benefit from shallow flooding and high soil moisture.	5800[3)]	5 / 3	0.14[4)]
	Cattle	Extensive cattle breeding mostly for meat production. Traditionally cattle were held on land subjected to water logging or temporary flooding.	520[5)]	28 / 25	1.03

1) Ten-year average (1998-2007) of the annual yield

2) Average procurement price over last ten years (1998-2007)

3) Average total fruit production (1998-2007)

4) Weighted average of procurement price of apples, pears, sour cherries, plums, apricots, peaches

5) Average of annual number of cattle per hectare grassland multiplied by cattle weight [kg/ha]

Crop revenue

Gross crop revenue (hereafter referred to as revenue) is calculated by multiplying annual crop yield with the annual procurement price of a crop. For reference, Table 3.1 lists average procurement crop prices. By excluding variable production costs and subsidies, gross revenue allows the analysis to focus on climate impacts on crop yield and to inform stakeholders about this particular aspect of agricultural decision making. The conclusion section reflects on this choice as well as on opportunities to include other costs and revenues of crop selection and land-use change such as opportunity costs and ecosystem services.

3.2.2 Assessing revenue, correlation and agro-economic risks associated with land-use strategies

To evaluate whether the combination of different agricultural crops can reduce climate related risks, the assessment builds on Modern Portfolio Theory (MPT). MPT quantifies how different investments might be combined into a portfolio that has a lower risk than the individual investments (Markowitz, 1952). Given different possibilities for investment, it is possible to assess trade-offs between revenue and risk associated with an investment strategy. For example, the minimum risk for a given revenue can be evaluated or the revenue to expect when seeking for the lowest risk (most stable income) can be determined. MPT can be applied when four preconditions are met (Elton and Gruber, 1995; Fraser *et al.*, 2005; see also Chapter 2):

1. There is more than one possible investment at any given time,
2. The investments are subject to risk,
3. There is information about the historical and / or expected return of the investments.
4. The same (economic) conditions do not affect all investments equally.

These preconditions apply to crop selection as well as land-use planning. Elaborating on the case of crop selection in agriculture, a farmer can choose between different crops to invest in (precondition 1). Crop yields for these crops are uncertain and subjected to amongst others climate related risks (precondition 2). There is information about historical crop yields and there may also be forecasts from agricultural organisations or crop models (precondition 3). Finally, different crops will respond differently to climate related stresses such as water shortage or inundation. Some crops are, for example, more drought tolerant than others (precondition 4). MPT shows how to use this information in a systematic examination of the relationship between revenue and risk of different crops in order to assess how crop diversification can reduce agro-economic risks. Notably, crop diversification is fundamentally different from crop rotation or crop substitution as it seeks to combine crops within a growing season.

Following MPT, this chapter describes different agricultural cropping systems (investments) by their mean revenue and risk (Harvey, 1995). Agro-economic risk is calculated as the standard deviation of crop revenue over a ten-year period (1998-2007).

Table 3.2 summarises how the terminology from Portfolio Theory is applied in this chapter to evaluate how diversification of agricultural land use can reduce the probability of low revenue. The analysis focuses on crop revenue to assess the risk from climate impacts on crop yield and to inform stakeholders about strategies to reduce climate related risks.

Table 3.2: Terminology used in this work compared to MPT

Terminology	Definition in MPT	Application in this work
Investment	Item within a portfolio (also called asset)	Different crops and agricultural land-use systems. Here: a) Intensive agriculture behind dykes (Crops: Wheat, maize, sunflower); b) Extensive grazing and fruits in the floodplain (Crops: meadows / cattle, fruits)
Portfolio	Set of investments held by a person or an organisation	Mix of agricultural crops in a particular region
Correlation	A measure of the degree to which assets are equally affected by external conditions	A measure of the degree to which agricultural land uses are equally affected by external factors such as climate change
Diversification	Dividing the portfolio into a variety of (partly-) uncorrelated investments	Combining different agricultural crops and land uses in a particular region
Revenue $\overline{Y}$	Total revenue is a measure of income gain (or loss) from a portfolio	Mean revenue earned from agricultural land use (mix of crops) over a 10 year period
Risk R	The uncertain outcome of an investment. Risk is measured by the standard deviation (or variance) of portfolio revenue	Standard deviation of the revenue (and damages) in an area
Efficient frontier	Portfolios on efficient frontier are optimal in offering maximal expected revenue for a given level of risk and minimal risk for a given revenue	Crop systems on efficient frontier are optimal in offering maximal expected revenue for a given level of risk and minimal risk for a given revenue

The expected mean revenue of a land-use system $\overline{Y}_{land\_use\_system}$ with n different crops is estimated:

$$\overline{Y}_{land\_use\_system} = \sum_{i=1}^{n} \overline{Y_i} * X_i \qquad (3\text{-}1)$$

with $\overline{Y}_i$ here the average revenue per hectare over the period 1998-2007 for a particular crop or land use *i*. And X_i the fraction of the total arable land occupied by crop or land use *i*.
The agro-economic risk $R_{land\_use\_system}$ of an agricultural land-use system is represented by the standard deviation SD_i of its revenues. It can be estimated with the formula:

$$R_{land\_use\_system} = SD_{land\_use\_system} = \sqrt{\sum_{i=1}^{n} X_i^{\,2} SD_i^{\,2} + 2\sum_{i=1}^{n}\sum_{j=i+1}^{n} X_i X_j \rho_{ij} SD_i SD_j} \qquad (3\text{-}2)$$

With X_i being the share of the individual crops in the land-use system, SD_i the standard deviation of the revenue of land use *i* over the assessment period and ρ_{ij} the correlation of the revenue of land use *i* and *j* over the assessment period.

A negative correlation ρ_{ij} between two crops *i* and *j* indicates that when the revenue of crop *i* turns out to be above its expected value, then the revenue of crop *j* is likely to be below its expected value, and vice versa. A positive correlation suggests that when *i*'s revenue is above (below) its expected value, then *j*'s will also be above (below) its expected value. Equation (3-2) shows that the standard deviation (risk) of a land-use system is less than the weighted sum of the standard deviations of the individual crops if the correlation between the crops is less than one. Thus the equation recalls the importance of knowing the correlation of the revenues of different activities that a farmer or water manager can choose between.

Crop diversification for two crops (A and B) is illustrated in Figure 3.2. The figure plots the expected revenue and standard deviation (risk) of a hypothetical land-use system. The curved lines are obtained by changing the crop share in the agricultural land-use system from growing only A (point A) to only B (point B). The different curves correspond to different values for the correlations ρ between the two crops.

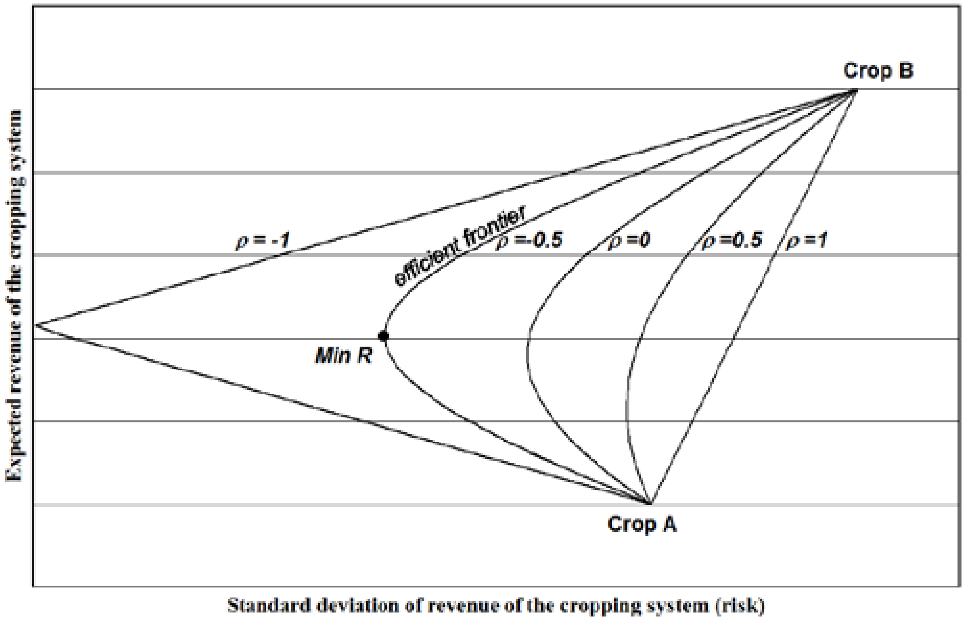


Figure 3.2: Expected revenue of a crop system with two crops for different correlations ρ between the crop revenues

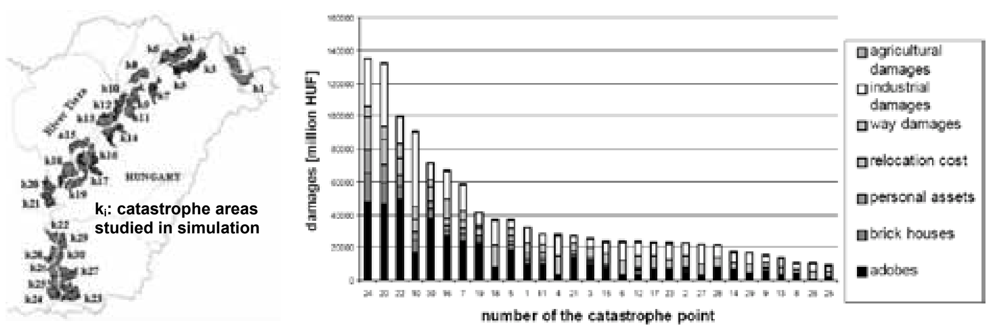
The curved lines illustrate the diversification effect. The lower the correlation between the two crops, the more bent is the curve indicating that the same revenue can be earned at lower risk. Diversification is beneficial when the risk associated with the crop combination is less than the risk of the individual crops. This always occurs if $\rho \leq 0$, but may or may not occur for $0 < \rho < 1$, depending on the relative size of the individual crop risks. The point MinR (minimum risk) on each of the curves represents the minimum risk crop mix. The share of the crops in the minimum risk cropping system is determined by the standard deviation *and* correlation of the crops. To grow crops with expected revenue below that of the minimum risk crop mix is considered inefficient. The part of the curve between MinR and B represents all efficient crop mixes for a given correlation. It is therefore called the efficient frontier.

When risk (standard deviation) and revenue for individual crops can be estimated as well as the correlation coefficients between these crops, MPT allows for quantitatively determining the trade-offs between risk and revenue and efficient frontiers such as plotted in Figure 3.2.

3.2.3 Assessing flood risk

To assess the benefits from water retention, the expected avoided damages and reduced flood risk are estimated together with the costs of building and maintaining water retention areas in the floodplain.

The assessment of flood risk is based on an existing assessment of damages D_i^S for different land-use sectors *S (agriculture, industry, road, relocation, personal assets, brick houses & adobes)* in a series of catastrophe areas *i* along the river (Koncsos and Balogh, 2007). Koncsos and Balogh (2007) identified thirty areas along the Tisza that are most at risk of being flooded. For each of these areas they simulated the inundation area and depth during a typical catastrophic event (a five day discharge of 520 m^3/s into the area following dyke failure), taking into account elevation differences and infrastructure. Loss functions were estimated for major land-use types. Damages were then assessed for each catastrophe area by combining land-use maps and inundation estimates. Figure 3.3 shows the catastrophe areas and the estimated damage in each area. Agricultural damage here represents crop losses due to inundation. However these losses are negligible compared to the industrial and other damages. The agricultural sector will mostly be affected by damages to houses and infrastructure as half of the households in the region are rural, depending at least partially on agricultural activities (www.szszbmo.hu, Csanádi, 2005). In this chapter the total agricultural sector damages are estimated by adding the direct agricultural damages to half of the damages in the land-use sectors *road, relocation, personal assets, brick houses & adobes* (see Figure 3.3). The estimated damages are conservative, as they do not include the cost of the emergency operation in times of disaster.



Source: Koncsos and Balogh (2007). Note: 1000 million HUF ≈ 4 million Euro

Figure 3.3: Simulation of damages in catastrophe areas along the Tisza River

Each catastrophe area *i* has an inundation probability p_i^0 assigned that is a combination of overtopping and dyke failure (Koncsos and Balogh, 2007). Simple relations are derived to estimate how water retention in a fraction of the floodplain X_{FP} reduces water levels *z* in the river and thereby reduces the inundation probability for a catastrophe area p_i:

$$p_i^* = p_i^0 * a^{\Delta z_i} \tag{3-3}$$

With $\Delta z_i = c_i * X_{FP}$, and $p_i^* \in \langle 0, p_i^0]$. The constants *a* and c_i are estimated using the hydrological assessment for the new water management plan, and from historic data of maximum flood levels and the area of active floodplain.

Next flood risk *R* is estimated as a function of the fraction of the floodplain that is used for water retention X_{FP}:

$$R_{flood}^{X_{FP}} = \sum_{i \in A} p_i^* * D_i^S \tag{3-4}$$

Thus flood risk reduction achieved by using a certain fraction of the floodplain X_{FP} for water retention is estimated as the difference between flood risk with and without water retention:

$$\Delta R_{flood}^{X_{FP}} = R_{flood}^{X_{FP}=0} - R_{flood}^{X_{FP}} \tag{3-5}$$

Reduced flood risks are compared to the costs of building and maintaining the water retention areas in the floodplain in micro-region *i*. The costs are estimated from the budget tables in the new water management plan, listing the construction costs of eleven retention areas at different locations along the river Tisza. Expressed as a function of the fraction of floodplain used for water retention, the costs of water retention in the micro-region *i* are estimated:

$$Costs_i^{retention}(X_{FF}) = X_{FP} * Area_i * c^{\cos ts\_retention} \tag{3-6}$$

With:

X_{FP}: fraction of the floodplain used for water retention,

$Area_i$: the total area of floodplain that could be used for water retention in micro-region *i* [ha],

$c^{costs\_retention}$: the total costs over the planned lifetime of the retention area (including building and maintenance) of retaining water on one hectare of retention area.

3.3 Land-use revenue, agro-economic risk and flood risk

3.3.1 Yields, revenue, agro-economic risk and the diversification of land uses

Table 3.3 lists the average crop yield, crop revenue and agro-economic risk (standard deviation) in the assessment period (1998-2007). It is recalled that revenue refers to gross revenue.

Table 3.3: Average crop yield, revenue and risk in the Szabolcs-Szatmár-Bereg County (1998-2007)

Crop	Yield [kg/ha]	Risk [kg/ha]	Revenue [euro/ha]	Risk [euro/ha]
Wheat	3730	690	404	82
Maize	4966	1359	500	119
Sunflower	1839	300	426	81
Fruit	12527	3859	1765	410
Cattle	470	25	504	112

Table 3.4 lists the yield correlations of the different crops in the assessment period. Because the correlation matrix is symmetric, only the lower half is shown.

Table 3.4: Correlation of crop revenue in the Szabolcs-Szatmár-Bereg County (1998-2007)

Correlation	Wheat	Maize	Sunflower	Fruit	Cattle
Wheat	1				
Maize	0.92	1			
Sunflower	0.76	0.84	1		
Fruit	-0.04	-0.20	-0.60	1	
Cattle	-0.57	-0.44	0.06	0	1

Crop correlations are decisively determined by their response to the weather conditions in the consecutive phases of their growth. The low correlation between sunflower and wheat for example can be explained by their different growth seasons. Wheat is a crop sown in autumn or early spring, whereas sunflower is a summer crop. Thus a wet period early in spring or a summer drought will affect these crops differently.

A correlation smaller than unity suggests there can be a benefit from diversification, where the risk associated with the crop combinations is less than the risk of the individual crops (see Equation (3-2)). This is examined in Figure 3.4 for the main crops used in intensive agriculture (wheat, maize and sunflower, Figure 3.4 - left) and in floodplain agriculture (cattle and fruit, Figure 3.4 - right). Following the example in Figure 3.2, Figure 3.4 illustrates the trade-offs between average revenue and risk for these crops. In intensive agriculture, maize is a high revenue crop that comes at a high risk. That is: the variation in revenue between consecutive years is larger than for the other two crops. The revenue of sunflowers is lower, yet the risk is also lower. Wheat is a crop with which the people in the region have a long tradition. Its average revenue is lower than sunflower and its risk higher. This makes wheat –at first sight- a less attractive crop than sunflower. Its medium correlation with sunflower, however, makes it an attractive crop for risk diversification. Over the last ten years wheat, maize and sunflower were grown on average at a surface ratio 1:3:1. The revenue and risk associated with the present crop mix in the study region are shown in Figure 3.4 and prove to be on the efficient frontier. This suggests some risk reduction is traded in for higher expected revenue. The same holds true for floodplain agriculture, with cattle the less risky-lower revenue land use over fruit production. Over the last ten years cattle and fruit were produced at a surface ratio 2:1.

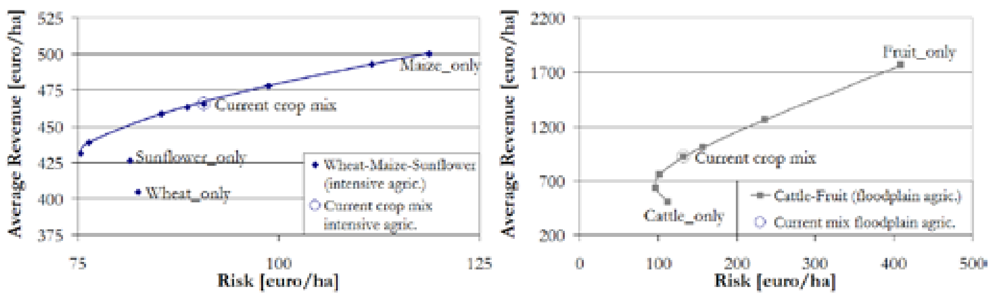


Figure 3.4: Average revenue and risk of (mixes of the) main crops in intensive agriculture (left) and floodplain agriculture (right) in the Szabolcs-Szatmár-Bereg County

Figure 3.4 is based on crop revenues for the county as a whole. How individual farmers handle trade-off between risks and revenue is a clear topic for future research. Likewise, other reasons for choosing a certain mix of crops, such as required crop rotation, speculation on increasing world grain prices or crop insurance, are outside the scope of this chapter.

3.3.2 Diversification of intensive agriculture and floodplain agriculture

The previous section presented results for crop diversification within the two main agricultural systems: i) intensive agriculture protected by flood levees and ii) floodplain agriculture with the possibility of water retention. This section investigates whether a combination of these two strategies reduces risks for the agricultural sector. To this end the current crop mix in the two systems are treated as two investment options in a portfolio. Figure 3.5 illustrates the revenue and agro-economic risk of a portfolio with a mix of intensive agriculture and floodplain agriculture. It shows that the present mix of these production systems (60 per cent intensive - 40 per cent floodplain agriculture) has the lowest risk. A lower agro-economic risk can only be achieved by changing the fraction of wheat, maize, sunflower, fruit or cattle within the current production systems or by altering the way these crops are produced. For example, cattle breeding may be made more efficient or irrigation may be considered. These options are now excluded from the analysis. The analysis illustrates the benefit of diversification given the existing production systems in the region. It also illustrates how people in the region may perceive a shift from one production system to another -as supported by the government in the new water management plan- based on their present experience and risk perception.

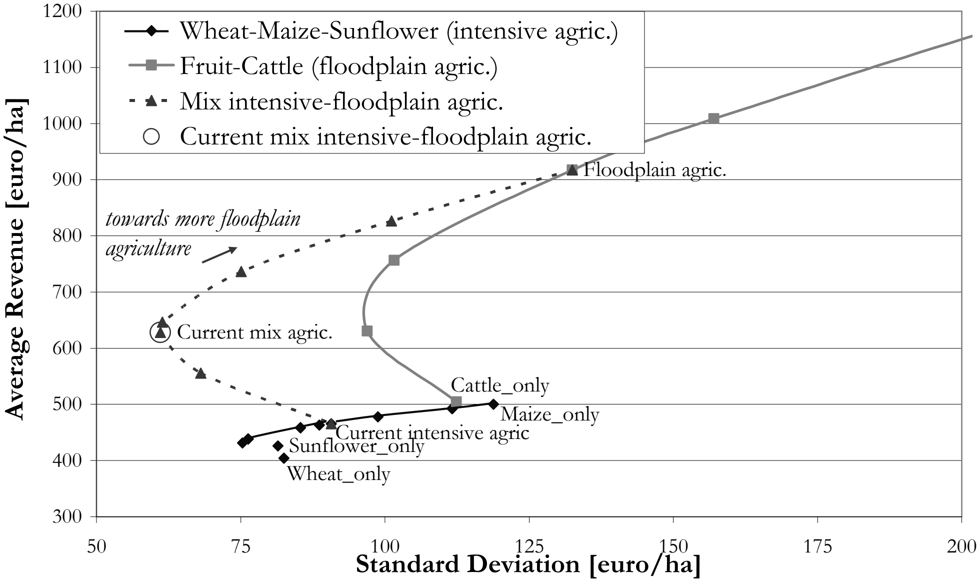


Figure 3.5: Average revenue and risk of combinations of intensive agriculture and floodplain agriculture in the Szabolcs-Szatmár-Bereg County

Summarising, Figure 3.5 suggests that shifting from intensive agriculture to floodplain agriculture in the study region will not currently reduce agro-economic risks in the region, unless the practice within one agricultural production system is changed. At the same time the figure shows that a shift towards more floodplain agriculture can increase the average revenues from agriculture, at the cost of accepting higher agro-economic risks.

Assuming that cattle and fruit production in the floodplain will be less profitable when the area is also used for water retention does not significantly alter the above result. Less profitable or more risky floodplain agriculture will shift the curve of 'fruit-cattle', yet floodplain agriculture remains of higher revenue and risk and diversification reduces risks. Only when the reduction in revenue of floodplain agriculture is greater than 50 per cent, does the current intensive agriculture becomes more profitable and a shift towards floodplain agriculture reduce the average revenue.

3.3.3 Trade offs between land-use diversification, agro-economic risk and flood risk

This section reports on the flood risk reduction that can be achieved by a shift from flood levees to water retention in the floodplain. Reduced flood risk was assessed as a function of water retention in the Bereg micro-region. The analysis distinguished between flood risk reduction in the Bereg region itself, in the Szabolcs-Szatmár-Bereg country and in the Hungarian part of the Tisza Basin.

Using the assessment for the new water management plan (KöViM, 2002) and historic data of maximum flood levels and the area of active floodplain (Barta *et al.*, 2000; Szlávik and Ijjas, 2003; Molnár and Nagy, 2007), the inundation probability for the Bereg micro-region is estimated using Equation (3-3):

$$p^{*}_{Bereg} = p^{0}_{Bereg} * 10^{-2.9 * X_{FP}} \tag{3-7}$$

Equation (3-7) expresses the trade-off between flood risk and water retention in the floodplain.

An assessment of flood level reduction along the Tisza for different reservoir sizes in the Bereg micro-region (Koncsos, 2007) is used to estimate the inundation probability for the catastrophe areas p_i along the river as a function of the inundation probability for the Bereg micro-region. Probabilities are mostly reduced in the areas upstream of the Tisza Lake. The current flood levees are built for a one in a hundred year flood. Yet dyke failure has occurred on average once every five years over the past 50 years (Szlávik, 2001b; Tóth and Nágy, 2006) with three major dyke failures between 1998 and 2008 (ICPDR, 2008). Figure 3.6 presents flood risk reduction, assuming that in the current situation without water retention in the Bereg micro-region (X_{FP} = 0) a dyke failure along the Tisza occurs once every five years, with two dyke failures in the same year once every hundred years. Total annual flood risk for the Hungarian part of the Tisza River Basin without water retention is estimated 28 million euro, in close agreement with the 29 million euro estimated from the flood damages and frequencies reported in Szlávik (2001b).

The total costs of water retention in the Bereg micro-region are estimated as a function of the fraction of floodplain used for water retention X_{FP} with Equation (3-7). The total costs of one hectare of water retention over the planned lifetime of a retention area (including building and maintenance)) have been estimated from Table 20 in the water plan (KöViM, 2002) and more recent project documents for the Bereg micro-region (Koncsos, 2007; Dajka, 2008):

$$Costs_{Bereg}^{retention}(X_{FP}) = X_{FP} * 27200[ha] * 219[euro/ha] \quad (3\text{-}8)$$

Figure 3.6 compares the cost of water retention in the Bereg micro-region to the expected flood risk reduction in the micro-region, the county and the Tisza basin. The figure shows that at the county or river basin scale, flood risk reduction is larger than the costs of water retention. Yet, looking only at the Bereg micro-region, the costs of water retention do not significantly outweigh the reduced flood risk. For the agricultural sector only, flood risk reduction in the Bereg micro-region does not exceed the cost of water retention. The costs of water retention are only below the total flood risk reduction in the Bereg micro-region as long as less than one third of the floodplain is used for water retention. The previous section showed that 'floodplain agriculture' at present covers 40 per cent of the Bereg micro-region. From an agricultural and hydrological perspective these lands could be used for water retention (Molnár *et al.*, 2007). Additional conversion from intensive agriculture to floodplain agriculture would increase agro-economical risk. For comparison these risks are included in Figure 3.6. Table 3.5 gives an overview of agricultural revenue, agro-economic risk and flood risk at different geographical scales for three different water and land-use systems in the Bereg micro-region: 1) intensive agriculture protected by flood levees only, 2) floodplain agriculture and water retention only, 3) a mix of intensive agriculture and floodplain agriculture, with floodplain agriculture and water retention covering 40 per cent of the micro-region.

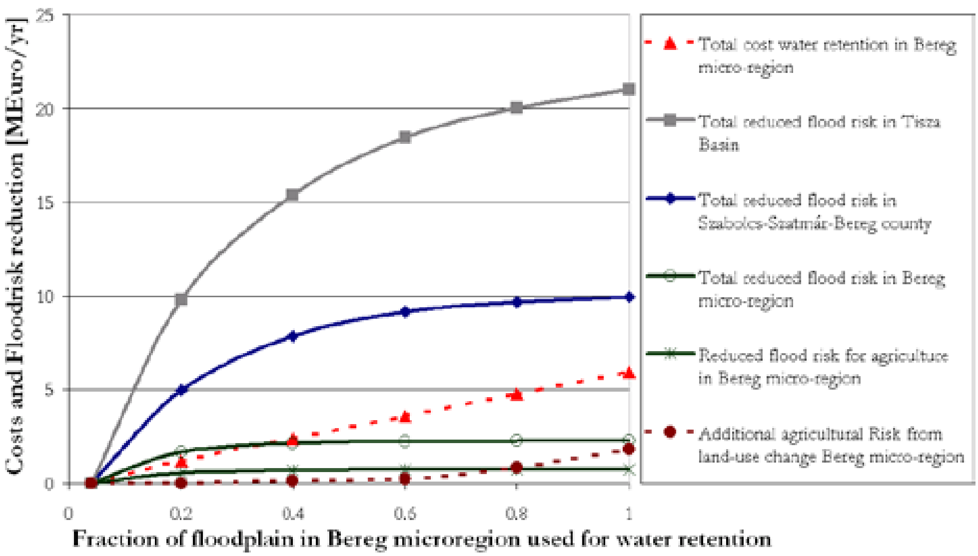


Figure 3.6: Flood risk reduction and total cost of water retention in the floodplain

Table 3.5: Summary agricultural revenue, agro-economic risk and flood risk at different scales

Revenue and risks [M euro / year]	Intensive agriculture only	Floodplain agriculture only	Combination with 60% intensive and 40% floodplain agric.
Agricultural revenue Bereg micro-region	12	23	16
Agro-economic risk	2.2	3.4	1.6
Flood risk agricultural sector Bereg micro-region	0.8	0.0	0.1
Total flood risk in Bereg micro-region	2.3	0.0	0.2
Total flood risk Szabolcs-Szatmár-Bereg County	12	2.5	4.5
Total flood risk in Tisza Basin	28	6.6	12
Cost water retention Bereg micro-region	0	6.0	2.4

It is tempting to subtract investments from land-use revenue or to add flood risk to agricultural risk to mirror the analysis in the previous section. Yet, I decided not to do so as it obscures the fact that the actors who make investments are different from those living from the land and/or those suffering damage. Comparing costs and flood risk is difficult as the national government is (co)funding water management and the damages are borne by many different parties. In addition, the costs of building, operating and maintaining water retention areas are uncertain and experience with the first reservoir suggest they could well be significantly above the official cost estimates. Climate change is a third important factor that adds to the uncertainty of future flood and drought frequencies and thus complicates the comparison of agro-economical risks and flood risk. These uncertainties at present have no probabilities assigned to them and are so far excluded from the analysis. Considering these uncertainties may be important as Figure 3.6 suggests that the total cost of water retention is of the same order of magnitude as flood risk reduction. Thus the perceived uncertainty in investment and maintenance costs may significantly affect an actor's willingness to invest in water retention.

3.4 Discussion and conclusions

This chapter shows that agricultural land uses, particularly intensive and floodplain agriculture, in the Tisza River Basin can be combined to reduce climate related agro-economic and flood risks. It shows how Modern Portfolio Theory (MPT) can help in determining land-use systems that generate the highest revenue under an acceptable risk, using the standard deviation of revenue as a proxy for agro-economic risk.

Table 3.6 lists the strengths and limitations of the approach presented in this chapter. Diversification can be used to reduce the risk of crop failure due to climate variability and change. The presented approach intends to support decision makers by estimating the benefits of land-use diversification as a possible climate adaptation strategy. As a result, climate risks can be included as one component in decision making about land-use systems, together with, for example, information about subsidies and regulation. The approach allows for the inclusion of non-climate factors, such as variable production costs, by replacing historic gross revenues with net revenues or (farm) net value added. Likewise, expected net revenues and price speculation can be included, for example, by using results from whole-

Table 3.6: Strengths and limitations of the presented approach

Strength	Limitation
+ Explicitly designed to deal with risk + Well documented methods and metrics to calculate risks and revenue along portfolio composition + Shows there are limits for reducing risks through diversification + Facilitates the combination of data from different sources + Facilitates comparison between spatial and temporal scales as well as future scenarios + Both net revenues and gross revenues can be used in assessment	- Land use and other activities are treated as homogeneous and non-location specific - The method assumes that revenues that are impacted by climate variability and extremes are normally distributed and well represented by their average value, risk and covariance - Currently focuses on gross revenue and climate risk, ignoring farm-level decision factors such as costs (labour, seed, irrigation, fertiliser, opportunity costs), subsidies, risk perception, personal experience & preferences - Requires extension to include social and environmental considerations in revenue

farm design models that explore the effect of a variety of farmer's decisions and objectives at the farm system level (Sterk *et al.*, 2006). Costs and benefits, however, have to be carefully assigned to specific actor groups. In the Hungarian case, for example, the government offers to compensate farmers for land-use change, opportunity costs or flood damages.

Another extension of this work is the addition of crops and crop management options that enable adaptation to climate change, such as irrigation techniques and changes in the timing of planting and crop handling. Stakeholders in the region expressed interest in the benefits of diversification with non-agricultural activities such as tourism or alternative agricultural production systems such as vini- and horticulture (cf. Varga, 1998). Whereas the analysis in this chapter can be broadened to include other activities and non-climate factors, it ultimately remains up to decision makers and individual farmers to handle trade-offs between risks and revenue. How risk perception and institutional aspects influence the willingness of actors to invest in water retention and land-use change is an important area for future research (cf. Werners *et al.*, 2009a; Chapter5).

Although the case analysis is relatively simple, it confirms that MPT encourages systematic discussion of the relationship between the risk and revenue of individual crops and agricultural production systems. It also shows the importance of understanding the correlation of the revenue of different crops. Given the land uses in a region and their dependence on climatic conditions, there is an upper limit to diversification beyond which risks cannot be 'diversified away'. The current combination of agricultural land-use systems minimises regional agro-economic risk. Land-use change towards floodplain agriculture raises the revenue from land use but also increases the probability of low revenue. This argument could be deepened if additional socio-ecological cost and benefits of water retention and floodplain agriculture were included in the analysis.

With respect to flood risk reduction in the Tisza Basin, the assessment suggests that investing in water retention and land-use change in the Bereg micro-region is particularly interesting for downstream areas. Taking account of externalities over the whole region, water retention areas can be a cost effective way to reduce flood risks. These results allow us to understand flood risk reduction as a service provided by floodplain agriculture (cf. Minca *et al.*, 2008). The analysis also shows that flood risk reduction levels off with increasing water retention at one location. MPT facilitates a systematic assessment of whether more cost efficient flood risk reduction can be achieved by combining water retention areas at different locations as proposed in the current water management plan. The assessment of combinations of water retention areas along with other water management options, such as raising flood levees or introducing flood insurance, would be an important extension of the current work.

For the micro-region itself flood risk reduction does not significantly outweigh agro-economic risks and investment costs. There is a trade-off between flood risk and agro-economic risks. The Tisza case study shows that risk allocation from the national to the local scale has to be carefully evaluated, including the additional agro-economical risks associated with land-use change and the uncertainty in investment and maintenance costs. Typically the investment costs of new measures are more uncertain and add to the perceived risk of investing in water and land-use change. To what extend uncertainty in investment costs and revenues of new land use and water management options determines the willingness of actors to consider these options to replace or complement existing practices, deserves more attention in future work. The regional water management plan proposes water retention and land-use change to reduce flood risk. To encourage people to engage in the implementation of the plan, compensation of additional risks associated with land-use change could be considered together with spreading risk through insurance.

Chapter 4

Adapting to flood risk through diversification of water infrastructure in the Netherlands

Abstract

This chapter shows, through a numerical example, how to develop portfolios of flood management activities that generate the highest return under an acceptable risk for an area in the central part of the Netherlands. This chapter offers a method based on Modern Portfolio Theory (MPT) that contributes to developing flood management strategies. MPT aims to find sets of investments that diversify risk, thereby reducing the overall risk of the total portfolio of investments. The chapter shows that risk is reduced through systematically combining different flood protection measures in portfolios. Portfolios with three or four measures can be constructed to have a lower risk than portfolios that contain only one or two measures. Adding partly uncorrelated measures to the portfolio diversifies risk. The chapter demonstrates how MPT facilitates the appraisal of trade-offs between the risk and return of individual flood mitigation activities and complete portfolios. It is also shown how important it is to understand the correlation of the returns of various flood management activities. The MPT approach fits well with the notion of adaptive water management, which aims to accept and cope with an inherently uncertain future. By applying MPT to the development of flood protection strategies, climate related risks can be reduced by diversification.

