Planning amid uncertainty

Adaptiveness for spatial interventions in delta areas

Mark Zandvoort

Propositions

1. A clear distinction between types of uncertainty is a prerequisite for adequate spatial planning.
   (this thesis)

2. Legal standards, such as the Dutch flood protection standards, create obstacles for adaptiveness.
   (this thesis)

3. The popularity of scientific innovations is proportional to the ability to visualize them.

4. The rigour of the scientific method impedes knowledge development in practice.

5. Exporting the expertise to build polders without also exporting proper institutions is ethically wrong.

6. The Dutch government is ill-prepared for the unprecedented loss of knowledge resulting from the upcoming wave of baby boomer retirements.

7. The depiction of scientists as socially awkward in series like the Big Bang Theory leads to the public's underestimation of science.

Propositions belonging to the thesis, entitled: Planning amid uncertainty: Adaptiveness for spatial interventions in delta areas

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Wageningen, 8 December 2017

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This research was conducted under the auspices of the Dutch Research School of the Socio-Economic and Natural Sciences of the Environment (SENSE).

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Thesis

submitted in fulfilment of the requirements for the degree of doctor
at Wageningen University
by the authority of the Rector Magnificus,
Prof. Dr A.P.J. Mol,
in presence of the
Thesis Committee appointed by the Academic Board
to be defended in public
on Friday 8 December 2017
at 1.30 p.m. in the Aula.

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Planning amid uncertainty: Adaptiveness for spatial interventions in delta areas
242 pages.

PhD thesis, Wageningen University, Wageningen, the Netherlands (2017)
With references, with summary in English

ISBN 978-94-6343-715-8
DOI http://dx.doi.org/10.18174/425822

Voor Ruth
Roos & Eva

Contents

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Introduction

Introduction

In February 2016, in the 100th year after the Zuiderzee flood, it was commemorated as the flood that has been decisive in determining the current appearance of the Netherlands. This flood catalysed an unprecedented long-term spatial planning effort: the closure and reclamation of the Zuiderzee. In the night of 13 to 14 February 1916, wind blew from the north across the North Sea. As the wind grew in strength, it propelled the sea in front of it into the Zuiderzee inlet (Figure 1.1 a). Reaching shore, the sea flooded large stretches of land and villages, and humans and livestock drowned in the freezing cold water. This flooding of the area surrounding the Zuiderzee was a catalyst for change. Change for the inhabitants of the Zuiderzee area, with the taking of lives of fathers, mothers, children and other family members and livestock, and the damage to houses and infrastructure. But also long-term institutional change, as the flood acted as a lever by which plans to dam and reclaim land in the Zuiderzee were pushed through. Because of the flood, the Zuiderzee inlet was closed with the construction of a dam. This Afsluitdijk was completed in 1932 and turned the Zuiderzee inlet into a large freshwater lake (van der Ham 2007). The lake was renamed the *IJsselmeer* (IJssel lake), after the IJssel, a river branch of the Rhine River that discharges into the lake (van Lier & Steiner 1982). After its closure, large stretches of the former Zuiderzee seabed were reclaimed, a process that continued up to the 1970s (Gort & van Oostrom 1987; van de Ven 1993). Today, the IJsselmeer area forms a group of large lakes and polders in the middle of the Netherlands (Figure 1.1 b) (Geurts 1997). The largest polders make up the new province of Flevoland, which is currently home to about half a million inhabitants and a thriving agricultural sector.

Planning the reclamation of this new land and directing its spatial transformation into a thriving province was done in an adaptive manner and shows traits of an adaptive approach (Kato & Ahern 2008; Kwakkel et al. 2012; Walker et al. 2013; Mills et al. 2015). Adaptiveness refers to a type of planning which is stepwise and intentionally focussed on ongoing adaptations after encountered change. The reclamation of the IJsselmeer was phased, with each stage building on insights gained from the stage before. In draft plans, five large polders (the Wieringermeer, Noordoostpolder, eastern and southern part of the Flevopolder and the Markerwaard) were proposed (van der Ham 2007) and, by reclaiming these one by one, an array of experiments could be

conducted to improve the subsequent phases of land reclamation or stop intermittently, which happened when was decided to not reclaim the fifth polder, the Markerwaard, because of lower expected returns