Keywords: *Adaptive water management; diversification; flood risk; Modern Portfolio Theory; uncertainty; vulnerability.*

Chapter based on:

Aerts, J., W. Botzen, A. v. Veen, J. Krykrow and S. Werners (2008) Dealing with uncertainty in flood management through diversification. Ecology and Society 13 (1), 41.

4.1 Introduction

Flood management in the Netherlands still relies strongly on technical engineering capacity (see Chapter 7). This situation has arisen historically. Over centuries water managers have developed flood protection systems with the highest safety standards in the world (Vellinga, 2003). The major storm surge of 1953, which flooded large coastal areas in the southwest of the Netherlands encouraged the technical innovations of flood protection (Aerts and Droogers, 2004; Meijerink, 2005). However, since the 1980s, flood managers have been exploring approaches other than technical investments such as dykes or pumping stations. Furthermore, long-term developments such as economic growth and climate change pose a challenge to Dutch water management (Kwadijk and Middelkoop, 1994; Kabat *et al.*, 2009). Long-term trends are inherently uncertain and hard to predict. This makes it difficult to translate these trends into particular investment demands for daily operational water management (DWW, 2005a).

New approaches for dealing with future uncertainties in water management have recently been proposed (Gleick, 2003; see Chapter 2). For example, the development of flood insurance, flood risk mapping systems, and risk management approaches that specifically address the probability of certain future trends, common in spatial planning, are gaining increasing attention in water management (e.g. Burby *et al.*, 1999). Furthermore, in the social sciences the concept of adaptive (water) management has been introduced. Adaptive management aims to give more institutional flexibility and provides stakeholders with a central role in an iterative "social learning process" (Folke *et al.*, 2005; Pahl-Wostl *et al.*, 2007c). In climate and vulnerability sciences, it appears that the process of determining future vulnerability holds too many uncertainties and some authors advocate that research should focus on reducing current vulnerability instead of simulating vulnerability under long-term climate change (e.g. Smit *et al.*, 2000; Adger *et al.*, 2004; O'Brien *et al.*, 2004a; Füssel and Klein, 2006).

Despite new developments in cost benefit analyses under uncertainty (e.g. Boardman *et al.*, 2006), dealing with uncertainty in operational flood management remains a challenge. Studies attempt long-term cost-benefit analyses through (statistically derived) variable discount rates (Pearce *et al.*, 2003; Groom *et al.*, 2005). In most flood management studies, however, the selection of investments relies on classical cost-benefit analysis or optimisation approaches that have their origin in operations research (e.g. Levy and Hall, 2005; Penning-Rowsell *et al.*, 2006). The term "risk" in these studies represents the product of the probability of a hydraulic event, e.g., "discharge peak," of a given magnitude, and the damage costs, i.e., consequences associated with such an event. This is an accepted rubric for flood risk management. It implies that interventions in flood risk management involve one of two things: changing the probability-event relationship and changing the discharge-damage relationship. Both approaches are then linked to costs and benefits (e.g. of interventions, avoidance of losses).

In the area of financial investments, however, the term "risk" is used differently. In approaches, such as the Modern Portfolio Theory (MPT Markowitz, 1952), risk is referred to as the standard deviation of the return of an investment. MPT aims to find sets of investments that diversify risks thereby reducing the overall risk of the total portfolio of investments. This chapter adopts the terminology of MPT. Risk from here on refers to the standard deviation or variance of a particular investment's return.

In most current flood management studies the evaluation is primarily concerned with the costs and benefits of investments. It is therefore worthwhile investigating the role the risk of such investments play in these studies and whether or not the risk-return ratio provides useful additional information to the basic assumptions made in cost and benefit analysis for flood management investments. There are a number of studies that use the portfolio concept (e.g. Costanza *et al.*, 2000; O'Brien and Sculpher, 2000; Figge, 2004; Fraser *et al.*, 2005), but to the authors' knowledge, there has been no application in flood management. Hence, this chapter pursues an analogy with financial services where portfolio managers are not only concerned with the valuation of assets but also in which securities to invest (Tonhasca and Byrne, 1994; Figge, 2004; Fraser *et al.*, 2005). The task of a water manager, by analogy, would be to construct a portfolio of flood management activities that generates the highest return under an acceptable risk. Moreover, a water management portfolio should be developed in such a way that the risk-return ratio will be optimised through diversification of activities in the portfolio, hence through choosing activities in the portfolio that are non-perfectly correlated.

Since dealing with risk is one of the key issues in adaptive water management, this chapter explores how MPT can contribute to operationalising the concept of adaptive water management for developing flood management strategies in the Netherlands. This chapter provides a numerical example that applies MPT to flood protection and discusses the advantages and drawbacks of MPT as compared to existing approaches.

The objectives of this chapter are to:

1. Discuss the concept of diversification as formulated in MPT (Section 2);
2. Apply a numerical example of MPT to a case study in the Netherlands (Section 3); and
3. Discuss the advantages and drawbacks of MPT in flood protection management (Section 4).

4.2 Modern Portfolio Theory

The benefits of diversifying investments are widely recognised by financial economists. Investors rarely hold a single financial asset; instead they hold portfolios of financial assets. In this way, investors diversify risks and become less sensitive to price changes of individual assets. For example, total returns for an investor will be higher when low returns on an individual stock in a certain period are partly offset by higher returns from other stocks during the same period. Diversification is possible when stock returns are less than perfectly correlated. Modern Portfolio Theory (MPT) (Markowitz, 1952) addressed the question of which investment portfolio investors should select. The main criteria in MPT for portfolio selection are the risk and expected return. The latter can be measured by the variance or standard deviation of the portfolio return. A portfolio with a relatively high variance or standard deviation is riskier, because the probability of yielding an unfavourable return is larger. According to Portfolio Theory, investors should first identify the efficient set of portfolios from all feasible portfolios. This means finding portfolios that have the highest possible expected return for a given risk or the lowest possible degree of risk for any given expected rate of return. Subsequently, investors can choose a portfolio among the efficient ones according to individual risk and return preferences (Elton and Gruber, 1995).

The expected, or mean, return R_i of an individual asset A_i can be estimated by summing products of the actual return of that asset in a specific state of the economy and the probability that the corresponding state occurs. This can be represented by the following formula:

$$\overline{R_i} = \sum_{s=1}^{n} p_s R_s \tag{4-1}$$

where R_i is the expected return of an individual asset, p_s is the probability that state s occurs, and R_s is the actual return in that state s, with a total number of states equal to n.

The variance of the return of an individual asset is the average squared deviation of the actual return of that asset from its expected return. The variance V_i of an asset A_i can be defined as

$$V_i = \sum_{s=1}^{n} p_s (R_s - \overline{R_i})^2 \tag{4-2}$$

Another measure of dispersion is the standard deviation of an individual asset, SD_i, which can be calculated by taking the square root of the variance, thus $SD_i = \sqrt{V_i}$

The expected return $\overline{R^p}$ of a portfolio can easily be obtained after calculating the expected returns of individual assets. Consider a portfolio consisting of individual assets $A_1, A_2, \ldots, A_n$ with corresponding shares in this portfolio $x_1, x_2, \ldots, x_n$, where $0<x_i<1$ and $\sum_{i=1}^{n} x_i = 1$. The expected return of such a portfolio can be estimated by adding the products of the expected return of the individual assets, $\overline{R_i}$, and their shares in the portfolio x_i. It can be represented as

$$\overline{R^p} = \sum_{i=1}^{n} \overline{R_i} x_i \tag{4-3}$$

where the expected returns of individual assets, $\overline{R_i}$, are defined by Equation (4-1).

The covariance between individual assets in a portfolio can be used to estimate the variance of a portfolio. The covariance between assets A_i and A_j is the expected value of the deviation of the actual return R_i of asset A_i from its expected return $\overline{R_i}$ multiplied by the expected value of the deviation of the actual return R_j of asset A_j from its expected return $\overline{R_j}$:

$$\sigma_{ij} = E\left\{(R_i - \overline{R_i})(R_j - \overline{R_j})\right\} \tag{4-4}$$

Or alternatively:

$$\sigma_{ij} = \sum_{s=1}^{n} p_s (R_{is} - \overline{R_i})(R_{js} - \overline{R_j})$$

where p_s corresponds to the probability that state s occurs, R_{is} to the actual return of asset A_i in that state and R_{js} to the actual return of asset A_j in that state, with a total number of states equal to n.

The covariance between two assets is positive when returns between assets are positively related and negative when returns between the assets are negatively related. The interpretation of the actual covariance figure is difficult. Therefore, the calculation of the correlation between two assets that lies between -1 and 1 is used. The correlation between two assets A_i and A_j is defined as

$$\rho_{ij} = \sigma_{ij} / (SD_i * SD_j) \tag{4-5}$$

where SD_i and SD_j are the standard deviations of the individual assets A_i and A_j.

The risk of a portfolio V^p can be represented by the variance of its return. Risk can therefore be estimated as follows:

$$V^p = \sum_{i=1}^{n} x_i^2 V_i + \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} x_i x_j \sigma_{ij} \tag{4-6}$$

where V_i represents the variance of the individual assets A_i, as in Equation (4-2) and σ_{ij} represents the covariance as in Equation (4-4). From Equation (4-6) it follows that the portfolio variance is less than the weighted sum of the variances of the individual assets when the correlation between the assets is less than 1. In other words, diversification is possible as long as there is less than perfect positive correlation between the return of assets.

Portfolio diversification for a two asset case was illustrated in Figure 2.1. The figure shows different sets of portfolios composed of two assets A and B for different correlations ρ between these two assets. The curved lines represent feasible sets also called 'efficient frontiers'; points on these curves can be obtained by combining the two assets. Only one of these curves exists in the real world depending on the value of ρ. The investor can only choose between different points on a curve having different risk and return characteristics for a given correlation between assets. Different portfolios can be developed by varying the proportion of asset A and B in the portfolio. Points located more to the left represent portfolios with higher proportions of security asset A, which has a smaller risk and expected return than asset B. The straight line between the two assets represents possible return and risk characteristics of a portfolio composed of two assets (A and B) with a correlation of unity. The diversification effect applies to the curved lines, where the correlation is smaller than unity. The smaller the correlation between the two assets, the greater the bend in the curve indicating that the same return can be earned for a smaller portfolio risk. The point MinV, which is actually located on each of these curves, represents the minimum variance portfolio. This backward bending of the curve always occurs if $\rho \leq 0$, but may or may not occur if $\rho > 0$. Obviously, no investor wants to hold a portfolio with an expected return below the minimum variance portfolio. Therefore, the efficient set lies between MinV and B.

The above-described concept of MPT can provide additional value to current flood management practices. Most flood management investments have tended to focus on acceptable or tolerable risk defined as Probability multiplied by Damage, with emphasis on the consequences of flooding rather than probability. An MPT approach in flood management might add new information on the robustness of different investments, not only with respect to their return in terms of net costs and benefits, but also to the risk in achieving this return. This aspect is further explored in this chapter.

4.3 Climate change and flood management in the Netherlands

The Netherlands is one of the most densely populated countries in the world with 395 inhabitants/km². Millions of people live protected by dykes in areas below sea level and along rivers. About half of the Netherlands is prone to flooding. The root of this situation is historical. Many low-lying parts have been reclaimed from former lakes. Subsidence of the soil induced by agricultural practice is one of the processes that causes increased exposure to floods. This situation is further exacerbated by projected sea level rise.

The low-lying areas in the Netherlands are protected by a system of dykes and embankments along the main rivers and coastal areas. A so-called 'dyke-ring' is a geographical unit bounded by its flood protection system of dykes (Figure 4.1). It is also a separate administrative unit under the *Water Embankment Act* that was enforced in 1995. *The Water Embankment Act* aims to guarantee a certain level of protection against flooding for each dyke-ring area. According to the *Act*, a dyke-ring area should be protected against floods by a system of primary embankments, and each dyke-ring has been designed such that it meets a safety norm. These safety norms are based on potential high flood levels with a certain probability. For example, a dyke-ring with a safety norm of 1/10,000 means that it has been designed such that it can withstand a flood that occurs every 10,000 years. These numbers have been extrapolated from historical data (Figure 4.2). There are 95 dyke-ring areas in total, each having different safety norms. The most important safety norm areas are illustrated in Figure 4.1.

Source: DWW (2005a)

Figure 4.1: Map of the Netherlands showing the differentiation in safety norms. The location of the study area is indicated with the circle

4.3.1 Climate change and safety standards

Currently, safety standards in the Dutch part of the river Rhine are designed to withstand a flood that occurs once in 1250 years (1/1250). The peak discharge, also called 'design discharge', for the Rhine at Lobith associated with an incidence of the 1/1250 years flood is estimated to be 16,000 m^3/s. Figure 4.2 shows the distribution of water discharges at Lobith and the corresponding incidence in years. The return time in years shown on the horizontal axis can be interpreted as a probability measure. The dots represent observed peak flows for the Rhine from 1901 to 2000 (Ten Brinke and Bannink, 2004). Werklijn 15,000 and 16,000 in Figure 4.2 stand for the design discharges 15,000 and 16,000 m3/s respectively that occur 1/1250 year under different extrapolations.

The upper and second highest lines represent climate change scenarios. The second highest line in Figure 4.2 corresponds to an increase in peak flows caused by 1°C warming and the upper line corresponds to an increase in peak flows as a result of 2°C warming. These lines can be used to estimate the new probability of a design discharge of 16,000 m^3/s or higher. The dotted lines in Figure 4.2 show that the probability of having a discharge of 16,000 m^3/s and higher will increase to approximately 1/750 in 2050 with a temperature increase of 1°C and it will increase to approximately 1/550 when temperature increases by 2°C.

Thus, additional measures will be needed to protect the Netherlands from a flood that occurs once in 1250 years (1/1250). At present, a new water policy and a regular update of the design discharge are debated reach to maintain flood safety of a societal and political accepted risk level (Kabat *et al.*, 2005; Werners *et al.*, 2009c).

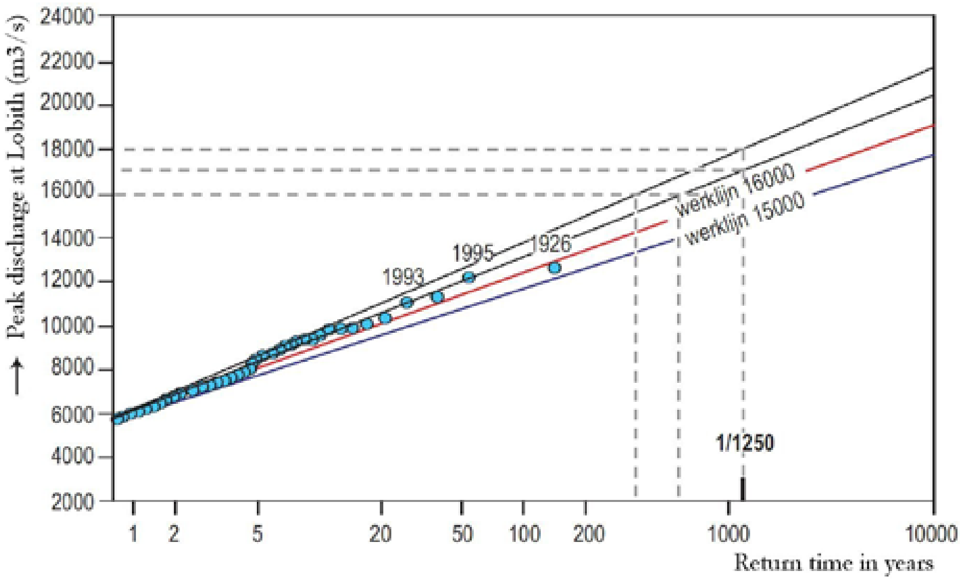


Figure 4.2: Peak discharges (m3/s) and their return time of the river Rhine in the Netherlands at gauging station Lobith

4.4 Application of Modern Portfolio Theory to flood protection

This section illustrates the principle of diversification by a numerical example using Modern Portfolio Theory (MPT) concerning four different flood management investments that are proposed for one representative dyke-ring area 'number 43'. The area is situated in the central part of the Netherlands (Figure 4.3). The hypothesis is that investing in a portfolio of flood protection measures has the potential to increase expected return and lower risk compared to investing in individual strategies. Investing in primary dykes alone will result in a relatively high-expected return, i.e., prevented damage, but also in a large variance, i.e., risk, of this return. Combining dyke investments with other investment strategies might lower the variance in returns, because these investments can prevent damage in situations of dyke collapse, in which the return is actually zero. Therefore, damage extremes may be reduced when investments are diversified, i.e., lower investments in primary dykes but also investments in other damage reducing measures.

The aim of this section is to provide an illustration of the benefits of diversification of water management investments. The analysis is indicative in the sense that the returns of investment strategies are merely approximations. Note that this chapter only focuses on prevented economic property damage and damage to land use, including crop damage, within the dyke-ring area. Macro economic costs and casualties are not considered in this analysis. The maximum potential damage is estimated at 18,000 million Euro (DWW, 2005b).

The analysis distinguishes between four states, each representing different levels of river discharges of the Rhine at Lobith, i.e., the location where the Rhine enters the Netherlands. The probabilities of observing these discharges are likely to change as a result of climate change. Therefore, one base line scenario and two climate change scenarios are defined, which generate different probability distributions for each of the four states. Finally, four assets will be considered, of which each is an investment option to prevent flood damage. The probabilities are listed in Table 4.1.

The discussion below defines the states of peak discharges, climate scenarios and assets that are used in the application.

4.4.1 States

Four discharge states are defined, corresponding to different peak discharges of the river Rhine. One state ('State D') is a situation where no damage will be caused (all discharges below 16,000 m^3/s), because current dyke designs are sufficient to withstand these discharges. The other three states (A, B and C) concern other intervals of peak discharges that will cause damage above the current safety level of 16,000 m^3/s. For these flood states three discharge intervals were selected: C: 16,000–17,000, B: 17,000–18,000 and A: >18,000 m^3/s (Table 4.1). The probabilities for each possible state under each climate scenario can be derived from the lines presented in Figure 4.2. First, the probability of state A (>18,000) is the inverse of the return time that corresponds to a discharge of 18,000 in Figure 4.2. Next, the probability of occurrence of state B (a discharge between 17,000 and 18,000) is calculated by subtracting the probability of observing a discharge of 18,000 or higher from the probability of observing a discharge of 17,000 or higher. Similarly, the probability of State C is obtained by subtracting the probability of observing a discharge of 17,000 or higher from the probability of observing a discharge of 16,000 or higher. Finally, the probability of state D (discharges <16,000 m^3/s) is calculated as 1 minus the probabilities of states A+B+C, in order to make the probabilities add up to unity. The probability of state D can be interpreted as the probability that no flood damage occurs in a given year.

4.4.2 Climate scenarios

Table 4.1 shows how the probabilities of observing a particular state change with a different climate scenario. The probabilities for each state A, B, C and D were calculated for three climate scenarios: current climate, climate change 1 (CC1) and climate change 2 (CC2). The probabilities of observing a particular state under the CC2 scenario can be derived from the upper line in Figure 4.2 and the probabilities under the CC1 and current climate scenarios can be derived from the second-highest and third-highest lines respectively. The probabilities for each state under a specific climate scenario should add up to '1'. The purpose of these climate scenarios is to examine how portfolio returns and variances change when flood probabilities rise as a result of climate change.

4.4.3 The assets: four flood protection measures

In and around the case study area, four different flood protection investments are considered to cope with an increase in future peak discharges (Figure 4.3). These measures aim to lower water levels under peak discharges whereby reducing the risk of dyke failures and reducing flood damage. The four possible investments, or assets in terms of portfolio management, are:

1. Asset D+: Dyke enforcement
2. Asset Cp: Compartments
3. Asset Fp: Flood proofing houses
4. Asset R: Retention area.

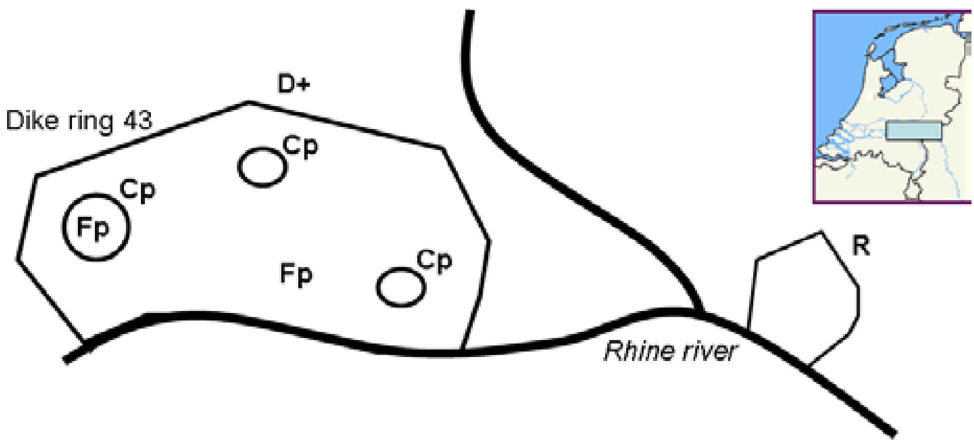


Figure 4.3: Schematic overview of the possible flood protection investments in dyke-ring area 43 in the central part of the Netherlands

Asset D+: Dyke enforcement

Enforcement of the primary dykes of the dyke-ring area refers to raising the height of the dykes at the design discharge level of 17,000 m^3/s. This means that after having invested in this option no damage can be expected at discharges from 17,000 m^3/s or lower. At higher discharges, the damage will be equal to the maximum potential damage, which is estimated 18,000 million euro. The damage prevented in state C (or expected return) equals the maximum potential damage.

Asset Cp: Compartments

Compartments around economically valuable areas. This investment leaves the current primary dykes at the safety level below the design discharge of 16,000 m^3/s, and constructs new 'internal dykes' within the dyke-ring for protecting the most economically valuable areas, such as urban and horticulture areas. This example assumes three extra dykes are built: two that protect urban areas and one that protects horticulture areas. The new two internal dykes for urban areas can withstand floods in the state B: 17,000-18,000 m^3/s. The new internal dyke for horticulture areas can withstand floods in the state C: 16,000-17,000 m^3/s. The potential damages for urban areas and horticulture areas are estimated at 8,000 million euro and 4,000 million euro respectively (DWW, 2005b). Hence, this results in 12,000 million euro avoided damages for *Asset Cp* under State C and 8,000 euro avoided damages under State B.

Asset Fp: Flood proofing houses

This investment refers to developing additional flood protection measures for individual houses including the development of floating houses, raising the height of houses, etc. These measures limit economic damage once a flood occurs. It is estimated that through additional flood protection measures for all houses in the area, about 3,000 million euro damage can be prevented in case of any of the three flood states from 16,000 m^3/s and more that are considered.

Asset R: Retention areas

Creating upstream retention areas involves the development of upstream areas that are designed to temporarily store water during a peak discharge. In such a case, the area would be deliberately flooded to cut off the peak, thereby lowering the water levels downstream. In this example, it is expected that using a 'flood storage area' would prevent damage to dyke-ring area 43 at discharge levels between 16,000 and 18,000 m^3/s. However, although the retention area only holds a few urban settlements and could be quickly evacuated in a flood, flooding the retention area would cause economic damage (crop damage, nature area's, etc) of about 4,000 million euro.

Table 4.1 summarises the return of the four investment assets under different discharge states. Note that investment costs are not taken into account. Returns are measured as the 'prevented damage loss'.

Table 4.1: Probabilities and returns of the different states A, B, C and D (possible discharges) under three different climate scenarios (current, climate change low and climate change high)

Source: DWW (2005a; 2005b)	**States**			
	A	**B**	**C**	**D**
Discharge[m³/s]	> 18,000	17,000–18,000	16,000–17,000	< 16,000
Climate scenarios	**Probability**			
Current	0.000125	0.000250	0.00080	0.9988
Climate Change low scenario (CC1)	0.000167	0.000667	0.00133	0.9978
Climate Change high scenario (CC2)	0.000667	0.00133	0.00182	0.9962
Assets	**Actual Returns [10^6 Euro]**			
D+: Dyke enforcement	0	0	18000	0
Cp: Compartments	0	8000	12000	0
Fp: Flood proofing houses	3000	3000	3000	0
R: Retention areas	-4000	14000	14000	0

4.4.4 Calculation of portfolio return and variance

By inserting the above-described information in Equations (4-1) to (4-6) it is possible to calculate sets of flood protection portfolios. For this purpose, the expected return and the variances of the return are first calculated for each asset. Subsequently, expected returns and variances of portfolios are estimated. The expected return R_i of each individual asset (Equation (4-1)) is calculated using the actual returns and probabilities that are provided in Table 4.1. For example, the expected return for Asset D+ under the current climate scenario is calculated as follows:

$$\overline{R_{D+}} = 0.000125 * 0 + 0.00025 * 0 + 0.0008 * 18000 + 0.9988 * 0 = 14.4 \quad (4\text{-}7)$$

The variance V_i for each individual asset can be calculated using Equation (4-2) yielding the numbers as shown in Table 4.2.

Table 4.2: Expected return, Variance and Standard deviation per asset

[10^6 Euro/year]	**Expected return**	**Variance**	**SD**	**SD / Return**
Asset D+	14.4	$259*10^3$	508	35
Asset Cp	11.6	$131*10^3$	362	31
Asset Fp	3.5	$11*10^3$	102	29
Asset R	14.2	$208*10^3$	455	32

The estimated expected returns and variances shown in the table indicate that the expected return of investment strategy D+ is highest, but the variation in returns is also highest for this investment. This means that the prevented damage on average is high when the government decides to invest in raising primary dyke levels. The disadvantage of this strategy is that risk, defined as variance, is very high since the dyke only prevents damage up to some level of river discharge and for higher levels of discharge the full potential damage is suffered. The other investment strategies have lower expected returns, but the variance in these returns is also lower. The reason being that these investment strategies do not prevent all of the maximum potential damage. However, the advantage of these investment strategies is that risks are smaller, since they also prevent damage in states A and B. The individual risk and return characteristics of these assets suggest that a combination might be desirable in order to reduce overall risk. This will be illustrated by calculating expected returns and risks of different portfolios of assets.

The expected portfolio return can be calculated using both the expected returns of the individual assets as displayed in Table 4.2 and the shares x_i of each asset A_i in a portfolio. By choosing a variety of shares, different portfolios can be constructed. These shares can be interpreted as the percentage share of total government budget available for water management investments that is spent on a specific investment strategy. Obviously, expected returns of investments depend on investment shares. For the case of simplicity, it is here assumed that lowering the investment share in raising primary dykes, will result in lower dykes. The prevented damage of the D+ investment strategy will also be lower. Lowering the investment share in asset Cp implies that the area protected by compartments will be smaller and the damage prevented by these compartments will be lower as well. Decreasing the investment share of flood proofing houses means that fewer houses will be flood proofed and damage prevented by this strategy will be correspondingly lower. Investing less in retention areas implies that the areas that are deliberately flooded are smaller, lowering the damage prevented in dyke-ring area 43. Naturally, this reasoning is reversed when investment shares of specific investments are increased.

By computing expected and actual returns by asset using Equation (4-7) and calculating the portfolio variance using Equation (4-6), the expected returns and variances of portfolios can be estimated. The results for several portfolios are presented in Figure 4.4 and Figure 4.5. Figure 4.4 shows two asset portfolios and Figure 4.5 shows two, three and four asset portfolios under the current climate scenario – hence using the probabilities for each state under the current climate scenario as displayed in Table 4.1.

Figure 4.4 plots portfolio variance against expected return for portfolios that consist of a combination of the assets D+ (raising dykes) and Cp (compartments). The upper right point represents the portfolio with a 100 per cent share in D+ and 0 per cent in Cp. This portfolio has a high expected return but also a high risk. Portfolios that are positioned more to the left are obtained by increasing the investment share in Cp and reducing the share of D+. The lower left point represents the 100 per cent Cp portfolio. Figure 4.4 shows that increasing the investment share in Cp reduces overall risk. However, this is comes at the expense of sacrificed expected return. The analysis shows that diversification away from the 100 per cent D+ portfolio reduces overall risks as well as expected return. Thus, water managers can choose a desired risk and return by varying investment shares.

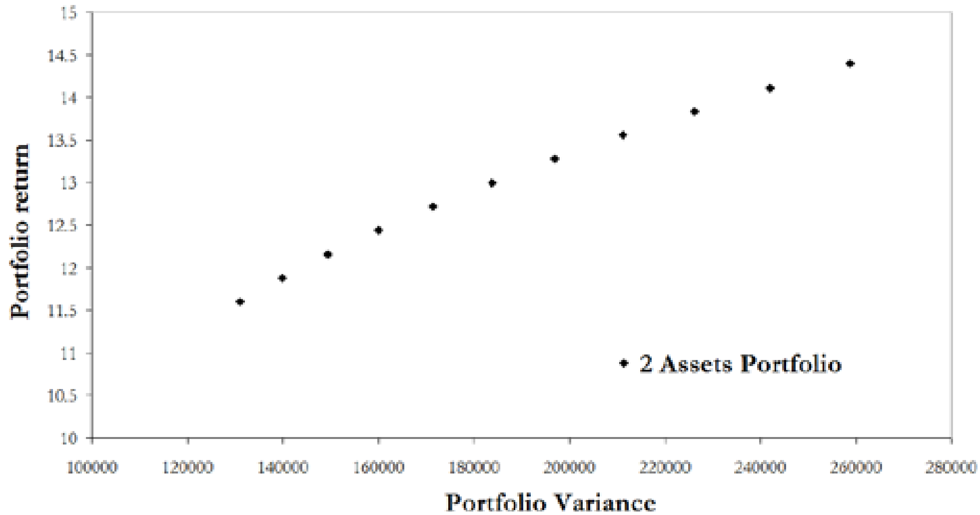


Figure 4.4: Portfolio return and variance values [106 Euro/year] for portfolios consisting of 2 assets (D+ and Cp) under the current climate scenario

Figure 4.5 illustrates that benefits of diversification can be larger when more investments are available. This figure adds a three-assets portfolio curve consisting of the assets D+, Cp, and Fp (flood proofing), and a four-assets portfolio curve consisting of assets D+, Cp, Fp and R (retention areas). The figure shows that adding assets to the portfolio increases the range of possible risk and return characteristics available. The overall portfolio risk can be reduced considerably when the portfolio includes asset Fp, since the three-assets portfolio curve includes variances between 38,000 and 130,000, which cannot be attained by the two-assets portfolio curve.

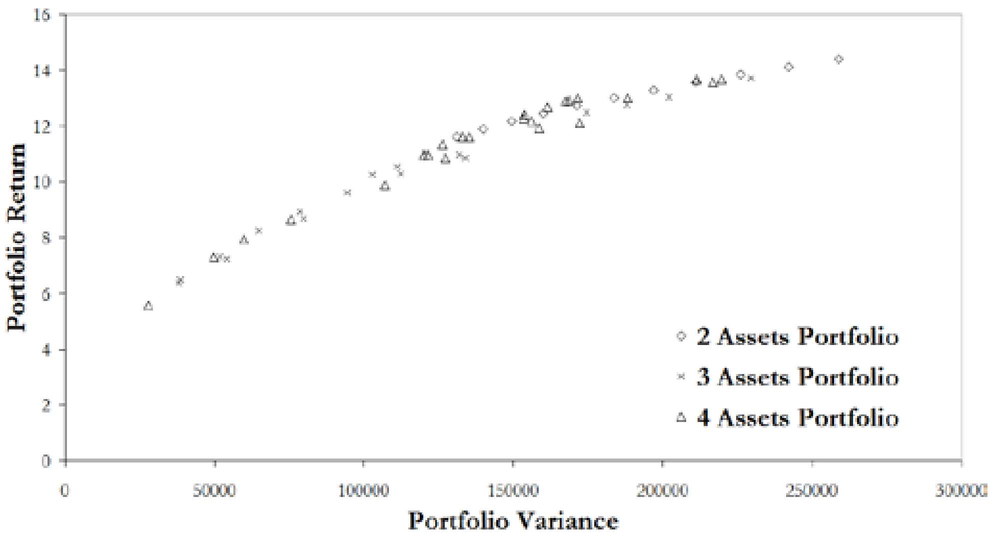


Figure 4.5: Portfolio return and variance values [106 Euro/year] for two (D+ and Cp) , 3 (D+, Cp and Fp) and four assets portfolios under the current climate scenario

Table 4.3 explains why adding asset Fp to the two-asset portfolio considerably lowers the portfolio variance. It shows that the correlation between the Assets Fp and D+ is relatively low at 0.82 (Equation (4-5)). The lower the correlation of returns between investments the larger the benefits of diversification, as has been discussed in Section 2.

Table 4.3: Correlation coefficients between pairs of assets using Equation (4-5)

Pair of Assets	Correlation
Asset D+ / C	0.94
Asset D+ / Fp	0.82
Asset D+ / R	0.93
Asset C / Fp	0.93
Asset C / R	0.99
Asset Fp / R	0.89

In relation to the three-assets portfolio, the portfolio variance can be decreased slightly when the fourth asset, R, is included in the portfolio. The lowest variance portfolio is achieved by combining approximately 60–70 per cent of asset Fp, with 10–20 per cent of assets D+ and Cp, and a small fraction (5–10 per cent) of asset R. Apparently, asset Fp correlates less with the other assets in terms of their return and hence diversifies the portfolio variance relatively well. Furthermore, the four-assets portfolio curve has a slightly higher expected return than the two- and three-asset portfolios for variances between 150,000 and 170,000, whereas expected returns are larger for the three-assets portfolios around variances of 100,000. This suggests that different portfolio mixes are desirable for different risk preferences.

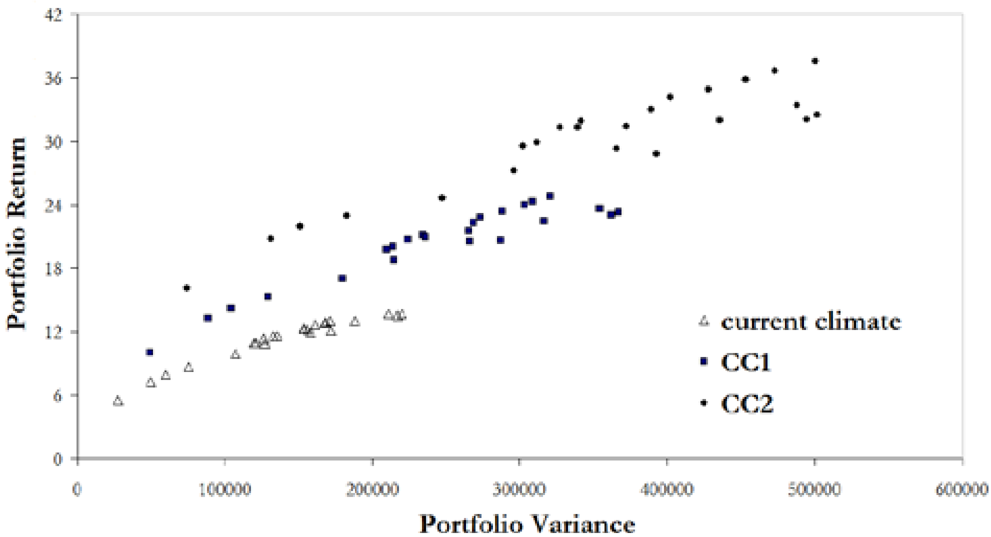


Figure 4.6: Portfolio return and variance values for portfolios consisting of 4 assets under the current and the CC1 and CC2 climate scenario

Finally, as a sensitivity analysis, the same calculations are conducted using the probabilities of the two climate scenarios CC1 and CC2 (Table 4.1). The results of these calculations for portfolios consisting of all four assets are displayed in Figure 4.6.

Figure 4.6 shows that climate change will have an important impact on the portfolio returns and variances. This figure shows the expected return and variance of several portfolios that consist of all four assets under the three aforementioned climate scenarios. As the probability of flooding will increase under both climate change scenarios CC1 and CC2, the expected portfolio return ('the prevented damage') will also rise, as for most assets the individual expected returns increase. Investing in preventing and limiting flood damage has a higher return when the probability of damage increases. Note, however, that the portfolio variance also increases under both climate change scenarios CC1 and CC2. This suggests that the necessity of diversification of water management investments increases with climate change, as an increase in risk is likely to be regarded as undesirable. For example, the individual risk level of the D+ strategy (100 per cent D+) in the current climate scenario can only be obtained through diversification in the CC1 scenario.

4.5 Discussion and conclusion

This chapter indicates that diversification of water management strategies has the potential to increase expected returns or reduce risks. The variance of expected returns can be reduced considerably compared to that in the strategy of solely investing in raising the height of primary dykes. The analysis indicates that in most cases a trade-off between risk and return exists, in such a way that the lower risk levels can only be obtained by accepting lower expected returns. Calculations of risks and returns of portfolios under different climate scenarios show that increases in risk, i.e., variance in returns, can be limited through diversification. The costs of these investments, should then be subject to an evaluation as well, but this is not the topic in this chapter. It should be noted, however, that real-world trade-offs between investments within a portfolio can only be realised if proportional investment is meaningful in practice. Proper definition of what a proportion of an investment means in practice is important. For example, a 30 per cent investment in a retention area could mean that a smaller retention area will be developed which stores 30 percent of water of the full investment per cent case.

Cost-benefit analysis (CBA) plays a major role in Dutch flood management in order to decide where and how to invest in new flood defence systems. Research in cost-benefit analyses for flood management tends to focus more on the differentiation between direct and indirect economic damage in order to assess economic vulnerability to floods (Veen van der and Logtmeijer, 2005). Hence, most CBA studies of flood risk management consider options and or combinations of interventions. Most studies also consider a range of multi-criteria in the evaluation, however, variance is not usually explicitly considered. Considering variance could provide a broader understanding of the effectiveness of interventions and hence help evaluate different investment options.

In cost-benefit analysis there is a growing focus on the role of uncertainty in the decision-making process (Boardman *et al.*, 2006). The literature stresses that it is important to assess expected value over the public policy alternatives, also called the contingencies. This expected value leads to an ex post measurement of expected social surplus, incorporating changes in consumer surplus, producer surplus and net income for governments. Applying Portfolio Theory in cost-benefit analysis for flood management facilitates straightforward computation of expected social surplus over the sets of flood management alternatives. Examples of such applications can be found in health economics (O'Brien and Sculpher, 2000; Sendi *et al.*, 2004a; Sendi *et al.*, 2004b; Sendi *et al.*, 2004c).

Long-term developments such as climate change are inherently uncertain. The implications for investments in flood protection are difficult to assess. This chapter presents a numerical example of how portfolios of flood management measures can be developed that generate the highest return under an acceptable risk for an area in the central part of the Netherlands. Although the example is relatively simple, with many assumptions, it demonstrated that Modern Portfolio Theory (MPT) encourages a systematic discussion of the relationship between the risk and return of individual activities and the risk and return of complete portfolios. It also shows how important it is to understand the correlation of the returns of various flood management activities and that adding partly uncorrelated assets lowers the risk of the total portfolio. As such MPT is a valuable tool to use to re-evaluate portfolios once more information about flooding and their probabilities becomes available.

Apart from portfolio return and variance, the choice for a particular flood protection portfolio depends obviously on more factors than those mentioned in the case study example. For instance, the investment costs of the different assets are neglected. In reality, budget limitations may dictate the selection of a less preferred portfolio. In addition stakeholder preferences will dictate portfolio selection. In the Netherlands, there is a long history of government responsibility for full protection, with dykes being the preferred water management option. Gradually the Dutch government is starting to communicate that remaining risks are inevitable (see Chapter 7) and to endorse the combination of flood protection by dykes with water retention and possibly insurance policy.

Chapter 5

Applying earth system governance to floodplain management in Hungary

Abstract

This chapter aims to improve our understanding of governance systems that facilitate adaptation to a changing world. It does so by applying a recently proposed conceptualisation of 'earth system governance' to floodplain management in the Hungarian Tisza River Basin. The conceptualisation of earth system governance consists of three elements: problem structure, principles and research challenges. These three elements are explored using results from actor interviews and policy review. A regional example of natural resources management is found to be a valid case for earth system governance research. The proposed conceptualisation of earth system governance explains well the main problems, barriers and opportunities for adapting floodplain management to climate change in the Tisza region. Problem structure analysis highlights how previous socio-economic and political orders continue to shape expectations and patterns of conduct. Current barriers can be attributed to a lack of the key governance principles: credibility, stability, inclusiveness and adaptiveness. Interviewees perceived the lack of credibility and effective cooperation between organisations as the largest barrier. The research challenges proposed for earth system governance agree well with opportunities identified for adapting Tisza floodplain management, calling for inclusion of actors beyond governments and state agencies, and equitable resource allocation in particular. The analysis suggests that an additional challenge for earth system governance is the prioritisation of actions to support an existing governance system and its actors in adaptation.

Keywords: Earth System Governance, Adaptation, Floodplain Management, Tisza region, Hungary

Chapter based on:

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5.1 Introduction

Adaptation will be necessary to address already unavoidable impacts of global warming. Impacts are expected to increase with rising global average temperature. At present there is no clear picture of the limits to adaptation, or the cost, partly because effective adaptation measures are highly dependent on specific geographical and climate risk factors as well as institutional, political and financial constraints (IPCC, 2007). Analysis of adaptation to climate change frequently ends with the conclusion that adaptation is institutionally constrained (Folke *et al.*, 2005; Lebel *et al.*, 2006). But what exactly does that mean? It is often emphasised that governance and institutions play a major role in enabling adaptation (Yohe and Tol, 2002; Crabbé and Robin, 2006; USAID, 2007). The role that governance plays is, however, poorly understood. How should governance itself adapt to climate change or which governance systems are most adaptive? Research on these and related questions is complicated by the fact that concepts to analyse the role of governance in adaptation are not yet well developed. At the same time, practical experience with developing and implementing adaptation plans in different regions around the world is building up. These efforts are poorly known to those studying or coordinating climate governance regimes (Arvai *et al.*, 2006). One of the key challenges for adaptation research is to incorporate governance research on the mechanisms that mediate vulnerability and promote adaptive action and resilience (Adger, 2006).

Governance focuses on the relationship between civil society and the state, a relationship that plays a fundamental role in reducing the vulnerability of stakeholders (Hall, 2005). Governance can be defined as the structures and processes by which people in societies make decisions and share power (Lebel *et al.*, 2006). In the context of climate change, Diaz (2006) argues that governance involves the allocation and distribution of resources, not only of natural resources but also of those economic, social and political resources that are fundamental for coping with new climatic conditions. In this light, the process of developing successful adaptation, in which governance plays a fundamental role, entails the organisation of material and human resources. Governance combines institutions and organisations. This work follows North's (1990) demarcation between institutions and organisations. Institutions are the "rules of the game", consisting of both the formal regulatory rules and the informal social norms that govern individual behaviour and structure social interactions. Organisations are the groups of people and the facilities they create: companies, universities, ministries, clubs and unions are some examples.

Different governance concepts have been advocated recently to cope with climate change. Adaptive governance, for example, focuses on experimentation and learning and brings together research on institutions and organisations for collaboration, collective action, and conflict resolution in relation to natural resource and ecosystem management (Folke *et al.*, 2005). Biermann (2007) called for 'earth system governance' to analyse and design governance systems that can respond to future climate change, and in particular adapt to conditions that are projected to exceed in scope and quality most of what is known today. Earth system governance is defined as 'the sum of the formal and informal rule systems and actor-networks at all levels of human society that are set up in order to influence the co-evolution of human and natural systems in a way that secures the sustainable development of human society'. Biermann (2007) introduces earth system governance by outlining three elements: problem structure, governance principles and research challenges (see Table 5.1). This conceptualisation provided the organisational framework for the 2007 and the 2009 Amsterdam Conference on Human Dimensions of Global Environmental Change. Moreover, it has become the basis for the Earth System Governance Project (Biermann *et al.*, 2009), a new initiative of the International Human Dimensions Programme on Global Environmental Change (IHDP).

This chapter aims to contribute to the broader understanding of governance systems that facilitate adaptation to climate change. To do so, it discusses Biermann's (2007) conceptualisation of earth system governance by applying it to floodplain management in the Hungarian Tisza River Basin. It uses results from a series of workshops and semi-structured interviews with representatives of national and local organisations (ministries, water authorities, planning agencies, NGOs and academic organisations) on the development of the new floodplain management plan and the barriers and opportunities for its implementation. In addition, primary regional literature sources and secondary literature on floodplain management have been reviewed. Notwithstanding their diverse background, the interviewees agreed unanimously that the new floodplain management plan is a promising plan that puts flood protection measures and land-use changes in the overall perspective of regional development and adaptation to climate change. Yet, implementation does not comply with the initial design. By applying the recent conceptualisation of earth system governance (Biermann, 2007) to floodplain management in the Tisza region, this chapter seeks to answer:

1. Does floodplain management in the Tisza basin constitute a valid case for earth system governance in view of the problem structure of earth system governance?
2. If so, are the overarching principles for earth system governance met in the Tisza case and can lessons be drawn for the conditions that a governance system has to satisfy to facilitate adaptation?
3. Does the Tisza case suggest additional problems, principles or research challenges for earth system governance?

The chapter first introduces the Tisza region. Then drivers, barriers and opportunities for adaptive floodplain management in the Tisza River Basin are examined. Finally, lessons are drawn from the comparison of earth system governance and Tisza floodplain management. The chapter shows that a regional example of natural resources management can offer a valid case for earth system governance. Current barriers to floodplain management are well explained by a lack of the key governance principles of credibility, stability, inclusiveness and adaptiveness. The material from the Tisza region justifies additional attention for subsidiarity, creating networks and cooperation across scales, open access to information, risk mitigation, benefit sharing and compliance. With respect to the research challenges in Biermann (2007), actors express a particularly strong interest in the development of agencies beyond the state.

Table 5.1: Conceptualisation of earth system governance

Source: After Biermann (2007)

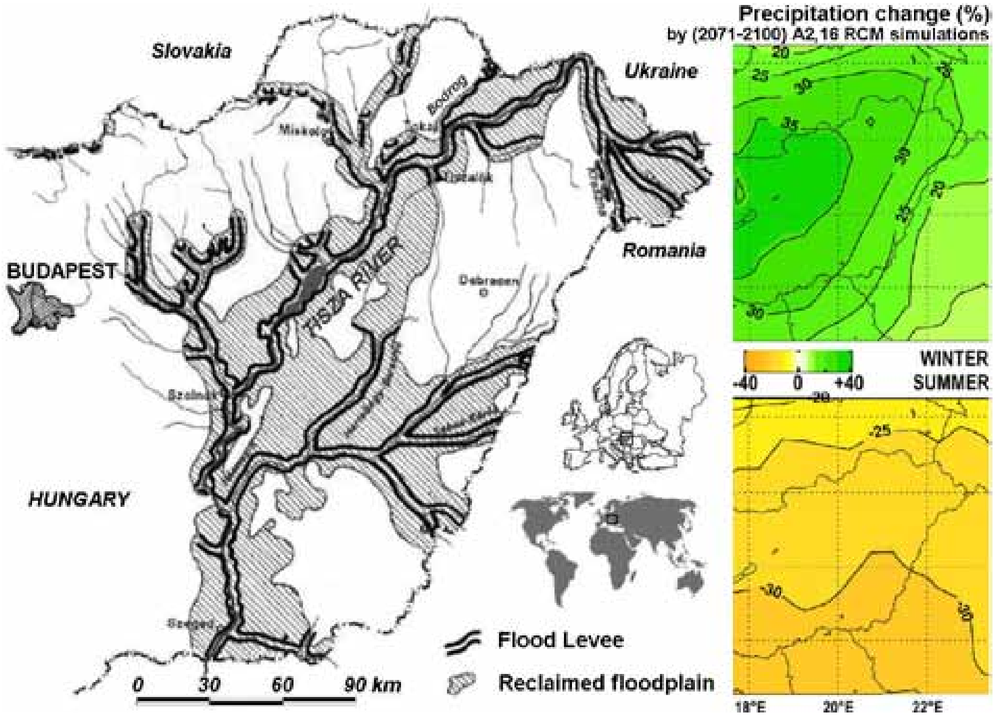
Problem structure - Earth system governance must cope with at least five problem characteristics:
1. Uncertainty: Persistent uncertainty regarding the causes of global environmental change, its impacts, the interlinkage of causes and response options, and the normative uncertainty of what governance outcomes are desirable for unprecedented problems. **2. Functional Interdependence**: Response strategies in one problem area or one policy domain are likely to have repercussions for other subsystems—linking, for instance, climate change to biodiversity or land degradation—as well as to the interdependence of social systems and policy areas. **3. Spatial Interdependence**: The anthropogenic transformation of the earth system creates new natural (direct) and social (indirect) interdependencies. Spatial ecological interdependence binds all nations and creates a new dependence of states. **4. Temporal Interdependence**: Cause and effect of earth system transformations are usually separated by decades, often by generations. **5. Extreme impacts**: An extraordinary and unprecedented degree of harm that current governance systems may not be prepared for.
Governance principles - Four core principles of earth system governance:
1. Credibility: Actors must be able to commit resources and rely on reciprocity. **2. Stability**: Actors must be able to rely on the normative governance framework over years, not-withstanding political change and the problem characteristics listed above. **3. Adaptiveness**: Within the stable framework, actors must have the ability to change governance elements to respond to new situations, without harming both credibility and stability of the system. **4. Inclusiveness**: As inclusive as possible regarding stakeholder involvement.
Research challenges – Five research areas to guide earth system governance:
1. Architecture: Structure and effectiveness of the interlocking web of principles, institutions and practices that shape decisions by stakeholders at all levels. **2. Agency beyond the state[1]**: Consent and involvement of actors beyond governments and state agencies. **3. Adaptive state[2]**: State able to adapt internally and externally to large-scale transformations of its natural environment. **4. Accountability and legitimacy**: Institutions that confer legitimacy and accountability to all stakeholders and its constituencies. **5. Allocation**: Fair and equitable allocation mechanisms for resources and values.

1 *The recent Science and Implementation Plan of the Earth System Governance Project (Biermann et al., 2009) extends this research challenge to 'agency' in general, with a focus on actors outside national governments.*

2 *The Science and Implementation Plan of the Earth System Governance Project (Biermann et al., 2009) develops this research challenge as 'adaptiveness'.*

5.2 Tisza River floodplain management

The Tisza River is the largest tributary of the Danube, receiving water from the Carpathian Mountains in Romania, Slovakia and Ukraine. Until the 18th century, socio-economic activities were mainly organised around the operation of a system of creeks and channels regulating the water flow between the main riverbed and the floodplain. The floodplains provided a secure income for the communities along the river, combining plough land, forest, orchards, grazing and fishing (Andrásfalvy, 2000; Bellon, 2004). Since then the river has been straightened and the floodplains drained to cater for large-scale mono-agriculture and river transport. The major modifications of the Tisza Basin were introduced by the Vásárhelyi Plan implemented in the 19th century by the Hungarian government under the Austro-Hungarian Empire. The communist era after the Second World War supported the large-scale intensive agriculture in the region, neglecting the traditionally important extensive livestock keeping. A powerful water bureaucracy controlled water management. Privatisation at the beginning of the 1990s led to a drop in the operation and maintenance of the large irrigation systems and in agricultural output. At present, much of the river is constrained by levees (Figure 5.1). The main land uses are intensive agriculture, wetlands and meadows (in Hungarian *puszta*). Scientists increasingly associate the prevailing water management of river regulation and drainage with problems such as risen flood risk, inland drought, water stagnation, soil salinisation, the degradation of peat lands and wetlands, and the loss of the traditional water management system and the related production systems (Barta *et al.*, 2000; Vámosi, 2002; Bellon, 2004; Fejér, 2004). Climate change projections suggest more irregular rainfall and a warmer climate in the Carpathian basin (Láng, 2006; Bartholy *et al.*, 2007), aggravating the three main water-related problems of the Tisza region: floods, in-land water stagnation and droughts (Barta *et al.*, 2000; Koncsos and Balogh, 2007). Socio-economic challenges include high unemployment rate, ageing, migration and inclusion of the Roma minority (Sendzimir *et al.*, 2004; Linnerooth-Bayer *et al.*, 2006). More promisingly, the region has an emergent potential for recreation and nature conservation (Vári *et al.*, 2003).



Source: after Szlávik and Ijjas (2003) and Bartholy et al. (2007)

Figure 5.1: Hungarian Tisza River Basin and projected change in average precipitation by 2071-2100 in SRES Scenario A2 using 16 regional climate models (RCM)

Already challenged by recurring flooding events, projections of an increased incidence of floods and droughts (Szlávik, 2001a) have been a driving force behind a new water management plan for the Hungarian Tisza River: the New Vásárhelyi Plan (VTT). The first version of the plan in 2001 focussed on flood protection and was mainly the work of the water authority. Its main innovation was the introduction of retention reservoirs, as national water experts largely agreed that raising dykes was no longer efficient from an economical perspective and likely to increase flood levels (Glatz, 2003; Váradi, 2003). In autumn 2002, a new NGO Bokartisz Public Utility (www.bokartisz.hu) in collaboration with other civic organisations along the Tisza asked for a review of the plan. At the same time they promoted their own shallow flooding based floodplain management concept to replace or complement the engineering solutions in the plan's first version (Botos *et al.*, 2002). This concept was inspired by traditional water management and ongoing local experiments, and emphasised that floodwaters can be used for the benefit and development of rural populations. In February 2003 the national government ordered by decree (number 1022/2003) that in the further development of the water plan, flood retention reservoirs were to be combined with floodplain rehabilitation, rural development and nature conservation (VITUKI, 2004). A large group of regional and national actors collaboratively prepared the implementation of the new water plan. Floodplain areas and smaller water bodies were identified for water retention and rehabilitation together with rural development (Figure 5.2). Major decisions were taken

Figure 5.2: Oxbow lake: traditional water management used oxbows and creeks for water regulation

by the inter-ministerial committee led by the Ministry of Environment and Water, to which representatives of the region and of civic organisations were invited (Werners *et al.*, 2009b; Chapter 6). The resulting implementation plan marked a substantial shift in land use and water management as it supported a change from intensive agriculture protected by flood levees, to water retention areas with floodplain rehabilitation and extensive livestock keeping or orchards. With the 2004 Tisza Law, the national government endorsed the implementation. Endorsement notwithstanding, since then only two of the first six retention reservoirs have been built (Figure 5.3). The engineering works are prioritised over rural development and floodplain rehabilitation related activities. In 2005, the survey of the State Audit Office of Hungary found under-spending and loss of harmonisation of flood protection and rural development objectives (Kovácz, 2005; Origo Newspaper, 2005).

Figure 5.3: Construction of the outlet of the first retention reservoir

Actors identified different reasons for the delays in the implementation. Most commonly mentioned are the reduced state budget, time consuming and costly project preparation and a lack of coordination during implementation (cf. ICPDR, 2008; Visnovitz, 2008). More specifically, the inter-ministerial committee – the main coordination body for the development of the plan - had neither an official legal position nor the mandate to allocate money for implementation. From the middle of 2004, the frequency of the inter-ministerial committee sessions and the consultation of stakeholders dropped. With it, the transparency of the planning process deteriorated (Cselószki, 2006). Application for European Union (EU) support caused additional delays, as the government postponed implementation to be able to apply for EU funds (Visnovitz, 2008). The Ministry of Environment and Water used available funds to move ahead with flood protection (Cselószki, 2006), not delivering on agri-environmental payments for affected farmers, which required support from the Ministry of Agriculture and Rural Development. In addition, the preparatory works (e.g. to reach agreement with stakeholders on land acquisition and the mandatory archaeological surveys) needed more time and were more costly than planned (ICPDR, 2008). The conditions laid down by local leaders and farmers for the acceptance of the retention reservoirs, ranging from infrastructural investments, one-off compensations or warranted agri-environmental payment, made it clear that it would be impossible to build flood reservoirs without the government providing other (rural development and agri-environmental) support (Cselószki, 2006). The next section analyses the drivers, barriers and opportunities for floodplain management in more detail, using the conceptualisation of earth system governance.

5.3 Drivers, barriers and opportunities for floodplain management

This section applies earth system governance (Table 5.1) to the Tisza study region in three steps. Section 5.3.1 compares the key water and land use related problems in the Tisza region to the definition and key problem structure of earth system governance to assess whether adaptive floodplain management in the Tisza region is a valid case for earth system governance. Section 5.3.2 compares the development and (barriers to) the implementation of floodplain management to the key earth system governance principles to assess whether these governance principles (or the lack thereof) explain the successful development and the slow implementation process. Finally, Section 5.3.3 compares options for furthering the implementation of floodplain management identified by representatives of regional and national organisations, to the research challenges for earth system governance. It does so to assess whether earth system governance research – when guided by these research challenges - will support the representatives' options and / or suggest new directions for the development of governance systems for adaptive floodplain management.

5.3.1 Problem structure: drivers of floodplain management

The Hungarian government considered the new floodplain management plan a sound starting base for flood protection, rural development and environmental protection (VITUKI, 2004). Representatives from the Tisza region in interviews and workshops confirmed their objective to make land use and water management more sustainable and climate proof with the new plan. Actors stressed that the plan's implementation requires setting up formal and informal rules and actor-networks from the regional level to the national and European level. Thus, the goals of floodplain management and the quest for a governance system that can support these goals are compatible with the definition of earth system governance in Biermann (2007).

5.3.1.1 Uncertainty

Individual, social and political uncertainty is increasing. Climate projections for the Tisza basin suggest a redistribution of precipitation over the year, with the wettest season shifting from summer to winter. Projections differ significantly between regional climate models and scenarios (Bartholy *et al.*, 2007) adding to the uncertainty water management has to cope with. Next to uncertainty in the occurrence of floods and droughts, actors are concerned about impacts on water quality (e.g. eutrophication at low flow, or toxic spills during floods), income inequalities (e.g. direct impacts on agribusinesses and indirect through access to compensation schemes) and social tension (e.g. Roma minorities, who often live in flood prone areas). Uncertainty about compensation schemes, property rights, the virtual non-existence of insurance schemes as well as non-compliance with existing regulation (e.g. for building recreation facilities in the floodplain) add to the uncertainty that individuals experience and the willingness of individuals to engage in community action. The slow implementation of nationally agreed programs such as the VTT plan adds to the political uncertainty that actors experience.

5.3.1.2 *Functional interdependence*

The area is struggling socio-economically and –ecologically and attachment of inhabitants to the region is waning. The interests of the local population in participation and solving problems has weakened. There is a strong tendency to move away from the region, especially among young people (Fekete, 2006). Regional and national actors stressed that due to the relatively poor socio-economic conditions in the Tisza region, the region is vulnerable to climate change and has less means to improve adaptive capacity. The weak socio-economic position also limits the capacity of the region to absorb external subsidies (Fekete, 2006). Water and land-use management are tightly connected to regional development through, amongst others, agricultural production, energy production and infrastructure, requiring regional development to be included in adaptation planning. A number of the interviewees felt that globalisation and monoculture have disrupted markets amenable to seasonal products and the interdependence between the rural and urban subsystem. They argued that at present, local parties respond to the interests of 'outside' parties exploiting the area rather than to climatic conditions and soil and landscape characteristics.

5.3.1.3 *Spatial interdependence*

The area strongly depends on local, regional, national and transboundary cooperation. Spatial interdependence reaches from the waning local cooperation to the national and transboundary setting. Transboundary interdependence includes the impacts of deforestation in Ukraine and toxic spills in Romania on the water quantity and quality in Hungary. Institutionally, the region is subjected to overlapping policies and regulations from the global and EU level down to the county and municipal level (Temesi, 2000). The project area of the VTT plan stretches over seven administrative regions (counties). In five of these it lies in the periphery. Development of the Tisza floodplain is not a high national or regional priority. Together with the centralised planning and budget allocation this has caused systematic under-funding. The implementation of the VTT plan depends heavily on European (co)funding. More especially, the dependence on European governance and financial mechanisms is largely one sided.

5.3.1.4 *Temporal/Intergenerational interdependence*

Current land-use patterns conflict with the natural capacity of the area to adapt to (climate) change. The river and its floodplains have been heavily modified. These changes have disrupted the natural river system and the ecosystem services it delivers. The capacity to buffer flood water has been reduced along with the diversity and abundance of local products such as fish and fruits (cf. Sendzimir and Flachner, 2007). Thus the historical context of the problems and traditional experience of coping with floods and droughts are of great importance. Some interviewees stressed that adaptation of the current flood and drought prone land is particularly difficult because the foundations of the prevailing water management regime of flood levees and drainage have to be changed. Another time-related problem is coping with different implementation speeds. Flood protection measures were made operational relatively quickly, whereas land-use change is taking more time as it requires the cooperation of many land users and land owners, and the implementation of supporting agri-environmental schemes.

5.3.1.5 *Extreme impacts*

Extremes are more frequent. Recently, scientists have shown that the water management solutions of the last 150 years are not sustainable, that the current flood defence system has reached its limits, and higher floods cannot be accommodated using engineering measures alone (Timár and Rácz, 2002; Balogh *et al.*, 2005). The more frequent and irregular floods and droughts in the region (Timár and Rácz, 2002; Láng, 2006) and the expected increase of flood damages (Koncsos and Balogh, 2007) are important drivers calling for floodplain management in combination with regional development.

5.3.2 Lack of governance principles: barriers for floodplain management

5.3.2.1 *Lack of credibility*

The different elements of the VTT plan are implemented at different speeds. The implementation of agri-environmental measures is lagging behind implementation of the flood protection measures. Although the VTT was given priority by the national government in the Environmental Protection and Infrastructure Operational Programme 2004-2006 (National Development Agency, 2005) and the National Rural Development Plan (Government of Hungary, 2007), it did not receive sufficient funding (cf. Kovácz, 2005). Financing depends heavily on the state budget, whilst EU accession and a budget deficit force the Hungarian government to cut expenses. How the national government makes use of EU funds conflict with what is needed for implementing the VTT plan (e.g. the focus is on the transport sector for the cohesion fund and on Pillar I in the EU's common agricultural policy instead of the agri-environmental payments). After the first enthusiastic approval, the cost of the measures (e.g. financial support for land-use change and land acquisition), were considered too high. In addition, parties that were contracted for the design of the plan were paid late or not at all. The unbalanced and delayed implementation has eroded the credibility of the national government for regional actors, especially for those who conditionally accepted the construction of flood reservoirs.

5.3.2.2 *Lack of stability*

From a government approved development program the new floodplain management plan became a political debate. Authorisation of the plan and land acquisition took longer than expected. EU accession and the accelerated implementation of European directives and legislation have added to the complexity of organisational responsibilities and financial flows. Divergence in the objectives and mandates of organisations has slowed down implementation. Although fragments of the VTT plan are included in the new national development plan, it is not included in the (regional) operational programs that are crucial for the allocation of funds. Stability of the implementation is also threatened by discontinuities in the availability of financial resources, which were more readily available after a flood, prioritising repair of existing flood protection works over prevention and proactive measures. Although a lack of stability is perceived problematic, a period of political instability after major floods and elections offered actors an opportunity for negotiating the shift in policy objectives and planning procedures for which the VTT is known (Werners *et al.*, 2009b; Chapter 6).

5.3.2.3 Lack of adaptiveness

The sectoral approach and disagreement between ministries on how to prioritise regional plans and spend available funds led to an impasse at the start of the implementation. Existing financial instruments have not been changed to support floodplain management but continue to favour intensive agriculture that depends on flood levees and drainage, and non-sustainable land use (e.g. compensation for agriculture in waterlogged areas). Almost twenty years after the communist era, large areas still have unclear property rights and the responsibility for water system maintenance and taxation is unresolved. In addition, interviewees report that their dependence on global markets and regional infrastructure hampers adaptation of land use to local conditions.

Partners in the design of the new plan have not been able to adapt to a new role in the implementation and operation of floodplain management. This was attributed in particular to some of the NGOs and the water authorities. A complicating factor here is that responsibilities for floodplain management were ill defined and facilities such as a local implementation office under-funded.

5.3.2.4 Lack of inclusiveness

After the development phase of the VTT plan the expectations in the region were very high. Yet, the inclusive involvement of different sectors in the design of the new plan has been disrupted in its implementation. For example, the Bokartisz coalition of municipalities, NGOs and scientists was actively involved in the development of the plan but could not secure a formal role in its implementation. Decisions (financial) about the implementation were taken centrally without formally consulting local representatives. Interviewees from the region report delays that are not recognised by interviewees at the national level. Actors are pointing to each other to take responsibility and allocate resources. People living in the area increasingly fail to see their interests represented in the implementation of the plan. This has strengthened actors in following their own interests, neglecting the concerns of others and the area as a whole. Land ownership and nature conservation interests hindered the selection of the most efficient retention areas from the water authority's perspective, adding to the frustration between national and local actors. Although not mentioned explicitly in Biermann (2007), another element of inclusiveness is that information on planning and on risks and benefits is not shared equally among actors.

5.3.3 Research challenges: opportunities for floodplain management

5.3.3.1 Architecture

The interviewees agreed there is a general need to evaluate the current governance system for its support of adaptive floodplain management. This includes the architecture of the mandates and responsibilities of the parties involved at different organisational levels as well as detailed elements of the legislative structure such as, for example, how land is classified under the agri-environmental schemes. With respect to the architecture of adaptive floodplain management, most interest goes into clarifying the roles of different parties in VTT plan implementation (at all levels of governance including civil society) and creating a mandated organisational structure responsible for the implementation, the securing of finances, the facilitation between different parties and/or auditing the project implementation. Actors disagree whether to establish national coordination through: i) one strong coordination office above the ministries, ensuring that elements of the VTT plan are included in the appropriate regional operational programs, ii) a revitalised inter-ministerial committee for strategic coordination and harmonisation, working with representatives of ministries, regions, NGOs and planners, supported by an operational and mandated coordination unit, or iii) a coordinating working group chaired by the national development agency with representatives of the operational programs.

5.3.3.2 Agency beyond the state

Most interviewees called for clarifying the roles of non-state actors as part of the evaluation and the architecture of the governance system. An alternative to national coordination of the VTT implementation is to establish a multi-stakeholder implementation agency with half state representation, half other stakeholders. The Tisza Alliance (www.elotisza.hu) that was established in June 2006 could play a role in representing regional and local actors. With these new agencies come questions of how to ensure the accountability and legitimacy of the governance systems (see Section 5.3.3.4). Next to redefining *formal* relationships, governance and participation, actors identified options to strengthen *informal* relations and cooperation between agencies beyond the government. Nationwide a "Hungarian Water and Climate Alliance" could be established as a national umbrella to continue building bridges between the climate and water sector, encourage capacity development to better cope with climate impacts and facilitate preparing and obtaining financial support for national, basin and regional level adaptation plans. Informed multi-stakeholder dialogues were proposed for debating climate related risks and how best to respond. Interviewees suggested restoring reciprocity between (flood prone) urban areas and rural areas willing to engage in water retention, for instance by letting cities invest in water retention, consonant with local interests and practices. Public-private partnerships can enable land-use change by supporting the full chain of land use related products. For example, if floodplain meadows are restored together with livestock keeping, milk and meat production will increase and market infrastructure is needed to support this.

5.3.3.3 Adaptive state

Interviewees identified many options to change state governance, especially in relation to architecture (Section 5.3.3.1) and allocation (Section 5.3.3.5). Although some of these options aim to make non-state actors more adaptive, few options were suggested to create what Biermann (2007) calls an adaptive state. One suggestion on how state regulation could become more adaptive is in allowing occasional flooding to be taken into account in the land classification schemes underlying agri-environmental subsidies. However, recent experiences have made non-state actors question the feasibility of a legitimate and accountable adaptive state. These include the delays introduced by the national government in order to adapt to the availability of national and EU funds, and the re-evaluation of the implementation plan and the associated Tisza Law that non-state actors feel has eroded the VTT plan's ambition.