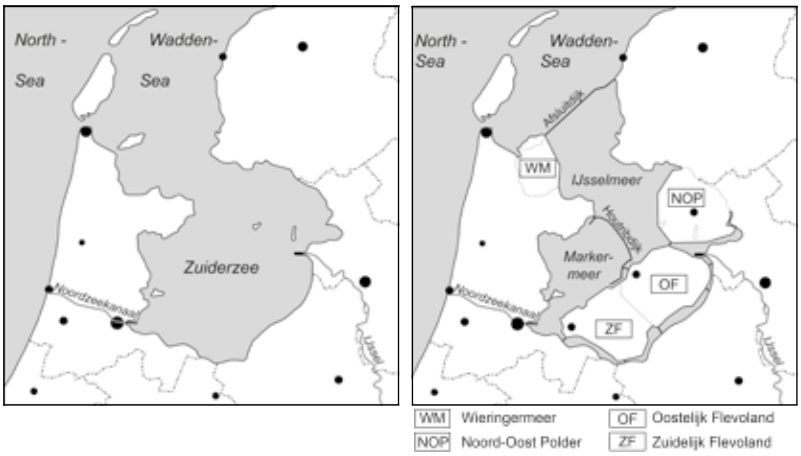

Figure 1.1. (a) The Zuiderzee inlet before and **(b)** after closure with the Afsluitdijk and reclamation of four areas of the IJsselmeer.

on the investment and an increased awareness of natural values of the lake. Experiments included new forms of dykes, innovations in the canal system and pumps to drain the area, different ways of cultivating land (including attempts to speed up soil improvement), studies on the best layout of infrastructure and buildings, and the selection of farmers and their families to shape future demographics of the villages (Gort & van Oostrom 1987; Hemel 1994). Water management, the agricultural sciences and land cultivation technology all greatly benefited from the public and private investments made in the area, and from the necessity to quickly bring fertility and prosperity to the land. The involved learning is seen as a precondition for handling in an adaptive fashion (Kato & Ahern 2008; Pahl-Wostl 2007). Extensive use was also made of what has been called pre-stored plans (Alterman 1988) or a prototyping approach (Mills et al. 2015), which are also indicative of an adaptive approach. Prototypical plans were drawn up as early as 1667 to elaborate on ideas for land reclamation. The number of plans increased in the mid-1800s, with constant redrafting based on new calculations and developing insights (van Lier & Steiner 1982). The final plan, which was culturally and legally accepted after the flood of 1916 (Parliament adopted the *Zuiderzeewet* (Zuiderzee Act) formally in 1918), was based on these old pre-stored plans and renewed calculations of the plan's impact (van der Ham 2007). A last recognisable trait of adaptive planning is the seizing of windows of opportunity. An understanding of the tipping points and a readiness to seize windows of opportunity to

shift to new strategies are important to handle uncertainty about future change in an adaptive manner (Kwadijk et al. 2010; Abunnasr et al. 2015; van der Vlist et al. 2015). In retrospect, the political manoeuvring that took place to reclaim the Zuiderzee might be perceived as taking advantage of such windows of opportunity (van der Ham 2007).

Planning in deltas, such as the development of the IJsselmeer and its polders, often needs to take a long-term perspective. Such a long-term planning perspective can be structured using an adaptive approach. This was recently addressed in the Dutch Delta Programme, a nationwide programme to deliver long-term strategies for water management, including for the IJsselmeer region. Contemporary theories about adaptiveness often mention uncertainty and future change as main reasons for advancing adaptiveness (Kato & Ahern 2008; Kwakkel et al. 2012). Proponents of adaptiveness argue that spatial planning prior to the 1970s did not consider uncertainty and future change in a structured way (Kato & Ahern 2008; Innes & Booher 2010). Instead, planning seemed to be more often propelled by mere opportunism in spatial planning efforts with long-term consequences or by utopian dreams, but without the appropriate resources or capabilities required for their implementation (Etzioni 1986; Friend & Hickling 2005; Healey 2007). Today, planners recognise that they need to account for change and uncertainty when planning long-term spatial transformations. To guide the future transformation of deltaic systems such as the IJsselmeer region, long-term strategies are needed to guide spatial interventions. Deliberate foresight is strived for when preparing for long-term planning efforts through adaptive approaches. So far, deliberate attempts to be adaptive to unpredictable change and to cope with uncertainty were, however, not undertaken without substantial criticism.

In this thesis, I am interested in how unpredictable change and uncertainty can be accounted for when planning spatial interventions in delta areas for the decades to come. Planners need to account for uncertainty and unknowable future change and one way of doing so is to be adaptive in a deliberate and anticipatory way. Meanwhile, spatial transformations (deliberate or otherwise) are ongoing, while the current configuration of deltas is strongly determined by past choices. Planners are bound by past spatial interventions but need to incorporate new uncertainties, such as those relating to climate change, demographic change and urbanisation. This raises the question of what needs to be

done to account for uncertainty when planning for spatial interventions with long-term consequences and what adaptiveness can offer planners in this respect. Before these issues can be addressed, something first needs to be said about how uncertainty is actually perceived within the context of spatial planning.