5.3.3.4 *Accountability and legitimacy*

Accountability and legitimacy are important governance challenges in Hungary. Over the last two decades Hungary has evolved from a communist state to a post-communist democracy and EU member, where remnants of previous economic and political orders still shape expectations and patterns of conduct (Pérez-Solórzano Borragán, 2005). At the end of the 1980s the national government was the only legitimate representative of the country's interests. In the following decade, the Hungarian public administration was reformed and its functions were shared by two main systems. The first includes central government bodies and their organs at the local and county level, such as the water boards, that are subordinate to the state administration. The second system consists of local self-government, based on the principles of decentralisation and autonomy. This has created competition for the fulfilment of functions at the local level (Temesi, 2000). The decision of the budget-constrained national government to tender operational water management under the new water plan has at present undermined the legitimacy of parties involved. The accession experience, and the domestic political and socio-economic changes encouraged a growing pluralist representation by numerous interest groups. Yet there is confusion regarding the nature and identity of these interest groups. Organisations representing similar interests struggle to create a common front and even question each other's legitimacy, while decision-makers try to come to terms with the variety or groups (cf. Pérez-Solórzano Borragán, 2005).

Against this background, actors identified a number of options to improve accountability in relation to floodplain management. Actors reported the need for a nationwide consensus about the measures in the development plans, including a land-use vision and land consolidation program together with its legislative support. Stakeholder consultation and information sharing on progress and operational management has to be improved and is a crucial responsibility of the body coordinating floodplain management – be it a governmental organisation or an agency beyond the state. In addition, government bodies are to recognise accountability for policy coherence, for example by encouraging extensive biomass production in the floodplain and by refraining from the deforestation of native forests for flood control.

5.3.3.5 *Allocation*

With respect to the allocation of resources, interviewees suggested the strengthening of the link between floodplain management and the regional development programs. The allocation of resources is closely connected to the land consolidation challenge that the Tisza region is facing. Restitution of property and different forms of privatisation were considered crucial to the creation of new market institutions under post-communist reforms (Horváth and Kiss, 2000). Notwithstanding the success of the land reform process, land fragmentation and mounting transaction costs (associated with large numbers of lease contracts) emerged as side effects detrimental to private and public investments, sustainable economic growth and social development (Riddell and Rembold, 2000). In the less-developed agricultural areas of the Tisza Basin, this has resulted in social and economic disintegration and widespread disappointment among local actors and stakeholders. Fragmentation of property rights has complicated land acquisition during the implementation of the water plan and perceived fraud has added to mistrust. The costs and benefits of land-use change and floodplain management have to be shared between many parties at different scales. A re-evaluation of resource allocation is crucial for floodplain management and includes the clarification of property rights and the use of EU funds in various sectors of the Hungarian economy (such as common agricultural policy schemes, cohesion funds, and support for 'less favoured areas' (cf. Dax, 2005) and Natura2000).

5.4 Discussion and conclusions

This chapter applies Biermann's (2007) conceptualisation of earth system governance to adaptive floodplain management in the Hungarian Tisza River Basin. It discussed the three main elements of the conceptualisation: problem structure, principles and research challenges.

The key ***Problem Structure*** '*Uncertainty*', '*Functional, Spatial and Temporal Interdependence*', and '*Extreme effects*' applies well to the key water related problems in the Tisza region. The major problems identified can all be associated with one or more of the key problems for earth system governance. Representatives of regional and national organisations confirmed that the overall objective of the new floodplain management plan is to support sustainable livelihoods in the region. This shows that the Tisza region constitutes a valid case for discussing earth system governance. The following observations are made with respect to the different components of the problem structure. In line with Root (2005) it is helpful to recognise sources of fundamental *uncertainty* that make it difficult to price climate related risks for government as well as private actors, to use cost benefit approaches to prioritise adaptation options and to accept and implement land consolidation schemes. How uncertainty is shared and transferred between actors in society deserves special attention. The *functional interdependencies* in the Tisza generally have both a *spatial* and *temporal* component. To what extent distinguishing between these interdependencies adds to the analysis remains ambiguous. An important extension of the temporal interdependence is that the root cause of present problems, vulnerabilities and inequalities often lies in unsustainable management of resources and state coordinated interventions in the past. Adaptation of the governance system may require a deeper change than maintaining the current resource base for future generations. Of particular importance are the remnants of previous economic, social and political orders that continue to shape expectations and patterns of conduct. This path-dependency deserves more attention in earth system governance. Another interdependency highlighted in the Tisza case is the growing domination of urban areas over rural areas. The Tisza region suggests that interdependencies are not only a problem, but that creating and restoring mutual dependency could also be one of the key principles for earth system governance. This holds for socio-institutional as well as socio-ecological interdependencies. The relatively well-preserved natural environment of the Tisza region can only become a real asset in terms of the sustainable development of the region if this asset is known, has been explored and is appreciated (cf. Fekete, 2006). Problems exist on all scales and care has to be taken not to associate adaptiveness and sustainability a priory with a particular scale or production system but rather to explore opportunities across scales (cf. Born and Purcell, 2006).

The barriers to adaptive floodplain management that actors report on in the Tisza region are well explained by a lack of the four ***Governance Principles*** '*Credibility*', '*Stability*', '*Adaptiveness*' and '*Inclusiveness*'. From the four principles, *adaptiveness* was mentioned least. The lack of *stability* is presently seen as a bigger barrier to the realisation of adaptive floodplain management. This can be explained from the perceived uncertainty and a lack of inspiring examples of adaptive governance. In particular, the Tisza case shows the tension between adaptiveness and stability. The lack of stability after major floods and elections offered opportunities for new networks to emerge and kick off policy change (Werners *et al.*, 2009b; Chapter 6). It is the lack of stability of the new networks and arrangements as much as the lack of adaptiveness of the institutions supporting conventional flood protection solutions that frustrates the actors aiming to implement floodplain management. The paradox of stable adaptive floodplain management is further complicated by a loss of accountability and credibility. Limited legislative support for long-term preventive actions is an important barrier for adaptive floodplain management. The lack of *credibility*, coordination and effective cooperation between organisations was perceived to be the largest implementation barrier. With respect to *inclusiveness*, evidence from the Tisza region confirms that cooperation in plan design facilitated consent and joint understanding, yet negotiated land-use patterns are not necessarily the most efficient in terms of flood risk reduction and floodplain management. Adaptive floodplain management requires interventions at the landscape scale, calling for cooperation of many actors, land consolidation programs and compensation. The associated benefits and costs are often difficult to compare or share between actors. To convince local partners as well as national development agencies to cooperate, the cost and benefits of multifunctional land use and water retention in the floodplain have to be evaluated against monoculture and flood levees. To remain credible, any governance system has to deal with enforcement and in the case of floodplain management, possibly expropriation. The Tisza case suggests that the four governance principles can perhaps best be seen as necessary but insufficient for earth system governance. Recognition is also recommended for subsidiarity, reciprocity, creating networks and cooperation across scales, coordination and leadership, open access to information, risk mitigation, benefit sharing and compliance.

Guided by the five ***Research Challenges*** '*Architecture*', '*Agency beyond the state*', '*Adaptive state*', '*Accountability*' and '*Allocation*', earth system governance research will be able to inform many options that actors identified to advance floodplain management. The reality that all research challenges are recognised by actors in the Tisza region indicates not only that they are all relevant but also that they cannot be studied in isolation and have to be addressed together. This observation is supported by the perceived overlap of the research challenges. From the five research challenges the *adaptive state* was mentioned least. It should, however, not be concluded that the adaptive state or the overarching concept of adaptive governance (Folke *et al.*, 2005) is less relevant, as it explicitly aims to respond to the key problem characteristics of earth system governance that are well recognised in the Tisza region. Rather the results from the Tisza region suggest that the adaptive state is a relatively new concept that needs to be demonstrated to gain in appreciation. Its institutions will have to be designed and research on this topic may inspire new options to be considered in adaptive floodplain management.

The Tisza Alliance that was established in June 2006 is an example of how state actors and non-state actors can cooperate to realise an *agency beyond the state* that supports sustainable livelihoods in the Tisza region (Chapter 6). A challenge for agencies beyond the state is to ensure accountability and legitimacy through formal regulation and informal relations.

Regulation is required to include adaptation in longer term planning, investment and large-scale infrastructure. Whereas informal relations are conducive to strengthening learning, autonomous adaptation and adaptive capacity (cf. Matczak *et al.*, 2008). The *allocation of resources* is closely related to the land consolidation challenge that the Tisza region is facing. The costs and benefits of land-use change and floodplain management have to be shared between different parties (at different scales). Actors search for an effective mix of compliance and compensation.

The main conclusions of the analysis are that a regional case study can inform earth system governance research and that Biermann's (2007) conceptualisation of earth system governance offers a comprehensive framework to discuss drivers, barriers and opportunities for adaptive floodplain management. It is felt, however, that the conceptualisation is less well equipped to inform the prioritisation of barriers to be removed, to cope with trade-offs between governance principles and to identify necessary and sufficient conditions for credible, inclusive, stable *and* adaptive floodplain governance. A remaining challenge for earth system governance is to support an existing governance system and its actors to set the necessary priorities to adapt to change. This is investigated in the next two chapters with respect to the role of supporters and opponents of water policy change.

Chapter 6

Individuals matter: Exploring strategies of individuals to change Tisza River water policy in Hungary

Abstract

This chapter offers a new interpretation of the introduction of floodplain rehabilitation and rural development into the water policy for the Tisza River in Hungary. It looks at the role of individuals and the strategies that they used to bring about water policy change. Five strategies are explored: developing new ideas, building coalitions to sell ideas, using windows of opportunity, playing multiple venues and orchestrating networks. This chapter discusses the importance of each strategy and the individuals behind it, based on interviews, group discussions and literature review. The international and political attention sparked by a series of floods, dyke failure and a major cyanide spill followed by national elections, opened a window of opportunity for launching ideas. A new regional coalition successfully introduced floodplain rehabilitation into the water policy arena. The analysis emphasises the importance of a responsible civil servant recognising a new policy idea at an abstract level and a credible regional coalition that advocates the new idea regionally.

Keywords: Individual actor, coalition, water policy change, transition, Tisza River, Hungary

Chapter based on:

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And:

Werners, S.E., P. Matczak and Z. Flachner (2009) The introduction of floodplain rehabilitation and rural development into the water policy for the Tisza River in Hungary. In Water policy entrepreneurs: A research companion to water transitions around the globe (eds Huitema, D. and S. Meijerink), pp. 250-271. Edward Elgar Publishing, Camberley, UK - Northampton, USA.

The whole world had already been created when the Tisza was standing alone before the Lord's throne. Then Jesus took a golden plough, harnessed a donkey to it and told the Tisza to follow. Thus he set the plough against the soil and ploughed the bed for the river, which followed faithfully everywhere. However thistles were scattered all around. The donkey that was feeling hungry, reached after one and then another, leaving the straight path. This is why the Tisza is so unpredictable, so winding and meandering.

Hungarian folk tale

6.1 Introduction

This chapter analyses the early 21st century transition in the water policy for the Tisza River in north-eastern Hungary. In the spring of 2003, the Hungarian government issued a decree that marked a substantial shift in water management. The new water policy for the Tisza River recognised rural development and nature conservation as important objectives side-by-side with flood protection. Floodplain rehabilitation and land-use change were introduced as water management measures to replace or complement the prevailing engineering approaches that primarily favoured flood levee construction. From an external perspective, this was surprising given a 150-year history of water management mainly through river normalisation, flood levees and drainage of floodplains, where water policy had mostly served the interests of large-scale agriculture.

The chapter attempts to explain what happened in the period leading up to the breakthrough year of 2003 and in the subsequent years, when actors had to realise the direction taken in the new water policy. The development of the new water policy (called the New Vásárhelyi Plan) between 1998 and 2006 is the main object of investigation. The changes in water policy for the Tisza have been described before, for example, from a governance point of view (Werners *et al.*, 2009a; Chapter 5). This chapter takes a new angle, specifically assessing the role of individual actors and the strategies that they used in bringing about policy change.

The chapter builds on the research carried out in a series of Hungarian and international research projects. Data were collected in three ways: through twenty interviews with actors from national and regional organisations (ministries, water authorities, planners, academic institutions, non-governmental organisations (NGOs), municipalities, and farmers); a series of group discussions with local and national stakeholders; and by analysis of policy and project planning documents and background studies.

First, an account is given as to why the water policy changes can be called a transition. Next the changes are described from the perspective of five strategies (Huitema and Meijerink, 2009):

1. Developing new ideas (cf. Hajer, 1995; Baumgartner and Jones, 2002; van der Brugge *et al.*, 2005),
2. Building coalitions for selling ideas (cf. Sabatier, 1988; Folke *et al.*, 2005; Olsson *et al.*, 2006),
3. Recognising and exploiting windows of opportunity (cf. Kingdon, 1995),
4. Using multiple venues (cf. Baumgartner and Jones, 2002), and
5. Orchestrating and managing networks (cf. Folke *et al.*, 2005; Caniëls and Romijn, 2008).

A discussion follows on the importance of each strategy and a review of the individuals found to use it. The analysis shows the importance of, firstly, responsible civil servants recognising a new policy idea at a conceptual level and, secondly, a credible regional coalition advocating the policy concept. The international attention and domestic political focus following the 2000 cyanide disaster on the Tisza River, the 2001 floods, and the 2002 national elections provided a window of opportunity for adoption of the new water policy. Ambiguity about the practical application of new policy concepts and the responsibilities of different actors initially facilitated consensus on the new water policy, but has hampered its implementation since.

6.2 Tisza River Basin and the transition in water policy

A short historical overview of water management in the Tisza River Basin helps provide the context for and arguments why the changes introduced into Tisza water policy can be called a transition in water policy.

The Tisza River is the largest tributary of the Danube, receiving water from the Carpathian Mountains in Romania, Slovakia, and Ukraine. The Tisza River Basin comprises almost 50 per cent of Hungarian territory. Until the 18th century, river management was mainly organised around the operation of a system of small streams and channels regulating the water flow between the main river bed and the floodplain (Balogh, 2002). The inundation frequency determined land use. Mosaic floodplain production systems combined plough land, forest, floodplain orchards, meadows, fish, and cattle (Andrásfalvy, 1973). Since the 1750s, the Tisza River has been heavily modified. To cater for large-scale mono-agriculture, mills and river transport, the river was canalised and straightened, and the floodplains drained. The 19th century First Vásárhelyi Plan initiated the main changes. Dyke building, river regulation and floodplain drainage decreased the total naturally flooded area by 84 per cent (see Figure 6.1). These changes put an end to the traditional water management system and the related production systems on which communities along the river had relied (Bellon, 2004).

The reoccurrence and high visibility of floods caused resources to be funnelled into an extensive flood defence system (Vári, 2001). Over a period of 150 years, deforestation and river normalisation resulted in stronger river flow variation and, together with population growth in the low-lying reclaimed floodplain, added to flood risks (Fejér, 2004). Besides flooding, water management became associated with problems such as drought, water stagnation, soil salinisation, and the degradation of peat lands and wetlands (Vámosi, 2002). The communist era after the Second World War advanced large-scale tillage and agricultural production systems that required floodplain drainage. Privatisation at the beginning of the 1990s led to a drop in the operation and maintenance of the large irrigation systems and of agricultural output. At present, a high unemployment rate, ageing, and migration challenge the region socio-economically (Sendzimir *et al.*, 2004; Linnerooth-Bayer *et al.*, 2006). On a more positive note, the region has great potential for recreation and nature conservation (Vári *et al.*, 2003).

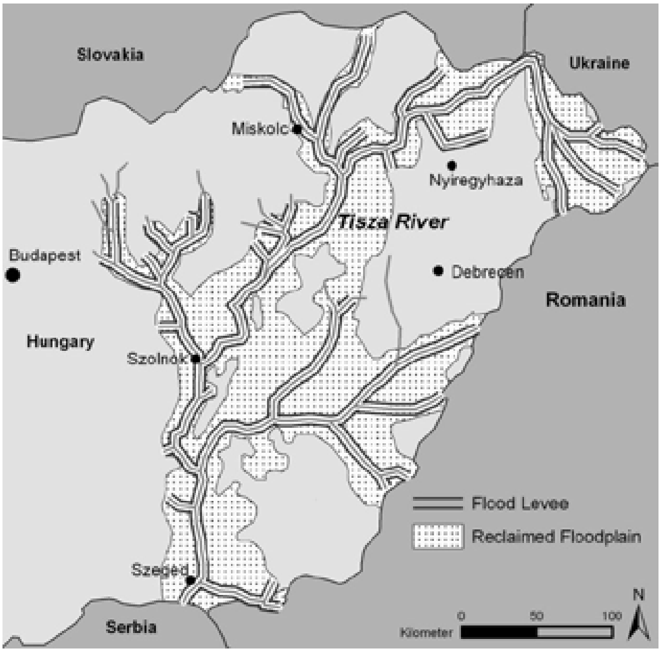


Figure 6.1: Tisza River Basin: river regulation has reduced river length by one third and the floodplain area by 80 per cent

The annual floods that returned in 1998 after twenty years of drought were a driving force behind the development of a new water policy for the Tisza River: the New Vásárhelyi Plan (in Hungarian: Vásárhelyi-Terv Továbbfejlesztése (VTT)). Interviewees distinguished three stages in the development and implementation of the VTT:

1. 1999 – 2001: The water authority and the Ministry of Transport, Communication and Water announced the first policy plan. The goal of the first policy plan was flood protection with nature conservation where appropriate. Mono-purpose flood retention reservoirs were the main innovation. The plan was mostly the work of the water authorities. National NGOs, such as WWF-Hungary, were invited to comment. Local NGOs protested against the plan, especially the new coalition Bokartisz.
2. 2002 – 2003: Intensive collaboration between government bodies, regional NGOs and research institutes. National government involvement was broadened and organised through an inter-ministerial committee chaired by the Ministry of Environment and Water (established after the 2002 reorganisation of the Ministry of Transport, Communication and Water) and involving the Ministry of Agriculture and Rural Development, the Regional Development Agency and other ministries (social, labour). Two Government decrees were passed. Government Decree 1022/2003 of February 2003 recognised the principles of floodplain revitalisation, nature conservation and rural development next to flood protection. It ordered development of an implementation plan for the first six retention reservoirs, including rural development and floodplain rehabilitation at local stakeholders' request. Government Decree, Oct. 2003 endorsed the implementation plan.

3. 2004 – Present: Implementation of the new policy. The approval of project sites is delayed. The implementation focuses on building emergency retention reservoirs. The associated rural development lags behind.

Why are the development and implementation of the new water policy called a transition in this chapter? Huitema and Meijerink (2009) postulate that a transition in water policy should become visible in a reorientation of the policy substance or the governance paradigm. The water policy endorsed in 2003 explicitly recognises rural development and nature conservation as important objectives alongside flood protection. Floodplain rehabilitation and land-use change were introduced to replace or complement flood levees that had been the preferred solution in water management for 150 years (Figure 6.2). The national planning agency VÁTI facilitated the intense collaboration of a large number of regional and national actors, preparing the implementation plan. This collaboration broke the hegemony of the water authority. Regional interests were represented by regional organisations such as the new Bokartisz coalition, founded in 2001 by the councils of twelve municipalities, three non-profit organisations (E-Misszió, the Hungarian Environmental Economy Centre and Palocsa Association) and individual scientists (www.bokartisz.hu). An inter-ministerial committee took major decisions, in consultation with regional and civic organisations. At the National Meeting of Environmental and Nature Conservationist Organisations in 2003, the environmental NGO E-Misszió was elected to be given full membership of the inter-ministerial committee, allowing them to make proposals, vote and veto. Actors involved report a "paradigm shift" or "new philosophy". The Government brochure for the new water policy captures this shift well in its text and new logo (Figure 6.2c). The brochure also introduces examples of the rural development and nature conservation component of the policy (VITUKI, 2004):

"The government has adopted on the 15 of October, 2003 a decision on the most ambitious rural development program of past decades [...] The program reflects a new government philosophy, in that it takes as far as possible into consideration the interests of environmental protection and nature conservation. [...] The complex project, the basic aim of which is to raise the living standards of the people in the Tisza Region, whilst ensuring a higher level of flood safety, would be accompanied by a number of important infrastructural developments. These include land drainage and sewerage, afforestation, construction of cycling lanes, as well as environment management schemes, such as creation of a mosaic landscape pattern by water routing, streamlet rehabilitation and conveying the water down the full length of the flood bed."

Photos: Werners, 2007

Figure 6.2: a) Tisza River at Tiszadada; b) Oxbow lake. In floodplain management oxbows and creeks are used for water regulation; c) Logo and motto for new Vásárhelyi water policy in government brochure (VITUKI, 2004); and d) Bicycle lane on retention reservoir dyke for rural development

The substance of water policy as well as the process by which it was designed, mark a transition in accordance with the definition of Huitema and Meijerink (2009). The development of the Tisza water policy is therefore the object of analysis in this chapter.

6.3 Exploring strategies of individuals

This section investigates the role of individuals in the development and implementation of the new Vásárhelyi water policy (VTT) from the perspective of the five strategies presented in the introduction of this chapter.

6.3.1 Developing new ideas

Here, the origin of the idea of floodplain rehabilitation, rural development, and nature conservation as introduced into Tisza water policy in 2003 is explored. The analysis started with asking different parties about the origin of this idea and whether one person or group of people could be identified as its source. Members from the Bokartisz coalition point to their own organisation and specifically its leader, Géza Molnár, as the key individual behind the idea of floodplain rehabilitation in the Tisza Region. They argue that their work initiated the discussion in the region and brought the idea to the national level. Since the 1980s, Géza Molnár had been studying the floodplain management system in the Tisza valley from old documents (Andrásfalvy, 1973; Bellon, 1991). Together with a small group of farmers and landowners he restored and experimented with traditional water steering systems at a small scale at various locations along the Tisza. Based on these two decades of individual experiments and theoretical studies, the founders of the Bokartisz coalition developed their concept of integrated floodplain management and floodplain rehabilitation, aiming to re-create a mosaic landscape structure and recurring shallow flooding for sustainable rural development. Coalition members began advocating their concept under the name "Last Straw" in 2001 (Botos *et al.*, 2002). It is important to stress that Bokartisz did not present floodplain rehabilitation as something new, but rather referred back to floodplain utilisation before river regulation. Their concepts derived from the shallow flooding, mosaic land-use, and community management of small-scale water infrastructure that was common in the Tisza region in the period 1500–1700.

I distinguish between the concept of floodplain rehabilitation that Bokartisz members advocated and the more detailed implementation plans for particular locations along the Tisza and in particular for the Bodrogköz area. Working both on the more abstract concept and the practical implementation at particular locations, Bokartisz members discussed the feasibility of the concept with local mayors, farmers, national park authorities, and NGOs and demonstrated its application. In the words of a representative of the Hungarian Environmental Economy Centre and Bokartisz (p.c. 9 August 2007, Budapest): "*after we founded Bokartisz, we began to elaborate a land-use and flood protection plan for the Bodrogköz. By the end of 2002, start of 2003, the concept was put together. The engine of course was Géza Molnár.*"

What is significant here is that the idea to promote floodplain rehabilitation came from a bottom-up process based on two decades of practical local experience. It was negotiated with local municipalities in cooperation with a small interdisciplinary group of researchers. These actors combined elements of the traditional water steering system with floodplain rehabilitation and rural development. Thus the new idea was developed in response to local problems independent of the national policy process and the problems recognised by the national administration.

The Bokartisz founders' knowledge of the local situation and of floodplain rehabilitation is impressive. It had to be questioned, however, how widely this explanation of the origin of the new idea and its development was supported. A series of interviews and a public survey carried out between 2000 and 2001 in the Tisza region shows that opinions on flood protection differ. Opinions diverge from increasing the height of the whole levee system, a measure supported by most of the water authority experts, to pursuing alternative solutions such as partial rehabilitation of the floodplains and removal of levees to create natural reservoirs, ideas supported by most local mayors and NGOs (Vári *et al.*, 2003). In the interviews for this work in 2007 and 2008, mayors who are members of Bokartisz, and farmers who collaborate with Bokartisz, share the opinion that Bokartisz originated the alternative solutions. The planning agency, VÁTI, also attributes the role of originator to Bokartisz. Other stakeholders, however, hold the alternative notion that new solutions emerged from the debates among different actors and cannot be attributed to one player. The water board director for the larger Bodrogköz area recalls (p.c. 22 August 2007, Sárospatak):

"I have no clear memory when new ideas were introduced. It was more a vision and an evolutionary process. Many people were asking: 'If there is an option to keep the water, what extra benefits could this provide?' It was quite obvious not to use the reservoir only once every 30 years, when there is a high flood. [...] this area has low agricultural value. Nature restoration was mentioned as a potential income source. For example, in 2002 the environmentally sensitive zones were launched and gave a push to this thinking. Later, the agri-environmental payments were introduced. And we are still waiting for other financial opportunities that will be attached to the reservoir-polder scheme."

The administrative agencies provide another perspective on the origin of new ideas incorporated in the water policy. The then ministerial head of department responsible for the new water policy (Department of Water Damage Prevention at the Ministry of Transport, Communication and Water) does not recall that floodplain revitalisation and a rural development program were new elements in the water policy for which the counties in the region had to ask. Instead, he argues that the first version of the new water policy already allowed for these elements to be included, as the main innovation - the retention reservoirs - were already foreseen (p.c. 30 October 2006, Budapest). In addition, the national government knew that, as an accession country to the European Union (EU), it would soon have to comply with European Directives such as the Water Framework Directive (Commission of the European Communities, 2000a) and was keen to make use of European funds. Civil servants were aware that ideas in line with integrated water management and rural development were more likely to comply with requirements attached to European support than classical flood protection. Representatives from various ministries had participated in European consultations and study tours where the prospects of regional support were presented. The head of the Hungarian office of the World Wide Fund for Nature (WWF) was a member of the body charged with preparation of the new water policy in 2000, bringing experience from the WWF living rivers project (Zöckler *et al.*, 2000). Notwithstanding these international influences, integral and participatory planning was relatively new in Hungarian water management. Many people at the water and planning authority had been trained as civil engineers and believed strongly in river normalisation. Under the socialist regime, the water authority had always been a strong hierarchical organisation with significant financial resources (Fejér, 2004).

In the international context, the degree to which introducing floodplain rehabilitation was new is debatable. The concept of river rehabilitation did not originate from Hungary. Hungarian actors may have taken inspiration from other countries. For example, in 2000, Hungarian scientists participated in the Conference on River Restoration in Europe that concluded: "*River restoration is internationally popular. Many river restoration projects are being implemented. River restoration will even get higher attention within the framework of the implementation of the European Water Framework Directive*" (Fokkens, 2001). Many countries were considering non-structural or "soft" measures from a sustainability perspective (Kundzewicz, 2002; Meijerink, 2005). Are there signs of investigation of river restoration and rehabilitation in the Hungarian scientific community? In the 1970s, a small number of scientists in the region studied the traditional water management system. Publications focused on the operation of the traditional system without making a link to present day water management (Andrásfalvy, 1973). In the 1980s and 1990s, scientists in Budapest engaged in similar studies (Lászlóffy, 1982). Karácsonyi (2001) published one of the first papers in English covering the topic. Building on the Association for Local and Regional Development's study (1997), his paper highlights benefits of reintroducing the traditional system and floodplain rehabilitation, but does not make reference to a new water policy. More recently, national and international researchers started to publish on the traditional system in relation to coping with flood risks (e.g. Vári, 2001; Linnerooth-Bayer and Vári, 2003; Sendzimir *et al.*, 2004).

In summary, two main sources of the new ideas in water policy in the Tisza were identified. Those in the Bokartisz coalition insist that their group developed the new idea independent of the government. Bokartisz members - and especially its leader - combined elements from historical analysis, theory, and field experiments. In this view the origin of the new idea is mostly local. On the other hand, people within the administration point out that some elements were already present in the first version of the water policy, and that the new idea evolved from the interactions during the development of the plan. What emerges from these separate points of view is the possibility that acceptance of the idea by "both sides" as their own, or at least not as something completely new, may have been instrumental in its acceptance in the water policy in 2003.

6.3.2 Building coalitions for selling ideas

This section explores the strategy of individuals to build coalitions for selling a new idea. Following Huitema and Meijerink (2009), coalitions are defined as groups of actors from more than one organisation with shared beliefs and explicit agreements on how to use resources to achieve common goals. Various regional and national NGOs emerged in Hungary in the 1980s that focused on rural development and nature conservation. In the Tisza region, a series of independent, locally driven initiatives began in the 1990s, each aiming to improve the economic and ecological situation at the local scale (Government of Hungary and UNDP - GEF, 2004). Typically these initiatives involved local government, local representatives, NGOs, private companies and scientists from a micro-region and covered one to several thousand hectares. To capitalise on local experience and to strengthen cooperation, Bokartisz was established in 2001 as a non-profit organisation. Its legal status allowed Bokartisz to attract funding and become the program office for a landscape rehabilitation program that produced a set of concepts that were discussed and endorsed by all its members. Beyond concept development, coalition members contributed in various ways. The participating municipalities gave moral support and support in kind, for example, by offering office facilities. Scientific and technical support came from researchers at national institutes. Together with Bokartisz members, these researchers assessed whether Bokartisz' concepts could lead to sustainable regional benefits. Linking traditional local water management with contemporary notions of nature conservation and rural development could prepare the ground for the new coalition to be formed.

This chapter focuses on Bokartisz as a case of a coalition aiming at water policy change. The analysis starts with the relationship between Bokartisz and the development of the new water policy (VTT). In the autumn of 2001, Bokartisz hosted a meeting in the region where the responsible ministry also presented its first version of the water policy. According to the leader of Bokartisz (p.c. 22 August 2007, Bodrogköz): "*We had our concept ready and wanted* *to present it at this meeting.*" This summarises the belief of the founders of Bokartisz that the new idea was developed first, independently from the new water policy. Only when the government made its initial presentation did Bokartisz members realise that it went against the new concept they had developed. In 2002 they started to formulate their critique against the VTT. According to a central member of the Hungarian Environmental Economy Centre and Bokartisz (p.c. 9 August 2007, Budapest):

"It was a great shock to see the VTT in that form with the 13 reservoirs [...] it was against our concept as Géza analysed it. The good thing for our concept was that the plan could not be done between two dykes, and water had to be channelled into reservoirs. The bad thing was that the core of the plan was against the holistic floodplain concept because its only aim was to decrease the flood level between the dykes. There was not much attention to what happens in and between the reservoirs."

Bokartisz held the prevailing water management approach responsible for many problems in the Tisza region. This opinion was supported by scientists who had concluded that the flood defence system had reached its limits, and dyke construction alone could not accommodate higher flood levels (Timár and Rácz, 2002). A central person at the Hungarian Environmental Economy Centre and Bokartisz recalls (p.c. 9 August 2007, Budapest):

"In the beginning of 2003, we issued a statement that the VTT in this form cannot be accepted as it conflicts with rational land-use. As NGOs do, we issued it to the press and raised our voice at all venues. As a result, the Ministry [Ministry of Transport, Communication and Water, represented by the responsible Head of Department and his Deputy] said: 'Let the civic organisations and NGOs tell what they would like.' [...] A meeting was organised in Budapest where Géza [Molnár] and Tamas Cseloszki presented the concept for the Bodrogköz and the whole Tisza. [...] This point of view was channelled into the VTT, it seemed. For me, my impression is that the high level leaders responsible for water management understood that we did not only like to shout, but that we had a concept and could work it out if given the opportunity."

Shortly afterwards, in February 2003, the Hungarian government endorsed the decree that included rehabilitation of the primary floodplain and rural development as objectives for the new water policy along with flood protection. This was still a long way off from the main innovation that Bokartisz was calling for: to channel water into the landscape and to connect water bodies. However, Bokartisz became one of the partners in developing the implementation plan and its leaders were thus given the opportunity to "sell" their concept.

The above suggests that Bokartisz members managed to convince other parties to consider their new concept. This raises the question as to when they felt their ideas were taken seriously, and the degree to which they were deliberately strategic in their efforts towards this result. In the words again of the actor at the Hungarian Environmental Economy Centre and Bokartisz (p.c. 9 August 2007, Budapest):

"The moment was maybe the first negotiations in spring 2003 and then when it became part of the planning in summer 2003. The proof was when we saw our work as an attachment to the government decree. We [the founders of Bokartisz] said then: 'It's real' [...] It came as a surprise. As an expert and NGO you get accustomed that you write papers, you send them in, you give your own statement, and nothing happens. Sometimes when it happens, when you open the revised plan and you find your own proposal there, it is a big surprise."

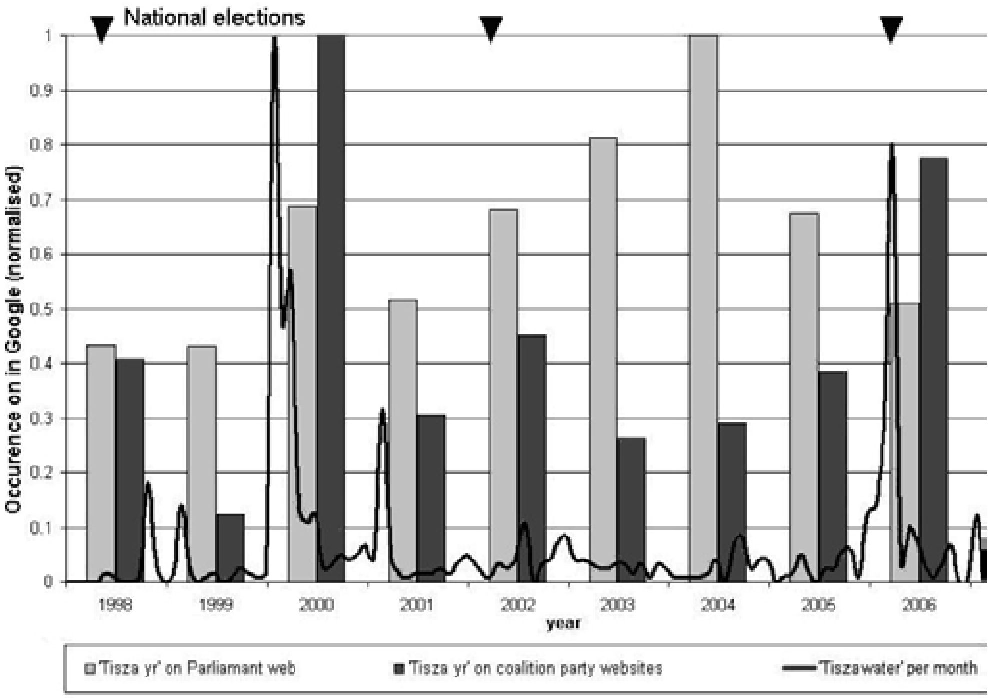
This account suggests that founding the Bokartisz coalition was important in uniting the voice of various organisations in the region that had not been heard before. The Bokartisz founders developed their concept in time for it to be considered in the new water policy, although it had not planned from the start for this to happen. Rather it raised opposition as soon as it considered the new water policy at odds with its own concept. Representing the larger Bokartisz coalition, a small group of two to three people communicated with the central administration. They presented decision makers at the Ministry of Environment and Water with their critique together with their new ideas. Is this enough to explain the transition in water policy? And why did it occur at that particular moment in time? Who allowed Bokartisz to become a partner at the negotiation table? The next section looks into these questions by reviewing the transition in water policy and key actors from the perspective of "windows of opportunity."

6.3.3 Recognising and exploiting windows of opportunity

This section assesses whether a window of opportunity was created, recognised or used to launch new ideas. First the three streams are described that must align for such windows to be exploited successfully: the problem stream (issue on public agenda); the political stream (issue on political agenda); and the policy stream (attention to policy options related to the issue) (Kingdon, 1995).

Looking at the problem stream, events began in 1998 with the first major flood in the Tisza for twenty years. The annual floods that followed each produced a new record water level in at least one section of the river (Timár and Rácz, 2002). In 2000, the eyes of the world were on the Tisza when first, in January, a cyanide spill at a gold mine in nearby Romania wiped out aquatic life, leading to tons of dead fish being pulled from the Tisza. Then in March, floodwaters rose to a 100-year high. Summer followed with a record-breaking heat wave. 2001 saw more disaster when the embankment broke at two places and the Bereg region was flooded, seriously damaging two thousand houses. Figure 6.3 illustrates the problem stream by looking at the Tisza news coverage. It approximates news coverage by the number of occurrences per month of the words "Tisza" together with "water" in Google News between 1998 and 2007 (line in Figure 6.3). News coverage shows clear peaks around the floods in November 1998, March 1999, and 2001. The Tisza River got most attention in international news around the flood and cyanide spill in 2000 and the floods in 2001 and 2006.

Figure 6.3 also illustrates the political stream by tracking the attention paid to the Tisza on websites of the coalition government parties. The figure shows the normalised total number of hits per year for Google searches of the coalition parties' website. The 2001 flood happened during the election campaigns and attracted sizeable political attention. 2006 shows another peak in interest in the Tisza from the political parties, judged by website coverage of the topic. This attention coincided with the 2006 elections and another major flooding event. A second illustration of the political stream in Figure 6.3 is the level of attention paid to the Tisza by the Hungarian Parliament, approximated by the number of occurrences of the word "Tisza" per year on the Parliament website (http://www.mkogy.hu). It shows how the Tisza gained importance on the parliamentarian agenda in 2000, peaking in 2004 when Parliament approved the "Tisza Law". The figure also shows that attention has waned and how the Tisza has never since attracted the same level of parliamentary attention.



Note: The incorporation of Internet-based figures comes with the recognition that the medium has become increasingly used by political parties and that the number of issues covered on their websites and the number of pages itself have increased. Thus the figure should be read only as an indication of the changing attention of party websites to the Tisza and not as an absolute assessment of the political agenda of the parties.

Figure 6.3: Windows of opportunity illustrated by the normalised number of occurrences of specified terms arising from online search using Google

A combined account of the problem, political, and policy streams suggest that the 1998, 2000, and 2001 flood events sparked the sense of urgency at the political level to develop a new water policy for the Tisza. In June 2002, a new coalition of socialists and free democrats replaced the conservative, centre-right government. The coalition members wanted to put their mark on the ongoing policy process that they had inherited. From this perspective, the autumn of 2002 provided an excellent opportunity for the introduction of new ideas. For the window of opportunity to open, the high visibility of the problem stream, the *negative* attention for existing policy options and the changing institutional context may have been crucial. As discussed in previous sections, the Bokartisz coalition had by this time published its ideas and started actively opposing the existing version of the VTT plan. Support for the existing policy options was waning. Municipalities and the Hortobágy National Park authority had rejected the location of a reservoir in their territory. The need for local support was becoming increasingly clear within the administration. At the same time, the Government had to reduce its budget deficit as a condition for EU membership, making it imperative to find new sources of finance (Vári *et al.*, 2003). European legislation, directives, and funding mechanisms, such as the new agri-environmental support schemes of the European Common Agricultural Policy, favoured integrated policies and management approaches. In addition, the EU promoted participation of civil society for a democratic system of government (Commission of the European Communities, 2000b; Commission of the European Communities, 2001). The combination of these factors opened a window for incorporating new ideas in water policy development.

Did Bokartisz members actually time their interventions and local experiments to be ready for cooperation at the end of 2002 and use this window of opportunity? Accounts of its founders suggest that essentially they developed their ideas independently from the political stream. In contrast, in the interview, the ministerial head of department who was at the time responsible for the water policy, expressed a conscious and purposeful consideration of high profile problems, national politics, and policy options. He recalls using the sense of urgency after recurring floods firstly, to secure financial support for a new flood protection program and secondly, to turn it into a national program (p.c. 30 October 2006, Budapest). He continues that after the 2002 national elections, to his distress, the water authorities were merged with the environmental authorities and their staff and budget reduced. This created a need to build new cooperation to ensure successful use of the window of opportunity. He became Deputy State Secretary for Water at the new Ministry for Environment and Water. He conveys that, at his instigation, an inter-ministerial committee was installed to develop the water policy further, both changing the role of the administration and adding a new venue in the transition process. The next section investigates the role of the new venues.

6.3.4 Using multiple venues

The previous sections have looked at the origin of the new ideas, the coalitions that were built to sell them, and the opportunities for introducing new ideas into the water policy at a particular moment in time. This section assesses whether individuals or groups of individuals sought out alternative venues to promote new ideas. Venues are understood as the possible places where policy issues can be debated, including various levels of government, forums of scientists and legislatures, and the media (Baumgartner and Jones, 2002). The analysis focuses on the choice of venue of the actors identified in previous sections: the national government (particularly the ministry responsible for water policy), the local government (including the mayors and water boards), and the Bokartisz coalition.

By 2000, the EU had opened up as a key new venue for debating policy requirements and funding opportunities (Veres, 2004). Politicians and civil servants from the accession countries were actively briefed on European funding possibilities, such as structural funds, cohesion funds, and agricultural subsidies. They were invited to participate in multi-national projects and conferences in the EU. Although Europe was not a venue where civil servants deliberately lobbied for the new water policy, they recognised the restrictions and opportunities in the European regulations and financing conditions. Whereas national funding had previously supported engineering solutions, the European financing conditions offered opportunities for the new idea of river rehabilitation. Government decree 1022/2003 on the improvement of the Vásárhelyi water policy specified "*financial resources should be determined with respect to the European Union's common joint financing conditions*".

To prepare the implementation plan for the water policy, the national government, at the instigation of the Ministry of Environment and Water, created two key new venues. First, it established the inter-ministerial committee that represented a larger group of ministries than in the planning stage. The committee was co-chaired by the Deputy State Secretary for Water who had been responsible for the water policy until then and a representative of the Ministry of Agriculture and Rural Development. The committee intensively consulted research institutions, national park authorities, and local government and civic groups (Váradi, 2003). The second venue consisted of five open public procurement tenders to support the drafting of the new water policy. VÁTI, the national planning agency for regional development, and VIZITERV, the water resources design bureau coordinated the tenders. Established through government decree 1022/2003, the tenders allowed for increased stakeholder involvement and representation of local interests in the planning process.

The Bokartisz members used additional venues to express their ideas or undermine the existing water management paradigm. As a coalition with members from municipalities, NGOs, and the scientific community, Bokartisz had in-house experience in playing different venues. Bokartisz issued protests and statements in the press written by its environmental NGO members. The rural development NGOs and municipalities brought experience with training and information dissemination. Farmers in particular were approached to participate in pilot projects or public hearings and training sessions. Just like the national government, Bokartisz members looked for new financial mechanisms, for example, helping farmers to apply for agri-environmental support schemes and small pilot projects.

In summary, a number of new venues were used to sell and develop the new ideas. The national government supported the transition in water policy by creating two new venues: the inter-ministerial committee and a participatory planning process supported by open public procurement tenders. The EU offered new financial instruments and called for more participatory policy making. Together with the national government's focus on European co-financing, this influenced the prioritisation of policy options. The NGO members in the Bokartisz coalition used a range of venues to discredit existing policy options and to lobby locals to support Bokartisz's ideas.

6.3.5 Orchestrating and managing networks

Turning to the last of the five strategies, this section explores how actors cooperated, what networks played a role in the transition in water policy and whether (groups of) individuals actively influenced the operation of networks. In particular, it analyses whether individuals influenced the breakthrough in the development of water policy for the Tisza by breaking up or providing alternative policy networks.

Such analysis requires determination of what networks shaped water management before and during the transition in water policy. In the 150 years before the transition, hard engineering solutions dominated water management. The water authority was very powerful especially under the communist regime. Engineers were partly trained in the Soviet Union (Fejér, 2004). A strong, informal network of water authorities and contractors developed from this period, with many individuals still in key positions today. This network entails cooperation over several decades, yet without the collective organisation and explicit agreement on spending shared resources that are fundamental to an advocacy coalition, such as Bokartisz.

Similarly, the environmental NGOs in Hungary form a strong network, where many individuals in key positions know each other from the communist environmental youth movement. In 2000, the environmentalists were becoming increasingly organised. They stressed that continuing levee construction and the resulting narrowing of the riverbed increased flood risks in Hungary. At the same time researchers at the Water Resources Research Centre VITUKI started to study the merits of water retention (Szlávik, 2001a; Szlávik, 2001b).

At the regional level, the founders of Bokartisz built on the existing networks of key players in the region. The long-running collaboration (or animosity) between the mayors and other central regional actors extends well beyond Bokartisz both in time and number of actors. Networks were built by people who held central positions in state enterprises (for example, the agricultural cooperatives) and in the administration under the communist regime. In the turbulent times after 1989, well-informed landowners could profit from land consolidation. The consolidation of land around the Cigánd reservoir illustrates the importance of regional players. It has been suggested that some mayors and large landowners speculated on the location of the reservoir and acquired land shortly before the site was selected. These individuals could benefit from expropriation or from the compensation and the agri-environmental support schemes proposed in association with the reservoir. Such benefits seem to have been more under consideration by these players than any particular water policy. In this way, they did not manage the transition in water policy, but were important in influencing site selection and the site-specific implementation. According to a civil servant from the Ministry of Agriculture and Rural Development (p.c. 25 October 2006, Hortobágy):

"*Local mayors - who might also be members of Parliament - are among the most powerful actors. They have a voice in Ministries, since an important part of ministerial routine is to give an adequate response to initiatives coming from the local administrations; moreover, local mayors have strong capacity to influence the process of practical implementation of the plans and projects*."

The research community also deserves notice as a network of actors in the transition. Bokartisz members – especially Géza Molnár – report that they took inspiration from scientists to conduct the 1980s experiments in river revitalisation. Studies of the traditional management of water and land-use were of particular importance (e.g. Andrásfalvy, 1973; Bellon, 1991). Following the cyanide spill in 2000, an increasing number of international research projects offered opportunities to discuss, test, and promote floodplain management and river rehabilitation. Individuals from the research community extended their networks through international research and development projects. In 2002, the state-owned Water Resources Research Centre (VITUKI) won the European commission funded Tisza River Project on sustainable use of water resources and ecological values in the Tisza River Basin (http://www.tiszariver.com). In 2004, individuals from the research community together with Bokartisz and other local organisations secured a substantial UNDP/GEF project for protecting biodiversity in the Tisza Basin (http://www.elotisza.hu) as well as INTERREG III project funding. The NGO members in the Bokartisz coalition sought national credibility by entering domestic and international research networks. The accreditation of VITUKI gave water management schemes crucial national support and legitimacy. The leader of Bokartisz (p.c. 22 August 2007, Bodrogköz) explains, "*that VITUKI in 2002 was willing to test and support the idea by [hydrological] modelling to see whether the concept works gave a big push because it provided the proposed water steering and shallow flooding with a more scientific foundation.*"

It cannot be said at present to what extent the emergence of international cooperation through research projects won new supporters for the concept of floodplain rehabilitation. Yet, these projects at least sustained a dialogue between Hungarians across the region about floodplain rehabilitation and rural development, sometimes abetted by international participants. In addition, the national government was very keen to find new sources of funding and the projects above underlined that the new idea of floodplain rehabilitation attracted more international support than engineering dominated solutions. Members of Bokartisz, especially the researchers, recognised this opportunity and used it to attract funding for promoting floodplain rehabilitation. This cooperation broke up the network of engineers that had designed most of the recent Hungarian water infrastructure, initiating a more interdisciplinary network of researchers. The tenders following the 2003 government decree allowed this network to test the new ideas, facilitated by the national planning agency VÁTI. The VÁTI team leader responsible for the water policy development process recognised the importance of strong regional cooperation and representation of local interests (p.c. 30 October 2006, Budapest):

"Another important element in this whole period is how local interests are incorporated. It is very difficult to request from them [local population] because these areas are [socio-economically] the least developed [..]. They also have low lobbying power. The reason why Bokartisz has such a key role in the whole process is that, immediately from the beginning, they were articulating their ideas as a local stakeholder and had the scientific basis and support for them. In addition, they were accepted by the locals. We [VÁTI] are coming from Budapest, and it would take us a long time to be accepted by the local people and to be part of negotiations. So throughout the work we did, we tried really to rely on Bokartisz and involve them in the whole process. They have this kind of special knowledge about the local situation that we from Budapest would never have. If there were more of this high quality organised local representation, then the whole VTT would be much farther ahead."

To summarise, strong networks existed at both the national and the regional level. New interactions between these networks occurred around the time of the transition in water policy. The VÁTI team leader became a major actor due to her facilitation of discussions between the national government, scientists and local representatives. The VÁTI team admitted Bokartisz as a counterpart and representative of regional organisations throughout the planning process. VÁTI's facilitation of the planning process and its administration of the tenders for the Ministry of Environment and Water cracked the network of the water authority, its engineers and contractors.

6.4 Discussion and conclusions

What can be learned from the Tisza case about transitions in water policy? The recurring major floods and the cyanide spill on the Tisza River in 2000 were obviously significant, but in what way? The floods and resulting damage were severe, but these two factors were probably not sufficient in themselves to trigger a transition in water policy. They did, however, highlight the problem stream and supported the strategy of regional NGOs to define the prevailing water management as unsustainable, demanding a different approach. This proved instrumental in broadening the debate about an alternative water policy. Flood retention and integrated river basin management already had supporters in the national government, the academic world and major NGOs, such as WWF. This was at least partly so because European directives advocated these approaches and offered indispensable financial support. In addition, local support and experience was needed. The new Bokartisz coalition of municipalities in the Tisza region, NGOs, and researchers offered both. The founders of Bokartisz had just developed their concept of floodplain rehabilitation and shallow flooding for the Tisza region and had contextualised it for specific locations. In the Bodrogköz area particularly, support from the water board and mayors inside and outside the Bokartisz coalition was high and opposition minimal.

The 2002 national elections brought a new coalition to power. Water affairs were transferred to a new Ministry of Environment and Water, setting the scene for the appearance of the transition in new procedures. The then upcoming accession to the European Union favoured a shift towards participatory and integral planning. In this way, 2002 opened a window of opportunity for linking the new idea, political will and a acknowledged problem (cf. Kingdon, 1995). A key player to open and use this window was the Head of Department assigned to the development of the policy at the Ministry of Transport, Communication and Water (after the 2002 reorganisation, the Ministry of Environment and Water). A government decree was passed in February 2003 that acknowledged floodplain rehabilitation and rural development and that created two new venues for preparing the water policy's implementation plan: an inter-ministerial committee and a series of tendered studies. The national planning agency VÁTI used the tenders to support a new network of researchers, NGO's and local representatives in creating the spatial plan for the water policy. The national government endorsed the implementation with the October 2003 government decree and the 2004 Tisza Law. Endorsement notwithstanding, however, since then only two of the first six retention areas have been built and the related floodplain rehabilitation and rural development has either not been attained, or attained only after many delays.

This chapter followed Huitema and Meijerink (2009), who postulate that a transition in water policy should become visible in a reorientation of the policy substance or the governance paradigm. Future work may ask what the implications of this work are for deep system transformation where issues are understood and done in new ways throughout society (cf. van der Brugge *et al.*, 2005; Folke *et al.*, 2005; Olsson *et al.*, 2006; Pahl-Wostl *et al.*, 2009). The record of the transition in water policy highlighted interactions among key individuals and groups of individuals. It attempted to provide a credible account of the principal actors involved. This chapter did not argue that the result of the interactions was inevitable nor that the policy was "correct", only that the prevailing conditions and interactions made its adoption feasible. The narrative is necessarily compressed and cannot do full justice to the work of the many people who cooperated in the Tisza. Yet, it aimed to convey the main thrust of affairs.

With regard to the two elements of a transition in water policy - change seen in policy substance or in governance arrangements - the Tisza case exhibits little formal organisational change sustained beyond plan development. In fact, actors identified coordination and clarity of the organisational structure as components that have been sorely lacking in the implementation phase (Werners *et al.*, 2009a; Chapter 5). This is one of the challenges that actors in the Tisza currently face as the implementation of the policy has been slow and could still fail.

The Tisza evidenced the key role of individuals and confirmed the use of the strategies identified in the introduction: to develop ideas, to build coalitions to sell ideas, to use windows of opportunity, to play multiple venues and to orchestrate networks. Closer analysis provided insight into the use of these five strategies. Regarding the development and promotion of ideas, the members in the central coalition that began small-scale experiments deserve extra attention. These experiments built trust and physical proof of cooperation. Here also the interplay of supporters and opponents of policy change became evident (see Chapter 7). A main challenge for the national government was to get local support. Local farmers, mayors and the national park authorities had already rejected two possible locations for a retention area. Both Bokartisz members and local mayors outside the Bokartisz coalition were aware of this situation. They offered an area close to the town of Cigánd in the Bodrogköz region to the preparatory body for the new water policy as an alternative location for a retention polder. In the words of the leader of Bokartisz (p.c. 22 August 2007, Bodrogköz), "*Another key element in the success was that we could find a territory that we could offer. There was a territory always affected by inland water stagnation without high nature value: Cigánd.*" The leader of Bokartisz reported that he was aware of this opportunity before the more detailed planning process started in 2003. It remained less clear when and how the local mayors began to support Cigánd as a location for a VTT retention area. In general, they were keen to highlight secondary benefits they ensured for their municipality by participating in the planning process. These range from national funding for a municipal sewerage system to city status for Cigánd, extending the legal status, financial resources, and status in Parliament of the local government representatives. The management of interests and (financial) resources, either to facilitate or slow the transition in water policy, emerged as a strategy. It was suggested that (p.c. 23 October 2007, Bodrogköz), "*Those opposing the plan thought it would never pass Parliament. When it did they were shocked. The easiest and most efficient way to block it is through the budget*." Related to interest management, are strategies that sidestep good governance principles as transparency and accountability. These strategies of individuals deserve more attention in future work. In addition, an analysis based on stakeholder interest could be a valuable addition to the idea-centred approach taken in this chapter.

A further observation with respect to the analysed strategies is the diverging framing of new policy ideas. Whereas civil servants and their technical experts described the new policy ideas as an effective response to new challenges in water management, coalition members stressed that the new ideas had roots in history and tradition, and opposed prevailing water management.

With respect to managing networks in the region, legacy effects were strong, with prior social networks and the historic legitimacy of actors determining the nature of the game. Analysis of policy change should be careful not to miss the activities of the private sector and so omit a potentially important actor and partner. Whereas the origin, advocacy, and management related to the new policy ideas in the Tisza did not lie with bigger private agents, their cooperation became crucial in implementation for two important reasons. First, interventions in the floodplain required the cooperation of landowners. Second, implementation of water policy in Hungary could no longer rely solely on national government support. New partnerships had to be built. The new water policy required the cooperation of many partners. It called for in-depth examination of multi-stakeholder organisations and institutions that were not well understood at the time of the transition in water policy and that represent an emerging and complex factor in many countries around the world.

Finally, to what extent the explored strategies are complementary deserves notice. Theoretically, looking for 'windows of opportunity' is more oriented towards finding the right time to present ideas, whereas 'venue shopping' is more about finding or creating the right place. In practice, however, these strategies were found to overlap, as individuals aimed to find the right place at the right time to promote ideas or oppose change.

Summarising, five potential strategies of individuals were explored: developing new ideas, building coalitions to sell ideas, using windows of opportunity, playing multiple venues and orchestrating networks. These strategies and the focus on individuals offered a simple and edifying frame for exploring a transition in water policy. Assessing the transition from the perspective of individuals and their strategies yielded a number of new insights about a turbulent time, with each strategy pointing at different key actors and events. Important lessons included the way a new coalition allowed for linking different objectives to a new idea. Furthermore, while this coalition elaborated its ideas at the regional level, national policy makers recognised a window of opportunity to link regional support to the policy change being advocated and supported financially at the international level. Development of the policy saw new venues and networks arise that proved influential during the transition. Beyond the importance of developing and debating new ideas, the Tisza case showed that it takes individuals to initiate a transition, as well as people that can take new ideas through a period of confrontation, change and reorganisation.

Chapter 7

Opponents and supporters of water policy change in the Netherlands and Hungary

Abstract

This chapter looks at the role of individuals and the strategies that they use to bring about or oppose major policy change. Current analysis of the role that individuals or small collectives play in periods of major policy change has focussed on strategies that reinforce change and on the supporters of change. This chapter adds the perspective of opponents, and asks whether they use similar strategies as those identified for supporters. Five strategies are explored: developing new ideas, building coalitions to sell ideas, using windows of opportunity, playing multiple venues and orchestrating networks. Using empirical evidence from Dutch and Hungarian water policy change, this chapter discusses whether individuals pursued these strategies to support or oppose major policy change. The analysis showed the significance of recognition of a new policy concept at an abstract level by responsible government actors and their engagement with a credible regional coalition that can contextualise and advocate the concept regionally. The strategies of supporters were also used by opponents of water policy change. Opposition was inherent to policy change, and whether or not government actors sought to engage with opponents influenced the realisation of water policy change.

Keywords: Individuals, coalition, water policy change, transition, Hungary, Netherlands

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And

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Werners, S.E., J. Warner and D. Roth (2009) Adapting to climate change: the introduction of water retention in Dutch and Hungarian water management. IOP Conference Series: Earth and Environmental Science 6, 292063.

"[...] we are open to any idea, whether it comes from a Democrat or a Republican or a vegetarian."

Barack Obama, February 10th 2009

7.1 Introduction

[1]During the last two decades the water policy in the Netherlands and Hungary, two flat and low-lying countries in Europe, underwent major change. Having relied on flood levees, river normalisation and drainage for over two centuries, water retention and floodplain rehabilitation were introduced to replace or complement prevailing water management practices. Whereas the substance and organisational aspects of water management in these countries are well documented, much less is known about the dynamics and path of the policy change itself. This chapter seeks to improve our understanding of how periods of major water policy change unfold. This chapter frames major policy change as a policy transition[1] (cf. Huitema and Meijerink, 2009) and builds on results from transition literature.

To analyse and interpret the dynamics of fundamental change, transition management frameworks have been developed that describe the different stages and processes of transitions (Rotmans *et al.*, 2005) and transition pathways (Geels and Schot, 2007). Research has attempted to uncover the process dynamics which can lead to a transition's success or failure (Olsson *et al.*, 2006). A new development is to look at governance and agency. For example, Kemp *et al.* (1998) and Smith (2003) studied incumbent actors and (niche) pioneers. Also, Schot and Geels (2007) aimed to provide insight into how actors create, nurture and sustain niches that can drive a transition. Huitema and Meijerink (2009) analysed strategies employed by individuals and small collectives during a transition, going beyond pioneers and recognising a broader set of roles that actors can fulfil. So far, the emphasis in the research on transition dynamics has been on how a transition is reinforced and on transition supporters (Rotmans *et al.*, 2005; van der Brugge and Rotmans, 2007). In transition literature, the opposition is typically described as a group that 'has to be persuaded' or 'aligned'. Opponents are rarely studied as actors in their own right. The influence of opponents on the direction of a transition, and the strategies they use remain largely unexplored. This is all the more surprising as, for example, Loorbach (2007) recognised that transitions go against existing assumptions and worldviews and that a transition may need a certain element of dissent, conflict and difference of opinion to facilitate innovation, competition and learning.

To add to the debate on the role of individuals and groups of individuals in the unfolding of major policy change, the analysis is narrowed to individuals (both supporters and opponents of water policy change) and compares their strategies in two case studies: the Hungarian Tisza River and the Ooij polder in the Netherlands. The cases have been selected to represent a so-called "most different cases design" in Europe. That is, the cases have been selected to minimise the difference in the type of water management activities under discussion, yet maximise the difference between historical and institutional contextual factors. In the face of these contextual differences, this case design allows for ground to suggest that similarities found between the cases are robust elsewhere.

1 *How to distinguish transitions from shallow levels of change is contested. Here it is postulated that policy transitions should become visible in a reorientation of the substance of policies (e.g. from flood levees to water retention) or the governance paradigm (e.g. from state control to privatisation). A transition consists of both changing policy on paper and implementing change on the ground. The more fundamental the change in policy and its implementation, the more it resembles what is called a transition.*

The cases have in common that water policy was reoriented towards measures to create space for rivers, water retention and emergency storage reservoirs (Roth and Warner, 2008; Werners *et al.*, 2009b; Chapter 6). This reorientation to non-structural and land use related water management activities has been observed since the 1980s in countries around the world (e.g. Fokkens, 2001; Kundzewicz, 2002; Huitema and Meijerink, 2009; Molle *et al.*, 2009), adding to the relevance of the cases. In both case studies this reorientation was confirmed by national policy, yet implementation was delayed or abandoned altogether. Here too, the cases are not unique as, for example, Rhodius (2008) and Hartmann (2010) note opposition to the introduction of controlled flood storage in Germany, while in Britain a 'green river bypass' to make space for the river Thames raised controversy.

The cases differ in terms of the historical and institutional context and the governance traditions upon which water management has developed. In Hungary, the Hungarian government under the Austro-Hungarian Empire started major drainage and river normalisation projects in the Tisza Basin. These projects continued during the communist era after the Second World War. Over the last two decades Hungary has changed from a communist state to a post-communist democracy and a European Union (EU) member, where remnants of previous economic and political orders still shape expectations and patterns of conduct (Pérez-Solórzano Borragán, 2005). The Netherlands, on the other hand, has been a constitutional monarchy since 1815 and a parliamentary democracy since 1848. It has an open economy, relying largely on international trade, and is one of the founding members of the EU. Water management and its institutions have evolved over several hundred years from private initiatives, to build dykes and reclaim land to a governance regime with well-recognised national and regional responsibilities.

The analysis in this chapter consists of three parts. First, the two case regions are examined from an empirical perspective, based on interviews, literature review and stakeholder workshops. The role of individuals are discussed during the attempt to change policy and in the following years when actors had to deliver on the new direction taken in water policy. After these chronological case descriptions, the chapter elaborates on the interaction of supporters and opponents in the discussion section. In particular, the research is synthesised to discuss the fivefold distinction of strategies of individuals in Huitema and Meijerink (2009):

1. Developing new ideas (cf. Hajer, 1995; Baumgartner and Jones, 2002; van der Brugge *et al.*, 2005),
2. Building coalitions[1] for selling ideas (cf. Sabatier, 1988; Folke *et al.*, 2005; Olsson *et al.*, 2006),
3. Recognising and exploiting windows of opportunity[2] (cf. Kingdon, 1995),
4. Using multiple venues[3] (cf. Baumgartner and Jones, 2002), and
5. Orchestrating and managing networks (cf. Folke *et al.*, 2005; Caniëls and Romijn, 2008).

The chapter closes with conclusions and recommendations for future research into the role of individuals in furthering or blocking water policy transitions.

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1 *Coalition building emphasises shared beliefs and explicit agreements on how to pool and use resources of those involved to achieve common goals.*

2 *A 'window of opportunity' opens when three issue streams align: 1) problem stream (issue on public agenda), 2) political stream (on political agenda) and 3) policy stream (attention for official policy options).*

3 *Venues are understood as the possible places where policy issues can be debated. Typical venues include levels of government, media and research forums.*

Our case studies suggested that opposition is an inevitable element of major policy change. The influence of individuals on policy change became particularly prominent in the interaction between supporters and opponents of (parts of) a transition. Engaging with or managing opponents was a strategy that individuals used to advance the transition. A special role was that of delivering the idea of the transition to other actors. In the analysed cases, there was a central individual in the influential coalitions who took this role. Whether or not government actors sought to involve these individuals in policy making, influenced the realisation of the transition. In the Dutch case, where this was omitted, the coalition obstructed the transition. By engaging with opponents, negotiated solutions could give the transition a new impetus, yet at the same time cause a diversion from the original idea, alienating supporters. Successful strategies to discredit the transition included: challenging the legitimacy of (assumptions underlying the) new approach, engaging with experts from the supporters' research community and changing budget priorities.

7.2 Water policy change in Hungary and the Netherlands

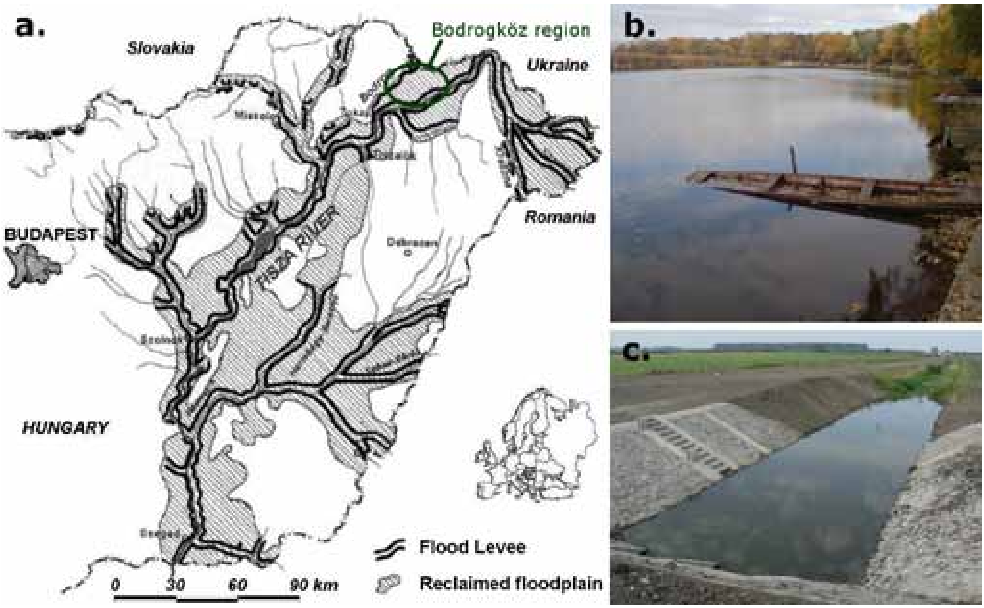
In order to analyse the strategies of supporters and opponents of water policy change, this section chronologically describes attempted transitions in Hungarian and Dutch water policy. The narrative is based on information from interviews and workshops with regional and national stakeholders and analysis of documents on the new water policies and related project plans. In the Netherlands, sixteen nondirective interviews were conducted with key players, mainly in 2005 and 2006, and a public information meeting of the water policy commission - operational at that time - was attended. This information was complemented by documentary analysis, including draft and internal documents. In Hungary, data were collected in three ways: through twenty semi-structured interviews with actors from national and regional organisations (ministries, water authorities, planners, academic institutions, non-governmental organisations (NGOs), municipalities, and farmers), a series of group discussions with local and national stakeholders; and by analysis of policy and planning documents and background studies.

7.2.1 River Tisza water policy, Hungary

The Tisza River is the largest tributary of the Danube, receiving water from the Carpathian Mountains in Romania, Slovakia and Ukraine before running through Hungary and meeting the Danube in Serbia. Almost 50 per cent of Hungary is located in the Tisza basin. Until the 18th century, river management was mainly organised around the operation of a system of small structures and channels that regulated the water flow between the main river bed and the floodplain (Balogh, 2002). The inundation frequency determined land use, giving rise to a patchwork of plough land, forest, floodplain orchards, meadows and fish ponds (Bellon, 2004). From the 1750s, the Tisza River has been heavily modified, with major changes introduced by the Hungarian government under the Austro-Hungarian Empire in the 19th century. Dyke building, regulation of one-third of the river's length and floodplain drainage decreased the total naturally flooded area by 84 per cent (Figure 7.1). The communist era after the Second World War supported large-scale intensive agriculture in the region. Water management was controlled by a powerful water bureaucracy that was well expanded socially (through prestige attached to engineering profession), politically (with close relationships between both local and national politicians, state bureaucrats and planners), informational (state support for research) and economically (due to a large budget and proximity with construction and consulting firms). Privatisation at the beginning of the 1990s led to a drop in the operation and maintenance of the large irrigation systems and of agricultural output. Scientists increasingly associated the prevailing water management of river regulation and drainage with problems such as increased flood risk, inland drought, water stagnation, soil salinisation, the degradation of peat lands and wetlands, and the loss of the traditional water management system and related production systems (Barta *et al.*, 2000; Vámosi, 2002; Bellon, 2004). At present, the Tisza region is socio-economically challenged by a high unemployment rate, ageing, and migration (Sendzimir *et al.*, 2004; Linnerooth-Bayer *et al.*, 2006). Large areas have an unclear property status and unresolved responsibility for water system maintenance and taxation (Matczak et al., 2008). On a more upbeat note, the region has great potential for recreation and nature conservation (Vári *et al.*, 2003).

After twenty years of drought, annual floods started again in 1998. These floods were a driving force behind the development of a new water policy for the Tisza River, in Hungary known as the New Vásárhelyi Plan. Below, the development of water policy and the activities of supporters and opponents in the last decade are described chronologically. Figure 7.3 at the end of this section summarises actions of key individuals.

The recurring major floods and the cyanide spill on the Tisza River in 2000 backed the strategy of local NGOs to define the prevailing water management as unsustainable and requiring a



Source: Photos: Werners, 2007

Figure 7.1: a) Hungarian Tisza River Basin; b) Oxbow lake; and c) Construction of water infrastructure in the first retention reservoir

different approach. At the time, the consensus amongst scientists grew that raising dykes was no longer efficient from an economical perspective and was likely to increase flood levels (Glatz, 2003). This consensus proved instrumental in opening up the debate about an alternative water policy. The abstract notions of water retention, floodplain rehabilitation, and integrated river basin management already had supporters in the national government and major NGOs, such as the WWF, as well as abroad (Váradi, 2003). This was at least partly so because European directives advocated such approaches and the European Union offered indispensable financial support (e.g. the pre-accession funds (McGuinn, 2003)) as well as pressure to take cropland out of production (Gere, 2007).

A group of civil servants and scientists developed a first version of the new water policy in consultation with the WWF. Its innovation was the introduction of water retention in built reservoirs[1] and the widening of riverbanks. Built retention areas had supporters among water engineers as an alternative to raising dykes (Szlávik, 2001a; Somlyódy, 2002; Váradi, 2003). An early supporter in the context of the development of the new water policy was the head of department at the Water Resources Research Center VITUKI (Szlávik, 2001a; Szlávik, 2001b). Although the policy's main aim was flood protection, it allowed for 'nature development' in accordance with the European Water Framework Directive and environmental regulations (Bálint *et al.*, 2000; KöViM, 2002). To achieve the target flood level reduction, and to keep reservoir size and depth manageable, the Ministry of Transport and Water Management presented a series of fourteen potential sites. Little attention was paid to affected parties: "*We will propose to enlarge the flood banks and make other corrections, but it will be the task of politicians to make people accept it and ensure compensation for them wherever homes would have to be moved*", said Lajos Kovacs, chief advisor at the Ministry of Transport and Water Management (Fenyo, 2001). Opposition grew and local parties refused to take part in the implementation (Gere, 2007).

Implementation of the policy required local support and a concrete example of the application of the proposed (abstract) principles to the regional situation. A new coalition of twelve municipalities in the Tisza region, three non-profit organisations[2] and researchers, named Bokartisz, offered both. Bokartisz opposed the government's version of the water policy, but offered to cooperate with the national planning bodies to implement water retention, on condition that its own concept of floodplain rehabilitation and shallow flooding would be considered and tested (alongside the government's plan). Bokartisz' leader, Géza Molnár, had studied the floodplain management system in the Tisza valley from old documents (Andrásfalvy, 1973; Bellon, 1991). Together with a group of farmers and landowners he had restored and experimented with traditional water steering systems at on small scale at various locations along the Tisza since the 1980s. Based on these experiments, the founders of the Bokartisz coalition developed their concept of integrated floodplain management and floodplain rehabilitation, aiming to re-create a mosaic landscape structure and regular shallow flooding for sustainable rural development. Coalition members began advocating

1 *Reservoirs created by building a ring dyke in the floodplain next to the river with a floodgate for letting in water during high water events and an outlet to return water to the river.*

2 *The E-misszió Environmental Association, the Hungarian Environmental Economy Centre and the Palocsa Association.*

their concept under the name 'Last Straw' in 2001 (Botos *et al.*, 2002). The main difference with the government plans and Bokartisz' concepts was that the former proposed to build retention reservoirs to be used during extreme floods, whereas the latter focused on rural development and revitalisation of the floodplain through annual shallow flooding, making use of natural landscape elements. It is important to stress that Bokartisz did not present floodplain rehabilitation as something new, but rather referred back to floodplain utilisation before river regulation. Researchers at the Hungarian Academy of Science and the national Water Resources Research Centre lent authority to the ideas Bokartisz promoted.

The 2001 flood and dyke break highlighted the problem. The 2002 national elections brought to power a new coalition determined to prove that it was different to the previous government. Water affairs were transferred to a new Ministry of Environment and Water, setting the scene for a change in procedures. The then upcoming accession to the European Union favoured a shift towards participatory and integral planning. In this way, 2002 brought convergence of the issue streams, opening a window of opportunity (Kingdon, 1995) for aligning a new policy idea, a relevant problem, and political will. The key player to use this window came in the shape of the Head of Department entrusted with the development of the plan at the new Ministry of Environment and Water, Dr. Váradi. He swiftly took the lead in strategy to ensure advancement of the new water policy, taking the strategic alliance of the water authority,[1] its engineers and contractors by surprise. A government decree was passed in February 2003 that acknowledged the concept of floodplain rehabilitation and rural development and created two new venues for the further development of the water policy: a new inter-ministerial committee, and a series of tenders to deliver support studies and a regional implementation plan.

The Bodrogköz area, which had not been one of the fourteen areas the national government had identified in the draft version of the built reservoirs plan, was added, as Bokartisz had suggested this territory for water retention (KöViM, 2002; Váradi, 2003). Bokartisz was active in the Bodrogköz area, where support from the water board and mayors inside and outside the Bokartisz coalition was high and opposition minimal. A planner for the national planning agency VÁTI successfully managed the network of research partners, NGOs and local representatives. Respecting regional representation and experience as well as national competencies, VÁTI used the tenders for policy development work to support a new interdisciplinary community in the creation of a body of evidence on floodplain rehabilitation in the Tisza region. In close cooperation with the inter-ministerial committee, VÁTI delivered the spatial plan for implementing the water policy, combining water retention in multifunctional reservoirs, floodplain revitalisation and rural development.

The development of water policy for the Tisza demonstrates a significant change in the substance of the policy and in the procedure applied in its design. The water policy endorsed in 2003 explicitly recognised rural development and nature conservation as important objectives alongside flood protection. Floodplain rehabilitation, retention areas and land-use change were introduced in parallel to replace or complement flood levees that had been the

1 *The National Water Authority (OVF) of Hungary implements water management under the control and supervision of the Ministry of Environment and Water Management. The regional water authorities (also called water boards) perform their duties under the control of the OVF.*

preferred solution in water management for 150 years. Government documents and actors involved talk about a paradigm shift or change in philosophy.

Figure 7.2 illustrates the main policy ideas in the Tisza.

With the October 2003 government decree and the 2004 Tisza Law, the national government endorsed the implementation of the policy. Endorsement notwithstanding, since then only two

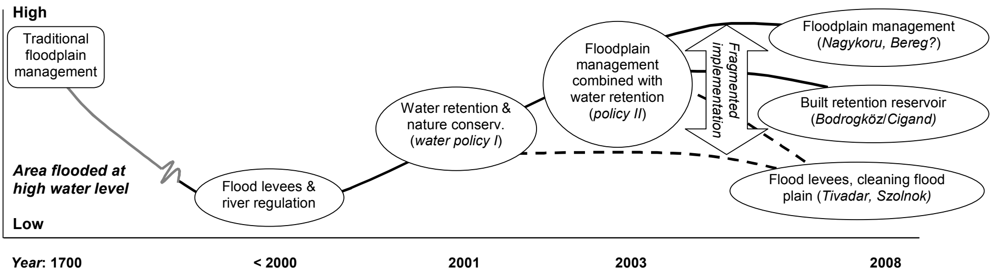


Figure 7.2: Schematic overview of main ideas in the transition

of the first six retention reservoirs have been built, while the related floodplain rehabilitation and rural development have either not been attained, or attained only after many delays. In 2005, the survey of the State Audit Office of Hungary confirmed that flood protection was favoured over rural development objectives in the implementation (Kovácz, 2005). Actors identified different reasons for the delays, including problems with land acquisition and fragmentation of responsibilities and funding. Divergence in the objectives and mandates of institutions as well as the complexity of national and European financial flows delayed the implementation of cross-sectoral initiatives (Werners *et al.*, 2009a; Chapter 5). The network of civil servants, experts and regional representatives that prepared the implementation plan fell apart. The high-ranking civil servants that had engaged with the regional coalition resigned after budget cuts. Their replacements never gained the same visibility and respect in the region.

The cooperation between the Ministry of Environment and Water and the Ministry of Agriculture and Rural Development decreased. The Ministry of Environment and Water used available funds to move ahead with flood protection (Cselószki, 2006), not delivering on agri-environmental payments for affected farmers, which required support from the Ministry of Agriculture and Rural Development. It was suggested that, under pressure from large landowners, the Ministry of Agriculture favoured using European agricultural funds for direct agricultural output-based support rather than for agri-environmental schemes. As a central member of the Bokartisz coalition and Tisza Alliance put it:[1] "*In November 2003 it seemed that all parties were on the best way to make an integral implementation plan for the Vásárhelyi plan. (...) As I see it now, the water engineers never changed their opinion. Their goal was still only flood protection. They just said: if the farmers want floodplain management and land use change we shall give them the opportunity and support (...). In a way Váradi and Szlávik were pioneers in the water engineering field because they let new ideas come into the planning.(…) when they resigned the old school water engineers came back into force*".

1 *Interview: 29 August 2007, Budapest.*

The venues created for the preparation of the plan were not maintained. The inter-ministerial committee – the main coordination body of water policy - had neither an official legal position nor the mandate to allocate money for implementation. From the middle of 2004, the dialogue between regional and national parties declined, as did the frequency of the inter-ministerial committee sessions. Consequently, the transparency of the planning process declined and, for example, in the Bodrogköz area, the information flow to stakeholders and their consultation practically stopped (Celószki, 2006). Application for EU support caused additional delays: the government decided to postpone reservoir building in 2005 to be able to apply for European funds in support of the implementation (Visnovitz, 2008). A new venue was explored when farmers went to court over perceived fraud in the expropriation; as one of the involved farmers expressed:[1] "*the whole expropriation is sensitive, because for a highway they [the government] pay much more. And we don't even get a highway, we only get a reservoir*".

Another sign of the deteriorating communication was that the interpretation of the policy idea of floodplain management started to diverge between actors during implementation. Key individuals in the water authority and the national water research institute began to question whether shallow flooding and floodplain revitalisation could attain the same flood protection levels as dry polders and pressed for putting flood defence above the protection of natural values (Visnovitz, 2007). A floodplain management pilot area of a key member of the Bokartisz coalition was written off by the Ministry and Environment and Water that contested its contribution to water level reduction during extreme floods (Visnovitz, 2007). Local mayors in the Bodrogköz area questioned whether the negotiations and expropriation were conducted in their best interest and started to express discomfort with the negotiated concept of floodplain management.[2] As more and more of the water management ideas of the Bokartisz coalition were given up or delayed at the implementation stage, Bokartisz' leader withdrew from active coordination. Key members started a new coalition - the Living Tisza Alliance - to pursue the objectives of floodplain revitalisation and sustainable rural development in another area close by.

By 2005, the 2003 window of opportunity for changing the water policy had closed. There had not been a major flood for some time. The political priorities had changed. The main policy ideas were challenged. The concept of floodplain management, rural development and nature protection disappeared from government publications and the language of the concerned department, in favour of floodwater retention and improvement of flood infrastructure (e.g. Visnovitz, 2008www.vizugy.hu/vtt/ sajtoanyag.html#37). The Living Tisza Alliance tried to use the 2006 elections to generate new momentum for the integral implementation of the water policy by soliciting support from potential coalition parties and initiating a memorandum to Ministers and political parties, which was signed by 120 concerned local governments, smallholders, civil organisations and researchers (Kajner, 2006). Although party representatives expressed their support, there was little effect on the implementation of the policy.

By 2009, two reservoirs had been built, and negotiations at other locations were continuing. The implementation of the water policy illustrated that support – as well as opposition -

1 *Interview: 22 August 2007, Nagyrozvágy / Bodrogköz region.*

2 *Interview: 23 August 2007, Cígand.*

had to be gained and maintained. Planners of the water policy, and politicians, witnessed that local leaders, farmers and residents of concerned settlements consistently laid down conditions for the acceptance of retention reservoirs, such as infrastructural investments, one-off compensation, or warranted agri-environmental payments (Cselószki, 2006).

Figure 7.3 summarises the narrative above, highlighting the actions of central individuals, on which the discussion section builds. The figure focuses on the actions of and interaction between the network of the national water authority and the regional coalition Bokartisz.

7.2.2 Flood policy, the Netherlands

Located in the delta of four European rivers - the Rhine, the Meuse, the Scheldt and the Ems - the Netherlands is crucially dependent on water management and effective flood protection. Water policy change in the Netherlands started with the new concept of 'nature creation' or green engineering. It emerged when, in the 1980s, a group of ecologically-minded mid-ranking bureaucrats from the Ministry of Agriculture and from the Public Works Department (*Rijkswaterstaat*) got together with the Dutch branch of the World Wildlife Fund to come up with new ideas for countryside planning (Warner, 2003).[1] The discourse on green engineering developed out of many social interactions and cannot be attributed to anyone exclusively. However, successful discursive entrepreneurs can exploit the ambiguities of a discourse to promote their legitimacy (van Hemert, 1999). The late 1980s were a propitious time for green engineering. The once unassailable Public Works Department had suffered legitimacy defeats after successful public protests against dyke reinforcements that sought to preserve the environment and cultural landscape. The Department wanted to rid itself of its technocratic, solipsistic image. It also needed a new problem to solve and programme of work after the completion of the coastal protection works (van Hemert, 1999). In addition, recurring agricultural surpluses (produce and manure) had made farming unpopular. Agricultural retrenchment through buyout would free up space for the river to meander and for more natural banks. Green engineering seemed to tie in well with the environmental consciousness peaking at the turn of the 1990s. Nature organisations such as the World Wildlife Fund, sceptical at first, bought into the concept with their Living Rivers publication (WWF, 1992), which introduced the idea of river bypasses to restore ecosystems.

The Public Works Department, spatial planners and the Ministry of Agriculture (now incorporating a nature branch) initiated landscape designs for the Border Meuse and proposed restoration interventions for the Rhine where it enters Dutch territory. The green engineering plans, however, suffered a setback when the Rhine and Meuse came close to overflowing in 1993 and 1995. Protection became the first priority and supporters of flood levees were quick to rush a crash programme of revetments through Parliament. These supporters were often engineers who were formerly involved in the major coastal protection works and who were sceptical about climate change, sea level rise and about spending public money on non-security issues. They contested the often-heard claim that dykes could no longer guarantee safety and

1 *The Dutch government organised the so-called Eo Wijers contest to elicit innovative policy ideas in town and country planning. The prize-winning project proposed bringing back the stork into the Dutch countryside by 'developing' natural values. Nature development seeks to increase the diversity and abundance of natural values through green engineering. (www.ecoplan.nl/inhoud/natuurontwikkeling/ natuurontwikkeling.htm)*

Time / context	**Actions of individuals in the network of water authority, water engineers (National)**	***Policy interaction***	**Actions of individuals in the regional coalition of municipalities, NGOs & scientists (Bokartisz)**
1990s Floods recurring. EU and NGOs promote 'living with water'	A few water experts challenge dyke reinforcement and engage with national nature protection NGOs		Individuals carry out pilot studies on floodplain revitalisation and *build network* of regional farmers, civil organisations and experts
2000 Flood & cyanide spill. *EU accession negotiation.*	*Develop new water policy:* Water retention in built reservoirs and widened riverbanks possibly combined with nature conservation		Led by Geza Molnár, municipalities and regional NGO's *create regional coalition Bokartisz* to promote floodplain revitalisation. They invite the responsible government actor to present policy plans
2001 Dyke break	Present policy plans in region. Try to secure funding (e.g.EU pre-accession funds)	*Ideas conflict.* *Objectives differ*	NGO members in Bokartisz organise opposition in region using media as a new *venue*
2002	Responsible government actor invites Bokartisz	*Discuss mutual ideas*	Researchers in Bokartisz strengthen cooperation with (inter-) national partners
2003 Elections & new coalition government. *Ministries & water authority reorganised*	Responsible government actor uses *window of opportunity* for government approval of new policy ideas and *creation of new venues*: inter-ministerial committee and five open tenders for background research	*Intense cooperation.* *Shared idea:* Water retention in multifunctional reservoirs. Shallow flooding in floodplain on demand regions	Mayors in Bokartisz coalition conditionally offer territory. Researchers in Bokartisz coalition secure Bokartisz' position in national water policy tenders and international projects
2004 *EU accession*	Key civil servants resign after budget cuts		NGOs train farmers (e.g. in applying for agri-environmental schemes)
	Start implementation. Cease inter-ministerial panel and interpersonal cooperation with region		Mayors protest in Budapest against limited information and lacking funds for, amongst others, land use change
2006	Reduce regional project bureau. Postpone implementation to apply for EU funds	*Occasional workshops*	NGO leaders start *new coalition* with supporters of floodplain management and develop plan for alternative region NGOs cooperate in Europe funded projects outside area water policy
2008	Water Ministry starts national media campaign, highlighting technical aspects		Conditionally offer alternative region for implementation water policy Press releases scorning media campaign

Figure 7.3: Main actions and interactions between a network of national actors and central regional coalition in Hungary.

needed to be supplemented with river widening. They felt 'security' as a prime objective was watered down by the alliances of water managers and environmental conservationists.

Nevertheless, the green wave persisted among top officials in the Public Works Department. Their solution was to create 'Room for the River' with measures such as dyke setbacks, widening and lowering the floodplain, and creating more natural river banks with shallower gradients. An important consequence of the high water periods was a growing awareness of the flipside of security provided by taming the rivers through dykes. Water experts from the national research institute RIZA and WL Delft Hydraulics, who also advised on water policy, had started to research non-traditional insecurity elements, ranging from human factors in dyke failure to climate change. This led to the public communication of a new message on flood security from the Public Works Department: dykes cannot guarantee total security and there will always be 'residual risk'. The question, then, became: How do we deal with the residual risk? A senior civil servant at the Public Works Department, Van den Hoek, advocated making a structural reservation for water retention or 'calamity polders'.[1] The research institute Delft Hydraulics gave this idea technical and intellectual legitimacy by stressing that flooding land to save other areas had historic precedents. The Vice Minister for Water[2] strongly welcomed the idea of retention areas. A window of opportunity for aligning green (nature), blue (water) and red (socio-economic) values, opened when the Vice Minister for Water got along well personally with the Spatial Planning Minister, whose public officers were developing a revolutionary White Paper (the Fifth National Policy Document on Spatial Planning (VROM, 2001)) in which they proposed spatial reservations for 'blue', 'green' and 'red' activities. This opportunity required maps of potential retention areas. To the surprise of key Public Works Department officers, these were appended hastily as an annex to the new water policy, Room for the River, presented on 29 February 2000.

Given the still shaky legitimacy of the Public Works Department, its liberal Minister made the unusual move of partly decentralising the decision making on Room for the River interventions. Provincial and local authorities were invited to take the lead and propose interventions, as long as the mandatory flood peak level reduction was achieved. However, participation in this seemingly open decision-making processes was strongly orchestrated and the outcomes prejudged (van Hemert, 1999). This raised tension with local parties and could eventually undermine the idea of the 'calamity polders' itself.

The case explored here is that of the State Advisory Commission mandated to assess the benefits and suitability of emergency flood retention areas, as well as the opposition that met its advice on flood retention. The commission had been instigated by the Home Office and Public Works Department after local opposition to the flood retention areas, included in the 2000 Room for the River policy document. The Commission was chaired by senior liberal senator Luteijn, a mentor of the Vice Minister. It took a restrictive policy with respect to its informants, talking to national and regional organised interest, including a mayor, but not

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1 *Different terms were used, which created much confusion when the idea was introduced. 'Controlled flooding' and 'retention' were considered less sensitive than 'calamity polders'.*

2 *In the late 1990s, water management was given its own Vice-Minister. Previously, the Dutch Minister of Public Works attended to both Traffic and Water Management issues.*

to local people, claiming "*security is too important to subject it to national debate*".[1] A limited number of pre-selected 'stakeholders' were invited onto a consultative board (*klankbordgroep*), in the hope that this orchestration of 'allowed criticism' would reduce protests. The work of this board was not taken seriously, as evidence surfaced that the Commission report had already been finalised before the board could discuss the conclusions.

The Luteijn Commission focused on searching societal support rather than asking critical questions about the idea of establishing flood retention areas itself. Next to giving a positive recommendation about establishing flood retention polders, the Commission identified three potential areas: the Ooij polder and Rijnstrangen area along the river Rhine and the Beersche Overlaat along the river Meuse. For its rich history of protest of well-informed inhabitants against a variety of government plans and interventions, the Ooij polder became the focal point of protests against all flood retention plans. The analysis therefore focuses on the case of opposition in the Ooij polder.

As uncertainty about the government plans spread among his clients, the director of the local branch of the Rabobank[2] started an information campaign. He invited Senator Luteijn, who happened to be on the bank's national Executive Board, to give a presentation during the annual meeting of the local Rabobank branch on 3 October 2002. The meeting room was filled with sceptical bank clients and members of the press. Outside the building agriculturalists had put up straw dolls with protest slogans. These protests struck a chord with property owners and other citizens, several of whom had been involved in earlier protests against dyke reinforcement and other unifying causes such as urban expansion of the nearby city of Nijmegen. The regional environmental conservation umbrella organisation, the Gelderland Environmental Federation, initially was in favour of the concept of uncontrolled flooding, as it would flush and regenerate the natural environment. However this stance was reversed in the Ooij polder debate, when its members realised their own houses were on the line.[3]

The emerging coalition against flood retention polders was not formed around an overarching idea, aspiring to be an anti-hegemonic coalition, which needs a shared agenda and ideological coherence to be successful, as Antonio Gramsci teaches in his Prison Notebooks (1935). Rather, the opponents were a collection of individuals with divergent agendas that entered a marriage of convenience in the new civic coalition 'High Water Platform' (*Hoogwaterplatform*), consolidating scattered protests. The local Rabobank provided the platform with initial funding. At the insistence of the Rabobank's director, a regionally well-recognised and active pensioner became chairman of the civic platform. The number of members and largely private sponsors increased rapidly. Many members were well-educated people working in education, private enterprise or administration rather than agriculture. Many originated from outside the Ooij polder, but felt a close connection with the polder after living there for years, even decades. The platform was organised in three working groups: 'technical', 'action

1 *Interview with D. Luteijn, 6 July 2005, Nieuwegein.*

2 *The Rabobank has a long history of cooperative banking and agricultural credit provision in the Netherlands. Most farmers have an account with the bank and show a high degree of trust in it. The supportive role played by officials of the local branch office in the Ooij polder during the 1995 evacuations had boosted this trust (see Roth et al., 2006).*

3 *Interview with R. van Loenen Martinet, 23 November 2005, Arnhem.*

and communication' and 'legal'. It created a website presenting an overview of the latest developments, press comments and research reports.

Initially, the High Water Platform tried to enter into dialogue with the Ministry of Transport and Water Management and its Vice-Minister. However, its chairman soon concluded that this was not paying off, shifting the platform's target to the House of Representatives. Platform members fostered a network of relationships with representatives from several political parties, feeding it with customised information.

The genius of the chair of the coalition was to start an information 'guerrilla' against flood retention whilst avoiding NIMBY[1]-ism (Roth *et al.*, 2006). The platform teamed up with river engineering and hydrological experts, who could devise alternatives and ask critical questions about the assumptions on river discharge, the cost-benefit ratio and climate-change projections used in the debate on flood retention polders. The platform shared the opinions of these credible experts with policy-makers and politicians to support the case against flood retention. While the High Water Platform's legal workgroup obtained a critical consultancy report withheld by the Water Department, the technical workgroup gathered information to challenge the economic and engineering assumptions of the Commission Luteijn's proposals for flood retention polders. Undermining the scientific legitimisation of flood retention polders was a smart move as supporters had so far ignored the uncertainties associated with the scientific material presented.

There is strong evidence of venue shopping (cf. Baumgartner and Jones, 1993). Coming from different backgrounds, coalition members could access multiple venues such as the national press, Parliament, the Council of State (administrative judiciary), municipalities and the province. While coalition members guided politicians around in the area, the Mayor of Ubbergen and Beek, the main population centre of the Ooij polder, steered his own course and went on national media. Through the contacts of the Province of Gelderland, platform members sought cross-border co-operation with the German state of Nordrhein-Westfalen, where similar policy measures were debated and which was sensitive to the Dutch plans because of the transboundary character of the effects of using the Ooij polder for flood retention. Townspeople initially argued that they were willing to do their bit for national safety by agreeing to a flood retention Ooij polder. However, as coalition members fed them with counter-expertise, they found the case for flooding becoming progressively weaker.[2] Property owners joined the Chamber of Commerce, social partners and homeowners in demanding counter-expertise from the same institute that had put flood retention on the map: WL Delft Hydraulics.

Notwithstanding the huge amount of time, energy and money put in to pushing the plan for flood retention polders, in 2005 the Vice-Minister abandoned the idea (WaterForum, 2005). It had been brought down by a combination of factors, including the expert criticism of the technical assumptions behind the plan, the withheld cost-benefit analysis and the pressure

1 *NIMBY is an acronym for 'not in my back yard', used to describe opposition by residents to a proposal for a new development close to them.*

2 *Interview with H.B.A.M. Sanders, 30 June 2005, Kekerdom. The High Water Platform had attracted water experts who cast doubts on, among others, the accuracy of the Ministry's climate scenarios, the degree of flood-level reduction realised by the intervention and, the cost-benefit ratio.*

put on the national political arena by the many activities of the High Water Platform.

Figure 7.4 shows the chronological narrative of Dutch water policy change above, highlighting the actions of central individuals, on which the discussion section builds. The figure focuses on the actions of and interaction between actors in the national water authority's network and the local citizens' coalition High Water Platform.

7.3 Strategies used by supporters and opponents

This section discusses strategies used by central individuals among the supporters and opponents of water policy change. Firstly, the chronological case description in the previous section is synthesised according to the fivefold distinction of strategies of individuals in Huitema and Meijerink (2009). Secondly, the section reflects on possible complementary roles of key individuals.

7.3.1 Developing and challenging new ideas

In both cases the transition idea started with discussions between mid-ranking civil servants from a department responsible for water safety, scientists from national water research institutes and people from nature conservation organisations. It is hard to pinpoint the origin of the new idea as many people worked on green engineering and 'living rivers' (e.g. Fokkens, 2001; Wolters *et al.*, 2001; Huitema and Meijerink, 2009). It is however possible to pinpoint a small number of supporters in the national government who pushed the idea over a period of several elections, background studies and (near) flood events. In Hungary, at first, the idea was treated as rather technical, aiming at safety and nature protection. After opposition from regional parties, regional interests and the more integral concept of floodplain management were embraced. The objectives of water management broadened from (flood) safety to include nature conservation and rural development. The adoption and implementation of this broadened concept was strongly influenced by a regional coalition. This coalition had developed its own ideas, separately from the national government, and was supported by European funds and inspired by (inter)national scholars. It is important to note that civil servants and their technical experts in Hungary framed their new policy differently from the regional coalition. Whereas civil servants described it as an effective response to new challenges in water management, coalition members stressed that it had its roots in history and tradition, and opposed prevailing water management.

In the Netherlands, the idea remained more confined to flood safety. After the near-floods of the 1990s, 'nature development' gave way to security as the primary focus. In the Ooij polder a strong coalition against the regional implementation of the new water policy, and in particular the idea of flood retention polders, emerged. The government did not enter into dialogue with this coalition nor did the coalition develop well-defined alternatives. In contrast with the Hungarian case, the opponents chose not to focus their protests on the consequences of the plan but rather on the assumptions and scientific underpinning. The supporters of the new idea were vulnerable to these attacks, as they had neglected to be explicit about and validate underlying assumptions and uncertainties, using analysis primarily in an 'advocacy' mode. In other words, their analysis aimed to justify and elaborate their position on the policy issue

Time / context	**Actions of individuals in the network of water authority & water experts (National)**	***Policy interaction***	**Actions of individuals in the local coalition of citizens (High Water Platform Ooij)**
1980s	Network: after opposition to technocratic water management approach, a few civil servants of Public Works Department engage with national nature protection NGOs and Ministry of Agriculture. Together they design 'green rivers' for major rivers		Individuals participate in protests against dyke reinforcement, favouring nature development (local)
1990s. Integrated water management increasingly recognised	Individual water experts advocate flood retention. Individual civil servants start to advocate the new policy concept 'living with rivers' within the Ministry responsible for water		
1995/98. Near floods	Advocates of 'living with rivers' concept reframe their ideas to fit in with the recurred popularity of dyke revetment		Ooij polder evacuated. Individuals build trust in region by giving support in evacuation. Population divided about dyke reinforcement
1999 / 2000	Civil servants advocate *policy idea* Room for the River and use *window of opportunity* to connect spatial policy and water policy. New *idea* of flood retention in water policy		
2001	*New venue:* Commission Luteijn, between politics and water experts		
2002 Provinces & municipalities protest	Luteijn presents policy idea in region	*Idea conflicts*	Business leader *uses network* to invite Commission Luteijn to present in region
2002/2003 Elections. Protests alarm national politics	Replacement of the Vice Minister of Water	*Individual water experts offer counter expertise*	Organise opposition in region. *Build coalition.* Challenge appropriateness of flood retention. Coalition members lobby in media, internet & own networks. Coalition members strengthen network with (inter-) national water experts, municipalities & private sector
2004/2005	New Vice Minister drops spatial reservation for flood retention		Platform remains active in scanning policy plans and providing information

Figure 7.4: Main actions and interactions between a network of national actors and central regional coalition in the Netherlands.

of flood safety. In Hungary opponents challenged the sustainability and legitimacy of the new idea, pointing to its strongly technical approach, and referring to the problems that technical solutions in water management had caused so far. In both cases, opponents highlighted the unwanted (future) situation that the new idea would create.

7.3.2 Building coalitions for selling ideas

[1]Following Huitema and Meijerink (2009), coalitions are defined as groups of actors from more than one organisation with shared beliefs and explicit agreements on how to use resources to achieve common goals. In both regions one person or a small group of people initiated a new coalition. Although these coalitions soon became associated with supporting or opposing a new idea, the members before entering these coalitions did not have a strong preference for a particular policy idea in water management, nor did they share core beliefs.[2] The coalitions were initiated by an individual that managed to link different core beliefs to a particular policy idea. The leader of the Bokartisz coalition in Hungary sold his idea explicitly as one that could serve regional development, nature protection, flood safety and drought control at the same time. Actors could join the coalition independently of their core belief. Although successful in its cooperation with the national government, this may have threatened the stability of the Hungarian coalition. More recently, partners left the coalition and active members remained mostly confined to those that see floodplain revitalisation as the only appropriate regional solution for sustainable rural development and nature conservation, reducing the fragmentation of beliefs (cf. Sabatier, 1988). Within the existing coalitions and actor networks in the Netherlands and Hungary, individuals did not significantly change their policy objectives and main policy idea (cf. Sabatier, 1988); rather, they took turns in supporting or opposing policy (change), depending on the policy objective.

In both cases the coalition entered the opposition *after* a meeting in the region where a national figurehead of the water policy presented the state's new policy idea. The initiator of the coalition hosted this meeting and invited the figurehead through personal and historically grown networks. In the Netherlands, for example, the Commission chairman was on the Board of Directors of the Rabobank and was invited to speak by the director of its well-established local subsidiary. After debating the implications of the plan in the region, opposition started to grow, with the new coalition taking a key role. Interestingly, core members of the Hungarian and Dutch regional coalition used the same words to describe the moment when the national government's policy idea was presented in the region: "*it was a great shock to see the plan (…)*".This supported the impression that actors in the region at the time were not well informed about the government's new policy ideas and had not yet formulated their critique or organised their opposition.

In effect, building coalitions and pooling resources under a common position was a crucial strategy for individuals in developing their own ideas as much as in opposing ideas of others. The cases suggest this was particularly true for actors outside the national government. Whether national government actors had stronger networks on which to rely, whether affiliation blocks coalition building or whether the Dutch 'state commissions', which became

1 *A set of basic values, causal assumptions and problem perceptions (Sabatier, 1988).*

2 *Interview: 29 August 2007, Budapest; and 14 October 2005, by telephone in the Netherlands.*

common for launching new ideas, were effectively the state-equivalent of coalition building, needs further attention.

7.3.3 Recognising and exploiting windows of opportunity

In both cases, there had been debates about new policy ideas in water management. The government had commissioned studies and hosted working groups. Various drivers of policy change were identified. Especially in Hungary, keen to enter the EU, European Directives, funding, and accession negotiations favoured a shift towards participatory and integral planning, ecological concerns and the reduction of cropland. Although in both cases (near) floods and growing recognition of climate risks carried the debate on the appropriateness of prevailing water management, their impact on the debate was different. In the Netherlands, supporters of both old and new water management paradigms stuck to their positions and secured the interventions that they had advocated for some time. As a result, the national government endorsed dyke improvements and floodplain restoration alongside flood retention polders in the Room for the River policy. In Hungary, the supporters of water retention managed to gain funds and policy support to change prevailing water management practices. In both cases the regional coalition was more active in mobilising people than in exploiting windows of opportunity. The exploitation of strategic opportunities seemed to be more confined to individuals in the administration in close proximity to the political arena. In Hungary, a key player at the Ministry of Environment and Water exploited the momentum for change created by national elections that brought to power a new coalition determined to prove itself different from the previous government.

More generally, the cases confirmed that elections and the changing of governing parties forced existing networks of civil servants and politicians to reconfigure, and could offer a window of opportunity to establish a new idea and kick-off a transition. However, elections after a new idea had started to take-off, could also disrupt the fresh networks. In Hungary key figures in the central administration withdrew or were replaced after the 2006 budget cuts and elections. 'Old-school' water engineers from before the transition returned to their positions. This changed the course of the water policy to more conventional solutions and frustrated many actors who believed in more fundamental changes in water management practice.

7.3.4 Using multiple venues

The previous subsections looked at the origins of the new ideas, the coalitions that were built to sell them and the opportunities for introducing new ideas into the water policy at a particular moment in time. This section asks whether individuals or groups of individuals sought out alternative venues to promote new ideas. Venues are understood as the possible places where policy issues can be debated, including various levels of government, the forums of scientists and legislatures, and the media (Baumgartner and Jones, 2002). The section focuses on the choice of venue of the individuals identified in previous sections: the central actors at the ministry responsible for water policy and in the new regional coalitions.

Both opponents and supporters of the new policy ideas actively created and used new venues including the national press, internet, Parliament, the Council of State (administrative judiciary) and cooperation with neighbouring countries. In the Netherlands, to boost the legitimacy of the new water policy, Room for the River, the liberal Minister took the new initiative to partially decentralise decision making on the implementation of the policy, using provincial and local authorities as a new venue. With varying degrees of success and sincerity in applying these new ideas, several Room for the River projects are now ongoing. In the Ooij polder participation was largely orchestrated and regional protests sidestepped when a State Commission was instigated to investigate the cost and benefits of the new policy idea of flood retention. With the creation of this new venue the national government aimed to strengthen the legitimacy of its policy idea. Failing to connect to local parties, the Commission triggered strong opposition, which itself successfully exploited new venues such as the media, political party meetings, the chamber of commerce and Parliament. In Hungary too, the national government met opposition from local authorities, civil organisations and national park authorities. In this case however, a regional coalition and local authorities took the initiative to offer a location for water retention under their own conditions. The national government representative responded by initiating new venues for more participatory policy planning and transdisciplinary background research.

In summary, actors from the new regional coalition stood out in using the media, issuing (public) communications to politicians, and legal action. Governmental actors used organisational and financial instruments such as allocating, blocking or diverting funds and changing budget priorities to block or support the implementation of a new policy idea.

7.3.5 Orchestrating and managing networks

Turning to the last of the five strategies, this subsection discusses how actors cooperated, which networks played a role in the transition in water policy and whether (groups of) individuals actively influenced the operation of networks. In particular, this subsection asks whether individuals influenced the development of water policy by breaking up or providing alternative policy networks.

Water management in both Hungary and the Netherlands had been dominated by a strong network of water authority civil servants (for policy support), engineers at national research institutes (for technical underpinning) and the private sector (consultants, civil engineers and agriculturists). The idea of water retention and flood retention polders was established in a network of mid-ranking civil servants from a department responsible for water safety, and experts from national research institutes and from nature conservation organisations. Civil servants are strategic in exploiting their relations with politicians. For example in the Dutch case, civil servants overruled politicians and exploited the good connections between the Ministers of Water, Spatial Planning and Agriculture. Conspicuous orchestration can also challenge the legitimacy of a network. In the Netherlands, for instance, the Luteijn Commission was criticised for orchestrating a consultation board, consisting of pre-selected stakeholders.

The leaders of the opposing coalitions also proved successful networkers. Opponents used multiple affiliations to extend their network. In the Netherlands, for example, members of the opposing coalition lobbied their business networks through the Chamber of Commerce, and national and regional politicians through their membership of different political parties. To challenge the technical basis of new ideas, opponents connected to specialists, operating in the background (civil engineers, ecologists, hydrologists, lawyers). In particular, the coalition linked up with researchers in the national water institutes to gain counter-expertise, which led to the leaking of a critical report on the costs and rationality of flood retention in the Netherlands. Opponents also exploited transboundary networks. The Dutch coalition consulted stakeholders, civil society action platforms and local authorities in Germany. In Hungary, opponents participated in internationally funded research and development projects with (inter-)national scientists and civil society groups.

7.3.6 Complementary strategies

Next to the strategies discussed above, five roles of key individuals are observed in the cases that deserve special attention: 1) translating the idea, 2) engaging with opponents, 3) managing information (cf. Olsson *et al.*, 2004), 4) managing time (cf. Holling, 2004), and 5) managing spatial scales (cf. Born and Purcell, 2006).

An important role that individuals played was '*contextualising the idea*'; both cases evidenced people who contextualised the new idea for regional use or implementation. These individuals acted in a similar way to Litfin's (1995) knowledge brokers, but were not confined to the science policy interface. They were found among supporters as well as opponents. As supporters, they contextualised the plans of the national government and attached regional objectives and benefits to it. Among opponents they were found to transform the plan, which the national government promoted, into an idea with negative consequences for the region. Both in the Hungarian and Dutch case local people did not initially show a great deal of interest in the plans of the national government. In the Ooij polder, the inhabitants had initially thought that the national government would not carry through its plans for water retention. Opposition started with an informed and trusted individual from the region, who brought home the message together with his critique of the plan, fuelling regional concern and, eventually, opposition.

Engaging with opponents, managing expectations and more specifically *engaging with individuals who contextualised ideas in the region.* In Hungary, national government actors successfully employed this strategy between 2002 and 2003. They invited an opposing regional coalition to join the implementation planning process and bring in its ideas. In this case the national government was able to realise its own policy ideas alongside some of those posited by the opposition. In the Ooij polder case there was little engagement with opponents. The opposing Hoogwaterplatform attempted to engage directly with the responsible Vice Minister. However, these attempts were abandoned after the opponents concluded that their arguments were not being given serious attention and a dialogue was impossible. Working in networks and engaging with opponents, the question had to be asked whether partners should compromise and change their objectives[1] or whether objectives were effectively combined and would have to be implemented alongside each other. In Hungary neither the idea of a retention reservoir nor the capacity of the reservoir changed in the negotiations and the national government got what it wanted from the start, whereas regional partners settled for a compromise. Engaging with opponents included the challenge to cope with individuals of the old paradigm. As a member of the Hungarian regional coalition pointed out: "*a paradigm change makes a lot of losers. All people whose life is built on intensive large scale agriculture. All those who were water engineers for decades and learned that water has to go down as quick as it can and that flood is an enemy. It is not easy to change for a person and to say 'what I said before was wrong'. And to include new ideas. Very few people can do that. I am open to older people, but I know that as people get older it becomes even harder* ".

The role of *managing (scientific) information and knowledge*: reports had a short lifespan in the administration. A lot depends on individuals and networks to keep (especially new) information alive. In both countries, researchers used the transition to secure significant research funds. With the protests and new policy ideas of the Hungarian coalition, research in Hungary was more transdisciplinary than in the Netherlands. Yet in Hungary, distribution of the reports that were produced during the transition period, to other ministries and parties was poor. Supporters of hard engineering (dry polders and dykes) did not trust the hydrologic or economic feasibility of floodplain management to reduce extreme flood levels. In the Netherlands, participation and decision making were more strongly orchestrated and limited to the network of water authorities and support research institutes. Research stayed confined to the familiar water research institutes. The Dutch institutes used the additional funding to attract experts from other disciplines and to become more interdisciplinary. Possibly as a result, information was more carefully managed in the Netherlands and new insights became better established throughout the government. At the same time, in the Dutch case, a background study report was withheld and only retrieved by the opposing regional coalition after threatening legal action. This incident itself became a weapon in the struggle for image, trust and legitimacy. Related to information management are tendencies of both proponents and opponents to sidestep the good governance principles of transparency and accountability.

Manage time. Parties used time differently. Regional coalitions were dependent on quick success to keep their coalition alive. The regional coalition in Hungary blamed the national government for selective implementation of the policy plans. Election times guided politicians, whereas civil servants and scientist could wait longer for the right time (and budget) to arrive. Civil organisations and coalitions had more autonomy in selecting a next generation of leaders and were thereby less subjected to sudden changes of policy and ideology.

1 *Or as Sabatier (1988) hypothesises: when change in a governmental action program cannot be restricted to secondary aspects, adherents will seek to modify the policy core in the following sequence: first, add a portion of the opposing coalition's core; second, delete a portion of the existing core; third, arrange a synthesis of the two cores; and, finally, acquiesce to a replacement of one's core by the challenger's, but try to get portions of it incorporated into the new secondary aspects.*

Manage spatial scales. National governments framed policy options as localised solutions for a national problem. Regional coalitions highlighted landscape and regional aspects and challenged the fairness of having to solve (suffer for) other people's problems. In the Ooij polder case, spatial-administrative scales played a key role. Flooding of the river Rhine was a transboundary problem, but the proposed solution was primarily national, not taking heed of the impact of upstream conditions and policies, nor of sensitivities associated with the idea of flood retention polders. While the supporters created tension and unrest by underestimating this factor in the relationships with Germany, the opponents made optimal use of it in networking, coalition building, the research agenda and communication.

7.4 Conclusions

This chapter aimed to examine the significance of individuals in supporting or opposing major water policy change by analysing what happened in Hungary and the Netherlands when water retention and floodplain rehabilitation were introduced into water management to replace or complement flood levees and drainage.

Since the new ideas (water retention, floodplain revitalisation, flood retention polder) emerged, people rotated in supporting or opposing policy (change), depending on the governing policy objective. In doing so, both supporters and opponents used the strategies identified in Huitema and Meijerink (2009): to develop ideas, to build coalitions to sell ideas, to use windows of opportunity, to play multiple venues and to orchestrate networks. Working together in coalitions, key members took complementary roles. With respect to the development of policy ideas, opponents used two different strategies: 1) discredit the new policy idea to block change and to maintain the status quo, and 2) advocate change towards another policy idea. In both cases opponents were successful in engaging with experts from the scientific community of the supporters to challenge the legitimacy of (assumptions underlying) the new policy idea. Additional strategies that opponents pursued included changing budget priorities and timelines.

Selecting and describing two cases with a visible opposition to new water policy inevitably introduced a bias in the analysis. Areas for future research include looking at strategies and the interaction of opponents and supporters in relation to stages of major policy change; addressing which conclusions are specific for transitional policy change or for better understanding transition dynamics in general; and reflecting on the effect of strategies of supporters *and* opponents on the outcome of major policy change in the context of other variables such as the role of ideologies, interests, institutions and path dependency.

Our cases evidenced the key role of individuals and suggested that this role becomes particularly prominent in the interaction between supporters and opponents of (parts of) major water policy change. A central difference between the Dutch and the Hungarian cases analysed in this chapter was that in the Netherlands a regional coalition blocked the implementation of an element (flood retention polders) of the national government's policy idea (Room for the River), whereas in Hungary cooperation with key opponents of the plan in the region allowed the national government to realise its objectives alongside recognising those of the opponents. The cases suggested that the choice of whether or not to engage with (potential) opponents influences the outcome of water policy change. A special role was that of individuals who delivered emerging water policy ideas to other actors. The influential coalitions in the analysed cases had such an individual at their heart. These individuals were also found to be successful networkers and creative in exploiting new venues. Whether or not government actors sought to involve these individuals in policy making influenced the realisation of the water policy. In the Dutch case, where this was omitted, the coalition could obstruct the new elements of the water policy. By engaging with opponents, negotiated solutions could give water policy change a new impetus, yet at the same time cause a diversion from the original idea, alienating supporters that measured success by the realisation of the original idea.

Chapter 8

Conclusions and recommendations: a synthesis of adaptation in managed river basins

Work of graffiti artist Laser 3.14. Photo: Werners, Amsterdam 4 Dec. 2009

8.1 Introduction

The main theme of my thesis is adaptation to climate related risks in managed river basins. To examine the challenges and opportunities for adaptation, I focus on one particular adaptation strategy: diversification of land use and water management activities. I interpret diversification as the combination of different land-use activities and water management options within a region. In line with the framing of adaptation in Figure 1.1, diversification was studied as an adaptation strategy in relation to adaptation objectives and actors, and by asking four central research questions:

1. Can diversification of land use and water management activities reduce climate related risks in managed river basins? (Chapter 2 - 4)
2. Can Modern Portfolio Theory be used to assess the reduction of climate related risks by diversification of land use and water management activities at different scales in managed river basins? (Chapter 2 - 4)
3. What governance systems enable diversification of land use and water management activities? (Chapter 5)
4. What is the role of individuals in diversifying land use and water management activities? (Chapter 6 - 7)

This chapter synthesises the lessons learned from addressing these questions in two case study river basins: the Tisza River Basin in Hungary and the Rhine River Basin in the Netherlands. It closes with a broader reflection on adaptation to climate related risks in managed river basins.

8.2 Diversification of land use and water management activities (Question 1, Chapter 2-*4)*

To increase our appreciation of how water and land-use change can reduce climate related risks in managed river basins, my research concentrated on a particular water and land-use change strategy: diversification. The term diversification was used for combining different agricultural land use and water management activities within a region. Diversification offered opportunities to reduce climate related risks that would have been missed if these activities were studied in isolation. In particular, the analysis in the Hungarian and Dutch cases revealed how agricultural land-use systems and water management activities could be combined into a portfolio that has a lower risk than the risk of the individual water and land-use activities. Risk was analysed as the standard deviation of the revenue of water and land use activities. Land-use revenues included crops yields as well as potential (avoided) flood damages. The presented analysis concentrated on the monetary benefits of water and land-use diversification as a possible climate adaptation strategy, excluding many non-climate costs and benefits of diversification. The approach, however, could also be used for inclusion of non-climate factors such as variable production costs and subsidies by replacing historic gross revenues with net revenues or (farm) net value added.

Another extension of this work is the addition of new crops and crop management options, such as irrigation techniques and changes in the timing of planting and crop handling. Stakeholders in the Hungarian Tisza region expressed particular interest in the benefits of diversification with non-agricultural activities such as tourism or alternative agricultural production systems such as vini- and horticulture. To what extend current and historic land-use systems reflect a suitable regional response to climate variability deserves more attention in future research (cf. Werners, 2009). Understanding the link between climate variability and land use can facilitate proactive adaptation to future change in climate and climate variability. Yet, costs and benefits have to be carefully assigned to specific actor groups. Whenever the government offers to compensate for land-use change or flood damages, lumping all cost and benefits in one risk assessment will obscure the perceived risks to which actors respond when they consider adaptation options. For the particular case study of the Tisza River in Hungary, my analysis showed that risks and revenues of land use and water management diversification at the regional level are different from those at higher levels of aggregation taking account of downstream flood risk. Downstream regions benefited from investments in water retention and reduced flood risks. Locally, flood risk reduction did not outweigh the costs of building and maintaining water retention infrastructure. For the county and the river basin, however, the reduced flood risks largely exceeded the costs of water retention. Thus, the regional perspective highlighted trade-offs between flood levees and water retention that are different from those at the micro-regional level.

My analysis showed that the current combination of intensive and floodplain agriculture minimises regional agricultural risk. A shift from conventional intensive agriculture protected by flood levees, to retention areas with extensive cattle breeding and orchards not only increased the expected revenue from agriculture in the analysis, but also the agro-economic risk associated with climate impacts. Downstream it decreased flood risk. My research showed that taking account of externalities over the study regions in Hungary and the Netherlands, combining flood levees with water retention areas is a cost effective way to reduce flood risks.

8.3 Portfolio Theory and adaptation to climate related risks (Question 2, Chapter 2-*4)*

Whenever decisions relate to different activities, and the return on the individual activities is subjected to risk, Portfolio Theory is suitable to combine activities into a robust risk reduction strategy. Although Portfolio Theory was developed for investment in financial markets, these preconditions also hold for developing adaptation strategies in managed river basins to cope with climate related risks. A portfolio is interpreted in my analysis as a collection of land-use systems and water management activities that a water manager can select. My research showed how Portfolio Theory could help water managers to develop robust adaptation strategies.

The Dutch and Hungarian case studies showed opportunities for using Portfolio Theory. The cases made explicit the risk under which current technical measures are being developed in terms of their investment cost and return under current climate variability and future scenarios. My application of Portfolio Theory relied largely on monetary costs and benefits (i.e. flood damages and crop revenue). Future work could try to include other performance indicators, such as, for example, those based on ecosystem services (cf. Minca *et al.*, 2008). The concept of diversification also fits well into current climate change and vulnerability research (e.g. Adger *et al.*, 2004; O'Brien *et al.*, 2004a), which focuses more on reducing the current vulnerability, which assumes that future –unexpected- shocks or extreme events can be absorbed or anticipated if current climate variability is well understood and embraced in resources management. Portfolio Theory could add to this research by offering appropriate proxies for assessing vulnerability and adaptive capacity (cf. Werners and Donaldson, 2006). In addition, portfolio thinking encourages the assessment of the added value of additional measures such as spreading risk through insurance or the creation of retention areas. The presented appraisal of the correlation between returns of various water management activities offers a tool to learn and re-evaluate portfolios once more information becomes available. Whereas the analysis in this thesis can be broadened to include other activities and non-climate factors, it ultimately remains up to individual farmers and decision makers to handle trade-offs between risks and revenue.

In my research, Portfolio Theory encouraged the systematic evaluation of the relationship between the risk and return of individual activities and those of portfolios of activities. In particular, Portfolio Theory called for risks to be evaluated in relation to the full range of activities that actors had at their disposal and the full range of external conditions these activities may be exposed to now and in the future. This is different from the current practice where water management activities are typically tailored to perform under a specific design discharge or narrow range of extreme events. My analysis showed the importance of understanding the correlation of the revenue of different water and land-use management related activities. It showed how combining agricultural land use systems, particularly intensive and floodplain agriculture in the Tisza River Basin reduced climate related risks. Given the land uses in a region and their dependence on climatic conditions, Portfolio Theory showed that there is an upper limit to diversification beyond which risks cannot be 'diversified away'. In this way, my analysis demonstrated that Portfolio Theory deserves more attention in water management.

8.4 Governance systems enabling diversification (Question 3, Chapter 5)

To appraise governance systems that enable diversification of land use and water management activities, a recently proposed conceptualisation of earth system governance (Biermann, 2007; Biermann *et al.*, 2009) was applied. This governance conceptualisation proofed a comprehensive framework to assess drivers, barriers and opportunities for adapting to climate related risks in the Tisza River Basins. The major challenges to be addressed in integrated floodplain management could all be associated with one or more of the key problems distinguished by earth system governance: '*uncertainty*', '*functional, spatial and temporal interdependence*', and '*extreme effects*'. Problem structure analysis highlighted how previous socio-economic and political orders continue to shape expectations and patterns of conduct. Current water management actors associate root causes of current problems, vulnerabilities and inequalities with unsustainable management of resources and state coordinated interventions in the past. Another interdependency highlighted in the Hungarian case study was the growing domination of urban areas over rural areas. Work in the Hungarian Tisza region suggested that interdependencies are not only a problem, but that creating and restoring mutual dependency also offered opportunities for adaptation. This held for socio-institutional as well as socio-ecological interdependencies. The relatively well-preserved natural environment of the Tisza region can only become a real asset in terms of the risk reduction and sustainable development of the region if there is awareness of this asset (cf. Fekete, 2006; Tàbara *et al.*, 2010). Challenges for realising diversification of land use and water management activities were found to exist on all scales and care has to be taken not to associate adaptiveness and sustainability a priori with a particular scale or production system but rather to explore opportunities across scales (cf. Born and Purcell, 2006).

Using the conceptualisation of earth system governance, current barriers for diversifying floodplain management can be attributed to a lack of the key governance principles '*credibility*', '*stability*', '*inclusiveness*' and '*adaptiveness*'. Interviewees perceived the lack of *credibility* and effective cooperation between organisations as the largest barrier. In particular, the Tisza River Basin case showed the tension between adaptiveness and stability. The lack of *stability* after major floods and elections offered opportunities for new networks to emerge and kick off policy change (Chapter 6). On the other hand, it was the lack of stability of the new networks and arrangements as much as the lack of *adaptiveness* of the institutions supporting conventional flood protection solutions that frustrated the actors aiming to implement river basin management. The paradox of stable adaptive river basin management was further complicated by a loss of accountability and credibility. With respect to *inclusiveness*, evidence from the Tisza region confirmed that cooperation in plan design facilitated consent and joint understanding, yet negotiated land-use patterns were not necessarily the most efficient from the perspective of flood protection. Specific barriers encountered were the required interventions at the landscape scale, the cooperation of many actors and the land consolidation and compensation programs. The benefits and costs of diversification were often difficult to compare or share between actors. To convince local partners as well as national development agencies to cooperate, the cost and benefits of multifunctional land use and water retention in the floodplain had to be evaluated against monoculture and flood levees (see also Chapter 3). To remain credible, water governance would have had to deal with enforcement and possibly expropriation.

The Tisza case suggested that the four governance principles in earth system governance can perhaps be seen as necessary but insufficient for river basin governance. Subsidiarity, reciprocity, creating networks and cooperation across scales, coordination and leadership, open access to information, risk mitigation, benefit sharing and compliance deserved additional attention. Adaptation of the governance system may require a deeper change than maintaining the current resource base for future generations. Of particular importance are the remnants of previous economic, social and political orders that continue to shape expectations and patterns of conduct. This path-dependency deserves more attention in earth system governance.

Finally, diversification of land use and water management in the Tisza River Basin benefited from inclusion of actors beyond governments and state agencies, and equitable resource allocation between different parties (at different scales). A key challenge for new governance arrangements and multi-stakeholder organisations was to ensure accountability and legitimacy through formal regulation and informal relations. Regulation was required to include adaptation in longer term planning and investment in large-scale infrastructure. Conversely informal relations were found to be conducive for strengthening learning, cooperation and implementation of diverse water management activities (cf. Matczak *et al.*, 2008).

8.5 The role of supporters and opponents of diversification (Question 4, Chapter 6-7)

This part of my analysis focussed on the role of supporters as well as opponent and the strategies that they used to bring about or oppose water policy change towards more diverse water management activities. The main inspiration for this analysis was a perceived limitation of the earth system governance concept to support an existing governance system and its actors in understanding change and in setting priorities to adapt to change. Thus, the analysis aimed to enrich lessons from using the concept of earth system governance with those of change processes and innovation. Insights from studying the role of individuals were found to be complementary to those from the earth system governance framework. This complementarity of concepts could be exploited (cf. Dewulf *et al.*, 2008). My analysis showed that water and land-use management can benefit biophysically from diversification through the combination of complementary water and land uses. Similarly, it can benefit procedurally from diversification and the combination of complementary concepts such as governance and the analysis of the roles of individuals. This could be achieved, for example, by reflecting on the effect of strategies of supporters *and* opponents on the outcome of policy change in the context of other variables and path dependency, as identified by applying the concept of earth system governance.

The analysis of the Hungarian and the Dutch case study uncovered the complementary roles individuals played in furthering or blocking the adaptation of land use and water management. The attempted adaptation of water policy became manifest with the change in the substance of the policy of bringing in new water management infrastructure (water retention and calamity polders to complement dykes) along with a broadening of policy objectives (from flood safety to include environmental concerns and, in Hungary, rural development). Although changes in the governance paradigm followed (decentralisation in the Netherlands, participation in planning in Hungary), these were less explicit. The reality that the operation of new water management infrastructure would require organisational change was largely ignored by national governments, adding to the ambiguity perceived by regional actors.

A central difference between the Dutch and the Hungarian case was that in the Dutch case a regional coalition blocked the implementation of an element (i.e. emergency retention areas) of the national government's policy idea (the water policy 'Room for the River'), whereas in Hungary the cooperation with key opponents of the plan in the region allowed the national government to realise its objectives alongside recognising those of the opponents. Thus the analysis suggested that engaging with (potential) opponents was a strategy employed by individuals to influence the outcome of policy change. The role of individuals became particularly prominent in the interaction between supporters and opponents of new ideas for river basin management. Individuals played a key role in testing, debating, furthering and opposing new ideas through the collaboration between recognised actors from civil society, policy and science. A special role was that of communicating or 'translating' a new policy idea to other actors, often with the intention of making these actors either supporters or opponents. In the cases I analysed, influential coalitions had an individual at their base that acted as such. To try and identify these individuals and to engage with them was an effective strategy to influence the realisation of policy change. Where this was ignored, the coalition could obstruct change. Successful strategies to discredit policy change included: challenging the legitimacy of (assumptions underlying) the new approach; obtaining counter-expertise from the experts who also advised the supporters; using local implementation problems to discredit the general policy idea and; changing budget priorities.

In summary, crucial factors for adapting water policy were the recognition of an adaptation strategy at an abstract level by responsible civil servants, and their engagement with a credible regional coalition that could contextualise and advocate the strategy regionally. Since the new ideas emerged (water retention, floodplain revitalisation), parties took turn in opposing each other's plans and policies, depending on location and existing regional and national networks and coalitions. In doing so, both supporters and opponents used similar tactics: to develop ideas, to build coalitions to sell ideas, to use windows of opportunity, to play multiple venues and to orchestrate networks (cf. Huitema and Meijerink, 2009). In addition, the cases suggested that opposition is inherent to policy change. Managing conflict, information and expectations were important activities of those aiming to manage climate risks in river basins.

8.6 Lessons learned: adaptation in managed river basins

In its assessment of adaptation practices, Chapter 17 of the IPCC's Fourth Assessment Report (Adger *et al.*, 2007) concludes that: i) adaptation measures are seldom undertaken in response to climate change alone, ii) adaptation to climate change is already taking place, but on a limited basis, iii) adaptation and adaptive capacity are uneven across and within societies, and iv) there are substantial limits and barriers to adaptation. My results support these insights. In addition to limits and barriers, I observe opportunities for advancing adaptation in water and land-use planning. In line with the conceptualisation of adaptation in the introduction of this thesis (Figure 1.1), this concluding section elaborates on the commonalities and contrasts in the two case studies in relation to adaptation objectives, actors and strategies. Figure 8.1 summarises the main conclusions.

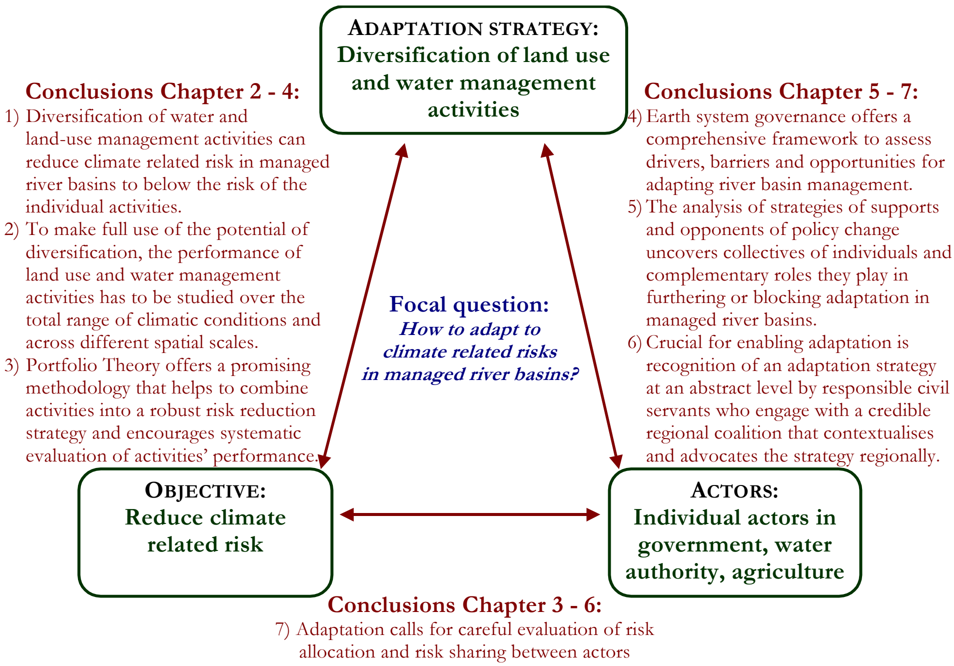

Figure 8.1: Main conclusions of my analysis in relation to the interaction of adaptation strategy, actors and objectives

8.6.1 Adaptation actors

Opportunities for using water and land-use planning to support adaptation and climate-proof regional development, have started to emerge. In both regions the capacity to participate in adaptation planning and the distribution of that capacity across different actors and governance levels prooved crucial for successful adaptation implementation. This includes, for example, access to information, governance and financial services.

Divided and ambiguous responsibilities of actors are key constraints for adaptation action in the Tisza River Basin. In both the Rhine and Tisza River Basin the analysis showed a lack of co-ordination between agencies, and tensions between actors at different scales. To achieve more adaptive governance structures capable of dealing with projected climate related risks and uncertainties, different actors need to work together to make policies, plans, roles and activities more coherent. Stable adaptive governance is a complicated paradox. Adaptive governance is a relatively new concept that needs to be demonstrated to gain in appreciation. Inspiring examples are the emerging coalitions of government and non-government actors that are helping to put adaptation in the regional context and encourage action. Successful coalitions often have close connections to academics who act as brokers in the communication of climate risk and adaptation information. My analysis in the Tisza region shows the importance of recognising adaptation at an abstract level by responsible civil servants and backing of an adaptation strategy by a credible regional coalition. Opposition is inherent to implementing more fundamental policy change and engaging with (potential) opponents is an important activity in adaptation planning.

Adaptation can fail or be counterproductive because social processes and structures are imperfectly understood. Some adaptation options have consequences that are socially unacceptable. In the Tisza basin, for example, proposed sites for water retention were rejected. The Tisza study region shows that informal social networks around local production systems have degraded, but are remediable. Local populations hold a wealth of knowledge on how to cope with climate variability. This knowledge deserves to be taken into account while developing adaptation policies and measures. In addition, strengthening diverse local capacities offers opportunities for income diversification through, for example, agricultural and cultural related tourism. The Tisza region in particular shows the benefits of debating climate related risks and how best to respond. This supports the notion of adaptation as a social learning process (cf. Pahl-Wostl *et al.*, 2007a; Tàbara *et al.*, 2009).

The implementation of adaptation strategies is constrained by unequal distribution of costs and benefits among actors. For instance, water retention can reduce overall risks in a river basin while increasing the risks for those who store the water. The difference between those who are, and are not, included in adaptation pilots or support programs can raise tensions among residents. The perception of fair sharing of costs, benefits and risk between actors –locally, nationally and internationally- is central to the successful implementation of adaptation, and addressing it offers opportunities for adaptation planning.

8.6.2 Adaptation objectives

In both regions studied, people are experiencing impacts of a changing climate. Yet, in the Tisza region in particular, people struggle to connect regional trends to global climate change. The causes of trends in flooding are contested. Adaptation policy so far does not address the diverse perceptions of risks and their causes. Nor does it address risk allocation and how risks shift from the urban residents to the rural areas, and in particular the agricultural sector, under the new water management plan. Although climate change impacts have encouraged dialogue between different actors and policy communities (e.g. water and agriculture), actual adaptation planning and implementation remain largely sectoral.

Although the role of context-based science is increasingly being recognised and supported by national and regional institutes (cf. Weaver *et al.*, 2006), there is no clear connection between regional climate impact studies and adaptation objectives. Adaptation planning is typically based on general climate trends and scenarios, partly because detailed climate projections and assessments of climate impacts have only recently become available.

8.6.3 Adaptation strategies and diversification

At present, pro-active adaptation options are developed for future climate change, yet on a limited basis. Adaptation is mostly in the planning stage or implemented through pilot projects. Existing technical solutions, such as building dykes, have limits or are being challenged for adding to undesirable downstream or longer-term effects. Pilot projects and demonstration activities have started to test the feasibility of new technologies and policies for climate-sensitive land use and natural resource management.

In the Tisza region in particular, opportunities arise from combining traditional agro-environmental land-use systems with new technologies and institutional designs to preserve diversity in landscape and livelihoods, and to promote adaptive capacity and risk reduction. Traditional land-use systems, such as floodplain management in the Tisza, played an active role in regulating climate extremes and seem to be well prepared to respond to climate change. This climate regulating service of landscapes provides an important opportunity for climate change adaptation. My research in the Tisza and Rhine river basins showed that preserving and managing diversification of land uses has potential for reducing climate related risks. In both river basins diversification of land use in relation to the hydrological conditions is explicitly supported by the current water plan.

Yet, a gap remains between scientific adaptation assessment and adaptation practice on the ground. So far the primary focus of climate projections has been on temperature. Improved projections, especially of precipitation and secondary climate impacts, such as water shortages, remain important challenges. In addition, there is a mismatch between model assessments of impacts and adaptation on the one hand and 'real' adaptation practices and options as discussed by people in the region or in the policy plans on the other. Regional relevance of assessments depends critically on the scale and the resolution of the data used as well as on integration of socio-economic and political aspects in the evaluation of potential adaptation strategies. Currently available integrated assessment models are not parameterised for assessing new technologies or more complex and diversified adaptation portfolios, and forego social aspects of adaptation, creating a barrier for the appraisal of adaptation. For example, existing models in the Tisza do not include resource conflicts resulting from multi-stressors or win-win opportunities resulting from the integration of adaptation and longer-term sustainable land and water use planning. There is an observable tension between the information demands of the adaptation process and the support that scientific modelling frameworks offer (cf. Vogel *et al.*, 2007). In particular, current risk assessments focus on a limited set of extreme conditions (e.g. either floods or droughts) whereas the climate related risk that actors face is the combined effect of conditions met throughout time.

Financial instruments and resources are limited in each of the study regions, and adaptation is often considered too costly and uncertain in comparison to expected benefits. Whilst pressures cause existing financial services (e.g. insurance) to become more expensive, new financial instruments are also emerging (such as micro-grants for land-use change). In both study regions, European and/or national government financial support is sought for the implementation. However, the integration of adaptation options in water and land-use planning adds another level of complexity (and potentially bureaucracy) to existing relations with administrations, donors or subsidising bodies. The European agri-environmental schemes for instance are not designed for inter-annual land-use change depending on water availability.

Creating markets for adaptation is a key challenge for the Tisza region (e.g. encouraging cities and industries to buy in on upstream flood water storage and floodplain management) as well as for national and transboundary adaptation to climate change. Both case regions identified opportunities for public-private partnerships in which marketable products obtain additional support in exchange for providing social and environmental services that support adaptation. Agro-tourism is promoted as a means to diversify the economy, reduce climate related risks and create opportunities for tourism, water retention and traditional land-use practice. There is scope for sustainable technologies and information systems, including early warning systems and seasonal forecasts that allow for adaptation of land use. Small-scale techniques to provide wind breaks, store floodwater or harvest rainwater are opportunities for adaptation in local planning and design. These options are largely ignored in longer-term strategic water management (cf. Moors *et al.*, 2009).

8.6.4 Adaptation in managed river basins: linking actors, objectives and strategies

Adaptation to regional climate variability has always taken place. Traditional diverse agro-environmental land-use systems reflect the way local populations adapt to the region's climate variability. These traditional systems have subsided under competition from a globalising economy and changing institutional and societal contexts. Actors in the Tisza region suggest that the new market production systems tend to be less well adapted to regional climate variability. Thus climate impacts have to be dealt with in relation to the increase in scale of economic human activities. Climate and socio-economic change have together aggravated existing challenges for sustainable land and water use. Water shortages as well as floods highlighted the interdependence of water users and the need for interaction of different groups of actors, their objectives and actions. The emerging interaction also stimulated new cooperation, as in the case of linking sustainable tourism with agricultural diversification in the Tisza region.

Embedding adaptation in existing national policy and institutional frameworks allowed trade-offs and synergies, that are crucial for 'selling' adaptation, to be addressed. Yet it also complicated the realisation of the original policy and diffused the responsibility for implementing the adaptation agenda. I observed a clear call on central governments to delineate and communicate the roles and responsibilities for the implementation of adaptation strategies at national, regional, and local levels. At the same time, my study suggested that it is important to balance formal regulatory rules and informal social factors in planning and implementation. Informal networks were crucial for social learning and adaptive capacity and may be particularly useful in times of crisis; whereas formal rules were required to include adaptation in longer term planning, investments and financial support for experimentation (cf. Matczak *et al.*, 2008).

With respect to adaptation planning I observed a gap between ambitious adaptation policy goals and adaptation planning. Whereas adaptation policy goals often referred to transitions to adaptive systems, the measures eventually implemented in the case study regions more closely resembled gradual change and well-established existing practices (dykes, dams, irrigation, risk management, setting targets). In both regions, regional actors suffered from a lack of (access to) information about the new adaptation options and policies planned. Knowledge integration could take place through 'issue-linking' in adaptation planning (e.g. in the case of linking climate change to flood control and regional development). Newly emerging forums for debating adaptation strategies were found to be valuable in this regard. At the regional level these were often associated with European funded projects, experimenting with new forms of engagement between scientists, policy makers and the wider stakeholder community, allowing for the integrated appraisal of adaptation. A major opportunity for planning is to focus on the transfer of knowledge relevant for adaptation decisions including early warning systems. Another lesson is to implement cost-effective and flexible adaptation frameworks that can be modified whenever individual and scientific knowledge changes.

Summarising, opportunities and constraints for adaptation in water and land-use planning were analysed in relation to adaptation options, objectives and actors. At present, most adaptation assessments concentrate on climate impacts and the potential of adaptation strategies. The conditions that enable people to act on adaptation are studied less, yet have been identified as particularly important for successfully planning and implementing adaptation. My research allowed me to learn about diversification, risk and water management. The merits of diversification still fascinate me. At the same time, I have come to see that many challenges lie ahead to capitalise on these merits in managed river basins. My research conveys that consideration of actors and their objectives in relation to adaptation options discloses opportunities for planning and successful implementation of adaptation. The analysis in the Dutch and Hungarian study river basins confirms adaptation can be advanced through existing policies. In addition, it suggests there is a need for reaching across non-climate policies and actor groups to systemically compile an adaptation portfolio, guided by complementarity and risk sharing.

Chapter 9

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Chapter 10

Summary / Samenvatting

Work of graffiti artist Laser 3.14. Photo: Werners, Amsterdam Jan. 2008

10.1 English summary

The main theme of my thesis is adaptation to climate related risks in managed river basins. Since the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001) demonstrated that adaptation to climate change is both important and complex, there has been growing attention to appraising adaptation strategies and explaining the processes by which adaptation can occur (Adger *et al.*, 2005b; Adger *et al.*, 2007). Whereas the scientific literature on adaptation is rich in detail on impacts, vulnerability and constraints to adaptation (e.g. Smit and Pilifosova, 2001; Adger *et al.*, 2007), little is known about the conditions that facilitate adaptation in practice. The latter are, however, of paramount importance for realising adaptation to climate related risk in the long term (Werners *et al.*, 2010b).

This work conceptualised and aimed to assess adaptation as the process of actors developing and implementing adaptation strategies to reach adaptation objectives (see Figure 1.1). From the start, I was fascinated by the potential merits of a particular adaptation strategy: diversification. Here, I interpreted diversification as the combination of different land-use and water management activities within a region. Thus, my thesis aimed to study diversification as a strategy for actors to adapt to climate related risk.

The focal question for my thesis is:

How to adapt to climate related risks in managed river basins?

Within the context of the focal question, the research questions for my thesis are:

1. *Can diversification of land use and water management activities reduce climate related risks in managed river basins? (Chapter 2 - 4)*
2. *Can Modern Portfolio Theory be used to assess the reduction of climate related risks by diversification of land use and water management activities at different scales in managed river basins? (Chapter 2 - 4)*
3. *What governance systems enable diversification of land use and water management activities? (Chapter 5)*
4. *What is the role of individuals in diversifying land use and water management activities? (Chapter 6 - 7)*

Figure 10.1 illustrates the main research questions of this thesis and how they relate to adapting to climate related risks in managed river basins.

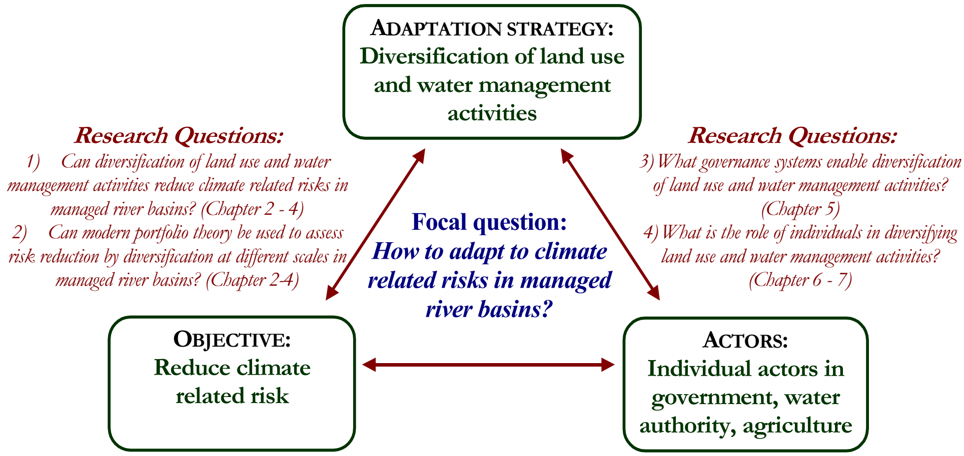


Figure 10.1: Main elements of this thesis

To examine the challenges and opportunities for adaptation to climate related risks in managed river basins I selected two study regions: the Tisza River Basin in Hungary and the Rhine River Basin in the Netherlands. These study regions have in common that, in response to flood events and climate change projections, water policy has been reoriented towards strategies that combine water retention in the floodplain and emergency storage reservoirs. The cases differ in institutional context and governance traditions upon which river basin management has developed. In the different chapters of this thesis I discussed adaptation in the study regions from a quantitative, empirical and analytical perspective, presenting model results and measured data as well as results from stakeholder interviews and workshops.

Chapter 1 introduced the research and Chapter 2 framed diversification and Portfolio Theory in the light of adaptation to climate related risks and the quest for robust water management strategies. Chapters 3 and 4 explored the use of Portfolio Theory to assess potential merits of diversification at different spatial scales in the case studies of Hungary and the Netherlands. My analysis showed that combining water and land-use management activities offers opportunities to reduce climate related risks that would be missed if these activities were studied in isolation. Risk was analysed as the standard deviation of the revenue of water and land use activities. The analysis in the Hungarian and Dutch cases revealed how agricultural land-use systems and water management activities could be combined into a portfolio that has a risk lower than the risk of the individual activities themselves. Combining flood levees with water retention areas was found to be a cost effective way to reduce flood risks in a river basin. Yet, at the location of the water retention area, risks might increase. Thus risk allocation from the national to the local scale had to be carefully evaluated, including the additional agro-economical risks associated with land-use change and the uncertainty in investment and maintenance costs. The uncertainty of the investment costs for water retention and land use change would add to the perceived risk of these new water management activities. To make full use of the potential of diversifying activities to reduce climate related risks, the performance of water and land-use management activities had to be studied over the full range of climatic conditions and across different spatial scales. Borrowing from economic theory, Modern Portfolio Theory offered a promising methodology to help combine activities into a robust risk reduction strategy and encourage the systematic evaluation of the performance of activities.

Chapters 5 - 7 looked at barriers and drivers that actors perceived for realising diversification. These chapters aimed to add to our understanding of the conditions that limit or facilitate adaptation in practice and its integration into ongoing sectoral planning to reduce climate risks. Two complementary frameworks that I found to be particularly useful in understanding the barriers and drivers for implementing diversification, were

1. A recent conceptualisation of governance in terms of key governance principles and challenges (such as credibility, stability, inclusiveness, adaptiveness, legitimacy and allocation (Biermann, 2007)), and
2. Transition literature that approaches major policy change from the perspective of individual actors and their strategies (Huitema and Meijerink, 2009).

Thus, Chapter 5 reported on barriers and bridges for implementing water and land-use diversification from the perspective of earth system governance. Earth system governance offers a comprehensive framework to assess drivers, barriers and opportunities for adapting river basin management. The framework consists of three elements: problem structure (with dimensions '*uncertainty*', '*functional, spatial and temporal interdependence*', and '*extreme effects*'), governance principles (with dimensions '*credibility*', '*stability*', '*adaptiveness*' and '*inclusiveness*') and research challenges (with dimensions '*architecture*', '*agency*', '*adaptive state*', '*accountability*' and '*allocation*'). The major barriers for realising integrated floodplain management could all be attributed to a lack of the key governance principles '*credibility*', '*stability*', '*inclusiveness*' and '*adaptiveness*'. Interviewees perceived the lack of credibility and effective cooperation between organisations as the largest barrier. In particular, the Tisza River Basin case showed the tension between adaptiveness and stability. The lack of stability after major floods and elections offered opportunities for new networks to emerge and kick off policy change. On the other hand, it was the lack of stability of the new networks and arrangements as much as the lack of adaptiveness of the institutions supporting conventional flood protection solutions that frustrated the actors aiming to implement river basin management. The paradox of stable adaptive river basin management was further complicated by a loss of accountability and credibility. With respect to inclusiveness, evidence from the Tisza region confirmed that cooperation in plan design facilitated consent and joint understanding, yet negotiated land-use patterns were not necessarily the most efficient from the perspective of flood protection. Specific inclusiveness related barriers for diversification of land use and water management were the required interventions at the landscape scale, the cooperation of many actors and the land consolidation and compensation programs. The benefits and costs of diversification were difficult to compare or share between actors. The Tisza case suggested additional attention was needed for the governance dimensions '*subsidiarity*', '*reciprocity*', '*cooperation*' and '*leadership*' across scales, '*access to information*', '*risk sharing*' and '*compliance*'. Adaptation of the governance system required a change deeper than maintaining the current resource base for future generations. Of particular importance were the remnants of previous economic, social and political orders that continued to shape expectations and patterns of conduct. This path-dependency deserves more attention in earth system governance. Diversification of land use and water management in the Tisza River Basin benefited from the inclusion of actors beyond governments and state agencies. A key challenge for new governance arrangements and multi-stakeholder organisations was to ensure accountability and legitimacy through formal regulation and informal relations. Regulation was required to include adaptation in longer term planning, investment and large-scale infrastructure. Informal relations however, were found to be conducive for strengthening learning, cooperation and implementation of diverse water management activities (cf. Matczak *et al.*, 2008).

Building on the analysis in Chapter 5, Chapters 6 and 7 analysed the case studies from the perspective of individual actors. Chapter 7 also compared the Dutch and Hungarian case. Insights from studying the role of individuals were found to be complementary to those from the earth system governance framework in Chapter 5. This complementarity of concepts could be exploited in future work. The analysis of the strategies of supports and opponents of policy change uncovered collectives of individuals and the complementary roles they played in furthering or blocking the adaptation of river basin management. Crucial for adapting water management were recognition of an adaptation strategy at an abstract level by responsible civil servants and their engagement with a credible regional coalition that could contextualise and advocate the strategy regionally. Opponents and supporters of policy change used similar tactics: to develop ideas, to build coalitions to sell ideas, to use windows of opportunity, to play multiple venues and to orchestrate networks (cf. Huitema and Meijerink, 2009). Opposition was found to be inherent to policy change in the case studies and managing conflict, information and expectations was an important activity for those aiming to manage climate risks in river basins.

Finally, Chapter 8 presented conclusions and recommendations. My analysis showed that adaptation to climate risks in managed river basins can be meaningfully analysed in relation to adaptation options, objectives and actors. At present, most adaptation assessments concentrate on climate impacts and the effectiveness of adaptation strategies. The conditions that enable people to act on adaptation are less frequently studied. Yet these have been identified as particularly important for successfully planning and implementing adaptation. My research conveyed that consideration of actors and the activities they called for, disclosed opportunities for successfully planning and realising adaptation objectives. Furthermore, my analysis suggests that, next to advancing adaptation through isolated sectoral adaptation options, there is a need for systemically compiling an adaptation portfolio across non-climate policies and actor groups, guided by risk sharing and complementarity.

10.2 Nederlandse samenvatting

Het centrale thema van mijn onderzoek is aanpassing aan klimaatverandering in rivierstroomgebieden. Het derde klimaatrapport van het internationale klimaatpanel (IPCC, 2001) liet zien, dat aanpassing aan klimaatverandering zowel noodzakelijk als complex is. Sindsdien is er toenemend aandacht voor het verkennen van aanpassingstrategieën en het verklaren van het proces van klimaataanpassing (Adger *et al.*, 2005b; Adger *et al.*, 2007). De wetenschappelijke literatuur over aanpassing aan klimaatverandering besteedt veel aandacht aan klimaateffecten, kwetsbaarheid en barrières voor aanpassing (e.g. Smit and Pilifosova, 2001; Adger *et al.*, 2007). Veel minder is bekend over de voorwaarden die klimaataanpassing mogelijk maken in de praktijk. Begrip van deze voorwaarden is echter van cruciaal belang voor het duurzaam realiseren van klimaataanpassing (Werners *et al.*, 2010b).

Deze studie conceptualiseerde aanpassing aan klimaatverandering als het proces waarin actoren strategieën ontwikkelen en implementeren om een bepaalde doelstelling te halen (zie Figuur 1.1). Al vroeg was ik gefascineerd door één bepaalde aanpassingstrategie: diversifiëren. Onder diversifiëren versta ik het combineren van verschillende landgebruiktypes of waterbeheersmaatregelen in een regio. Het doel van mijn onderzoek was daarmee: het bestuderen van diversificatie als een strategie van actoren om met klimaatrisico's om te gaan.

Mijn centrale vraag was:

Hoe kunnen actoren zich aanpassen aan klimaatverandering in rivierstroomgebieden?

Binnen deze context, waren mijn onderzoeksvragen:

1. *Kan het diversifiëren van landgebruik en waterbeheersmaatregelen klimaatrisico's in rivierstroomgebieden verkleinen? (Hoofdstuk 2 - 4)*
2. *Kan Portfolio Theorie worden toegepast om het verkleinen van klimaatrisico's door diversificatie te boordelen? (Hoofdstuk 2 - 4)*
3. *Wat voor governance systeem ondersteunt actoren in het diversifiëren van landgebruik en waterbeheersmaatregelen? (Hoofdstuk 5)*
4. *Wat is de rol van individuen in het diversifiëren van landgebruik en waterbeheersmaatregelen? (Hoofdstuk 6 - 7)*

Figuur 10.2 illustreert mijn onderzoeksvragen naar aanpassing aan klimaatrisico's in rivierstroomgebieden.

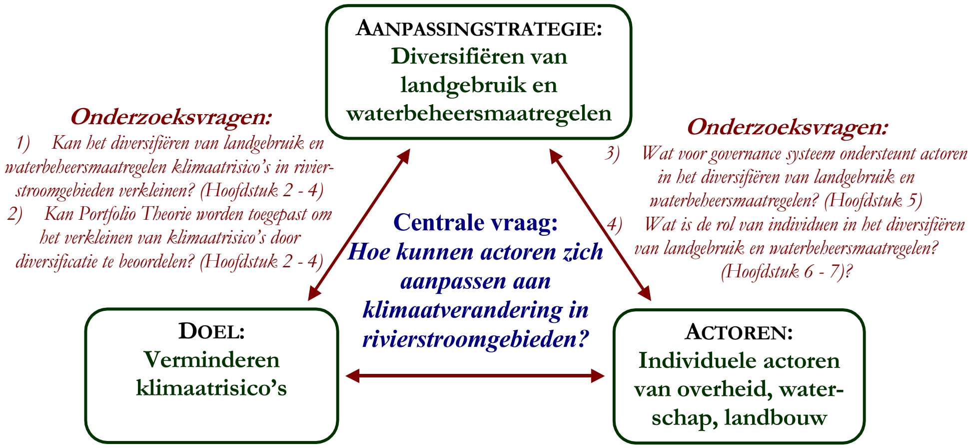


Figure 10.2: Centrale elementen van dit onderzoek

Om de barrières en kansen voor aanpassing aan klimaatrisico's te bestuderen koos ik twee studiegebieden: het stroomgebied van de Tisza rivier in Hongarije en van de rivier de Rijn in Nederland. Deze studiegebieden hebben gemeen, dat waterbeleid zich aan het heroriënteren is op het geven van ruimte aan de rivier en op retentiegebieden als aanvulling op het bouwen van dijken en drainage. De studiegebieden verschillen in bestuurlijke context en waterbeheer traditie. In de verschillende hoofdstukken van dit onderzoek besprak ik klimaataanpassing vanuit een kwantitatief, empirisch en analytisch perspectief. Ik combineerde modelresultaten en gemeten data met de resultaten van interviews en actorbijeenkomsten.

Hoofdstuk 1 introduceerde het onderzoek. Hoofdstuk 2 definieerde diversificatie en Portfolio Theorie in het licht van aanpassing aan klimaatrisico's en de zoektocht naar robuuste klimaataanpassingstrategieën. Hoofdstuk 3 en 4 verkenden het gebruik van Portfolio Theorie om de potentie van diversificatie als klimaataanpassingstrategie te bepalen in de studiegebieden in Hongarije en Nederland, respectievelijk. Mijn onderzoek toonde aan dat het combineren van landgebruik en waterbeheersmaatregelen kansen biedt om risico's te verkleinen. Deze kansen zouden over het hoofd worden gezien als de activiteiten individueel beschouwd werden. In het bijzonder volgde uit het onderzoek in de studiegebieden hoe landgebruik en waterbeheersmaatregelen gecombineerd konden worden in een waterbeheerportfolio, waardoor het risico lager is dan wanneer de maatregelen afzonderlijk zouden worden genomen. Risico werd geanalyseerd als de standaard deviatie van de opbrengst van landgebruik en waterbeheer activiteiten. Onder opbrengst wordt directe gewasopbrengst of vermeden waterschade verstaan. Het combineren van dijken met waterretentie bleek een kosten effectieve klimaataanpassingstrategie om overstromingsrisico's te beperken in een rivier stroomgebied. Echter, op de locatie van een water retentiegebied konden de risico's toenemen. Risico's moesten daarom zorgvuldig worden afgewogen van de nationale tot aan de lokale schaal, inclusief de risico's van landgebruikverandering, investeringskosten en onderhoud van water infrastructuur. Om optimaal gebruik te kunnen maken van het combineren van activiteiten ter vermindering van klimaatrisico's, moest het resultaat van activiteiten onderzocht worden onder alle mogelijke omstandigheden en niet alleen onder extreme situaties. De Portfolio Theorie, die is ontwikkeld in de economische wetenschap, bood een geschikte methode voor het combineren van activiteiten ten behoeve van risicovermindering. Daarnaast bood Portfolio Theorie handvaten voor het structureel en systematisch evalueren van activiteiten onder verschillende omstandigheden en op verschillende ruimtelijke schalen, waarbij de opbrengst en correlatie van maatregelen onder variërende omstandigheden kern parameters waren.

Vervolgens beschreven Hoofdstuk 5 - 7 de barrières en stimulansen die actoren ondervonden voor diversifiëren. Zo wilden deze hoofdstukken bijdragen aan ons begrip van omstandigheden die klimaataanpassing - en de integratie hiervan in sectoraal beleid - bemoeilijken of vergemakkelijken. Twee complementaire raamwerken ervoer ik als bij uitstek geschikt om barrières en stimulansen te identificeren voor diversificatie:

1. Een recente conceptualisering van aardsysteem governance in termen van principes en uitdagingen (zoals geloofwaardigheid, stabiliteit, participatie, flexibiliteit, legitimiteit en toedeling (Biermann, 2007)), en
2. Transitie onderzoek dat veranderingen bestudeert vanuit het perspectief van individuele actoren en hun strategieën (Huitema and Meijerink, 2009).

Aldus beschreef Hoofdstuk 5 barrières en stimulansen voor het diversifiëren van water en landgebruik vanuit het perspectief van aardsysteem governance (Biermann, 2007). Aardsysteem governance biedt een helder raamwerk om stimulansen, barrières en kansen te analyseren voor aanpassing van rivierbeheer. Dit raamwerk bestaat uit drie elementen: 1) probleem structuur (met dimensies *'onzekerheid'*, *'functie, ruimtelijke en tijdsafhankelijkheid'* en *'extreme situaties'*), 2) kernprincipes (met dimensies *'geloofwaardigheid'*, *'stabiliteit'*, *'participatie'* en *'aanpassingsvermogen'*) en 3) onderzoeksuitdagingen (met dimensies *'architectuur'*, *'vertegenwoordiging'*, *'flexibiliteit'*, *'rechtmatigheid'* en *'toedeling'*). De belangrijkste barrières die actoren aangaven voor het realiseren van integraal rivierstroomgebied beheer, konden worden toegekend aan het ontbreken van de kernprincipes. De geïnterviewden in het Hongaars studiegebied ervoeren het gebrek aan geloofwaardigheid van de overheid en samenwerking tussen verschillende organisaties als de voornaamste barrières. Daarnaast wees het onderzoek op de spanning tussen stabiliteit en aanpassingsvermogen: het gebrek aan stabiliteit na grotere overstromingen en na politieke verschuivingen bood kansen voor het ontstaan van nieuwe samenwerkingsnetwerken en het initiëren van beleidsverandering. Aan de andere kant waren het de gebrekkige stabiliteit van deze nieuwe netwerken en het gebrek aan aanpassingsvermogen van de bestaande beleidskaders voor conventionele hoogwaterbeheer, die actoren frustreerden bij de implementatie van op waterretentie geschoeid rivierbeheer. De paradox van stabiel en flexibel rivierbeheer werd des te gecompliceerder door het verlies van rechtmatigheid en geloofwaardigheid van de bestaande overheidsinstanties in een periode van beleidsverandering. Wat betreft participatie, bevestigde de Hongaarse studie, dat samenwerking in de beleidsvoorbereiding ten goede kwam aan de eensgezindheid en het begrip tussen partijen. Echter, de uitonderhandelde landgebruikoplossingen waren, vanuit het oogpunt van hoogwaterbeheer, niet de meest efficiënte. Specifieke participatie gerelateerde barrières voor diversifiëren en de daarmee samenhangende herinrichting op het landschapsniveau waren de noodzaak tot samenwerking tussen veel partijen en het compensatieprogramma. De kosten en baten van diversifiëren bleken moeilijk te vergelijken en te delen tussen actoren. De Hongaarse studie vroeg om extra aandacht voor de governance dimensies subsidiariteit, wederkerigheid, samenwerking en leiderschap tussen beleidsniveaus, toegang tot informatie, risico toedeling en nakoming van regelgeving. Aanpassing aan klimaatverandering bleek een ingrijpende verandering te vergen dan het duurzaam beheer van de huidige situatie en van natuurlijke hulpbronnen. Van significant belang was de doorwerking van voorgaande socio-economische en politieke ordes op de huidige verwachtingen en gedragspatronen. Deze afhankelijkheid van de voorgeschiedenis verdient meer aandacht in aardsysteem governance. Het diversifiëren van landgebruik en waterbeheer in Hongarije profiteerde van de participatie van actoren van buiten de overheid, zoals van milieu- en regionale ontwikkelingsorganisaties en wetenschappers. Een centrale uitdaging voor de nieuwe samenwerkingsverbanden was het veiligstellen van rechtmatigheid en geloofwaardigheid in formele en informele relaties. Formele regulering was nodig om klimaataanpassing in de wettelijke kaders van waterbeheer op te nemen en om financiering veilig te stellen. Tegelijkertijd bleken informele relaties bij te dragen aan wederzijds begrip, samenwerking en het uitvoeren van een diverse set waterbeheer gerelateerde activiteiten (cf. Matczak *et al.*, 2008).

Voortbouwend op de analyse in Hoofdstuk 5, beschreven Hoofdstuk 6 en 7 de studiegebieden vanuit het perspectief van individuele actoren en hun bijdrage aan beleidsverandering. Hoofdstuk 7 vergeleek ook het Nederlandse en Hongaarse studiegebied. De inzichten verworven uit het bestuderen van de strategieën van individuele actoren bleken complementair aan de resultaten van toepassen van het aardsysteem governance raamwerk in Hoofdstuk 5. Dit complementair zijn van concepten zou in de toekomst verder verkend en benut kunnen worden. Bij de analyse van strategieën van voor- en tegenstanders van beleidsverandering bleek dat individuen een belangrijke rol speelden in het bevorderen of blokkeren van aanpassing van het rivierbeheer. Cruciaal voor verandering van het beleid waren de erkenning van een aanpassingstrategie (bijvoorbeeld het concept van waterretentie in plaats van dijkverhoging) door verantwoordelijke rijksambtenaren en hun samenwerking met een regionaal geloofwaardige partij, die het concept in de regio uit kon werken en promoten. Voor- en tegenstanders van beleidsverandering gebruikten dezelfde strategieën: het uitwerken van ideeën, het vormen van coalities om ideeën te promoten, het benutten van kansen (zogenaamde '*windows of opportunity*'), het optreden in verschillende arena's en het regisseren van netwerken (cf. Huitema and Meijerink, 2009). Tegenstand was inherent aan beleidsverandering in de studiegebieden. Het beheren van conflicten, informatie en verwachtingen was een belangrijke strategie voor degenen die op een andere manier om wilden gaan met klimaatrisico's in riviergebieden.

Tenslotte, presenteerde Hoofdstuk 8 de conclusies en aanbevelingen. Mijn onderzoek toonde aan dat aanpassing aan klimaatrisico's deugdelijk geanalyseerd en begrepen kan worden in relatie tot aanpassingsopties, doelstellingen en actoren. Op dit moment concentreren de meeste studies naar klimaataanpassing zich op klimaatgevolgen en de effectiviteit van aanpassingsopties. De voorwaarden die het mensen mogelijk maakt zich aan te passen en aanpassingsopties te realiseren krijgen minder aandacht. Dit onderzoek benadrukte echter, dat deze bijzonder belangrijk zijn voor het succesvol plannen en implementeren van klimaataanpassing. Mijn onderzoek gaf aan, dat nieuwe kansen ontstaan voor het reduceren van klimaatrisico's door in achtneming van actoren, hun doelen en de maatregelen waarom zij vragen. Verder suggereerde mijn onderzoek dat, naast het stimuleren van klimaataanpassing door specifieke individuele maatregelen, er behoefte is aan een klimaataanpassingportfolio. Deze portfolio zou zich uit moeten strekken over verschillende niet-klimaat beleidsvelden, zoals waterbeleid en natuurbeheer, en over diverse actorpartijen, met risicotoedeling en complementariteit als gidsprincipes.

ANNEXES

Annex A: Certificate of Educational Programme SENSE Research School

SENSE

Netherlands Research School for the
Socio-Economic and Natural Sciences of the Environment

CERTIFICATE

The Netherlands Research School for the
Socio-Economic and Natural Sciences of the Environment
(SENSE), declares that

Saskia Werners

Born on: *11 May 1971* at: *Amsterdam, The Netherlands*

has successfully fulfilled all requirements of the
Educational Programme of SENSE.

Place: *Wageningen* Date: *25 May 2010*

The Chairman of the SENSE board	The SENSE Director of Education
Prof. Dr. R. Leemans	Dr. A. van Dommelen

The SENSE Research School declares that Ms. Saskia Werners has successfully fulfilled all requirements of the Educational PhD Programme of SENSE with a work load of 45 ECTS, including the following activities:

SENSE PhD courses:

- Environmental Research in Context
- Research Context Activity: Successfully applied for and convened session at European Conference on Sustainability Transitions (Amsterdam, June 2009)
- Complex Dynamics in and between Social and Eco Systems
- Managing change: Tools and Methods for Adaptive River Basin Management

Other PhD and MSc courses:

- Complex Systems Summer School, Santa Fe Institute, New Mexico, USA

Research and Management Skills:

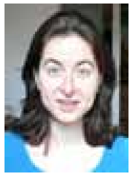
- IIASA Young Scientists Summer Program
- Visiting researcher at Department of Agronomy and Land Management (DISAT), Florence, Italy
- Organisation of a scientific workshop within the EU Adaptation and Mitigation Strategies (ADAM) project
- Organisation of a scientific workshop about transition entrepreneurs at a SENSE symposium
- Supervision of MSc thesis students
- Scientific Writing & Journalism (Communicatiebureau De Lynx – Cursus Wetenschapsjournalistiek)

Oral Presentations:

- Simulating global feedbacks between Sea Level Rise, Water for Agriculture and the complex Socio-economic Development of the IPCC Scenarios, Environmental Modelling and Software Society Conference, 15 June 2004, Osnabrück, Germany
- Institutional Adaptation of Floodplain management to Climate Change in the Hungarian Tisza River basin, Earth System Governance Conference, 24 May 2007, Amsterdam, the Netherlands
- Diversification of Agricultural Crops to Adapt to Climate Change in the Guadiana River Basin, International Conference on Climate Change, 30 May 2007, Hong Kong, China
- Supporters and opponents of a transition in Dutch and Hungarian water management, European Conference on Sustainability Transitions, 5 June 2009, Amsterdam, the Netherlands
- Mainstreaming climate adaptation into water management in the Netherlands: The governance of the Dutch Delta Program, Conference on the Human Dimensions of Global Environmental Change, 4 December 2009, Amsterdam, the Netherlands

Mr. J. Feenstra
SENSE Coordinator PhD Education and Research

Annex B: Curriculum Vitae Saskia E. Werners



Education

2008 Summer Program International Institute for Applied Systems Analysis (IIASA), Laxenburg Austria

2006 Complex Systems Summer School, Sante Fe Institute, New Mexico, US

2004 Training Scientific Writing & Journalism

2000 Technology of Participation, Group Facilitation Methods, ICA

1991-1997 MSc with Distinction in Water Resources Engineering and Management, Civil & Offshore Engineering Department, Heriot-Watt University, UK
MSc Environmental Sciences First Class, Vrije Universiteit, the Netherlands
MSc Experimental Physics First Class, Vrije Universiteit, the Netherlands

Professional skills

Climate Adaptation Broad experience in integrated water management, adaptation to climate change & variability, and policy analysis in Europe, Asia and the Americas. Assessed robust land and water management strategies and evaluated barriers and opportunities for mainstreaming adaptation to climate change

International cooperation Research and coordination in European research projects on adaptation and mitigation to climate change and adaptive water management

Outreach & facilitation Designed, hosted and facilitated numerous stakeholder and experts workshops, convened sessions at international conferences

Client oriented Worked for European Commission, World Bank, EEA, IDB, WTO, UNEP, various NGOs, National Government of India and Dutch Ministries

Employment record and *experience*

Present Research Specialist Integrated Water Management and Climate Adaptation, Wageningen University and Research Centre, the Netherlands
Research and coordination European research projects on adaptation and mitigation to climate change (ADAM project, www.adamproject.eu, MEDIATION project) and adaptive water management (NeWater project www.newater.info). Study areas: Guadiana River Basin in Spain / Portugal, Rhine River Basin, Tisza River Basin in Hungary and Alxa region in Inner Mongolia, China. Scenario development for long-term flood safety in the Netherlands, assignment National Delta Committee (www.deltacommissie.com). Assessment of Adaptation to Climate Change in the Netherlands for the European Environmental Agency

2004 Post-doc Participatory Planning for Water and Climate, Wageningen University and Research Centre, the Netherlands

Employment record and *relevant experience (continued)*

2003 Dialogue on Water & Climate, Science Support Office, Wageningen University and Research Centre, the Netherlands
Convened adaptive water management session at 4th World Water Forum, Mexico and prepared statement on Water & Climate to Ministerial Conference at 3rd World Water Forum, Japan

2002 Policy Advisor Global Environmental Policy Division, Ministry of Housing, Spatial Planning and the Environment, the Netherlands
Spokesperson at WTO, European Commission and OECD. Special focus on Environment & Trade, Agriculture and Services . Wrote position papers on fresh water issues and small island developing states (SIDs) for Mr Jan Pronk, Special Envoy of the UN Secretary General for the World Summit on Sustainable Development

2001 Coordinator e-Forum; Directorate for Strategic Policy Development (Forum), Ministry of Housing, Spatial Planning and the Environment, the Netherlands

1997-2001 Advisor Integrated Water Management, Consultant firm Resource Analysis, the Netherlands
Projects in Europe, India, Bangladesh and the Caribbean. Assessed vulnerability and adaptation options in Bangladesh for the donor community. Built framework for Integrated Coastal & Marine Area Management plan (ICMAM) for Chennai, India

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