1.1 Uncertainty in spatial planning

Uncertainty is of paramount importance in spatial planning (e.g., Christensen 1985; Abbott 2005; Balducci et al. 2011; Hillier 2011; Lau 2015), particularly in complex situations in which planners seek to achieve long-term spatial transformations (Batty 2013; de Roo & Silva 2010). Although the importance of uncertainty is recognised, the concept does not receive sufficient attention in spatial planning. While recent studies have addressed the question of what uncertainty is (Christensen 1985; Abbott 2005; Kwakkel et al. 2010b; Lau 2015), the seminal task for planners is to understand the ways in which uncertainty affects spatial interventions (e.g., Abbott 2005). Giordano (2012), for example, considers different uncertainties and their relevance to the planning of long-lived infrastructure. However, his study does not specify what uncertainty entails and consequentially means for the discussed planning issues. Also, Pahl-Wostl et al. (2007), although elaborating on what uncertainty is by using the definition of Walker et al. (2003), do not explain what the consequences of the different uncertainties are, especially not in view of long-term planning decisions. And while Lorenz et al. (2015) undertook a review of the inclusion and communication of 'physical science uncertainty' in 14 European national climate adaptation strategies, they do not offer any insight into how uncertainty translated into the adequacy of the adaptation strategies for dealing with the uncertainties found. To date, planners seem to have only a vague notion of the influence of uncertainty on planning interventions in light of pressing issues such as climate change.

So, what does uncertainty entail exactly? The concept is often described, but in multiple, contrasting ways. Some align the concept to risk (e.g., Gardiner 2010), while others see it as different from risk (e.g., Walker et al. 2003; Kwakkel et al. 2010b). Important for some is the source of the uncertainty (e.g., Skinner et al. 2014; Jensen & Wu 2016), while others stipulate the location at which it may concentrate (e.g.,

van den Hoek 2010a). Also, tools are proposed to reduce, contain or accommodate uncertainty in planning and policymaking (e.g., Friend 1993; Jensen & Wu 2016). All in all, uncertainty is a difficult concept to grasp, while it may have implications for both tools and interventions in spatial planning (e.g., Brugnach et al. 2008).

As a starting definition to further query the concept of uncertainty, this thesis refers to the definition of Walker et al. (2003), who accommodated a plurality of different, contradicting understandings of uncertainty in their typology. They defined uncertainty as: 'any deviation from the unachievable ideal of completely deterministic knowledge of the relevant system' (Walker et al. 2003: 5). This definition allows for the incorporation of a systems perspective (van der Vlist 1998; Healey 2007), while it also assumes a central role for actors with a specific type (or lack) of knowledge, which influences how decisions on interventions are made (Davoudi 2015) in a particular planning practice (Alexander 2015). This definition and resulting classification of uncertainties contradicts other attempts to understand the concept (Friend 1993; Skinner et al. 2014). For example, the description of Lorenz et al. (2015) of 'physical science uncertainty' contradicts the three types of uncertainty (environment, choice and value uncertainty) addressed in the strategic choice approach of Friend and Hickling (2005). In turn, neither of these align with the three characteristics (nature, level and location) of uncertainty and their subdivision proposed by Walker et al. (2003). These contradictions and confusions do not contribute to the adequate handling of uncertainty in spatial planning.

In this thesis, I am specifically interested in complex situations in which planners need to manoeuvre. In such situations, the adequate handling of uncertainty is important because uncertain future change may influence the long-term effects of interventions. This thesis is primarily concerned with physical interventions, but also socio-institutional interventions such as plans, design standards, planning tools and spatial strategies. Uncertainty does not only affect physical interventions, and socio-institutional interventions might abate some uncertainties. This reflects the domain of study, which is spatial planning. In spatial planning, both the physical structure of space and the structuring and restructuring efforts of planners are of concern (Healey 2007). Planners make use of approaches and tools to undertake such efforts and are involved in processes to achieve a desired physical structure for the benefit of society in particular situations (Healey 2007;

Allmendinger 2009; Alexander 2015). Therefore, approaches, tools and processes are the three elements of spatial planning of particular interest to this study. The main focus is spatial planning in delta areas, because complex situations and related uncertainties often arise at the confluence of land, river and sea. In delta areas, infrastructure is built to sustain land use and water-related functions, but also fixes the spatial situation for many decades. Uncertainty and future change affect interventions such as infrastructure, which in turn affects subsequent developments and interventions, while as yet unknown change may influence the future functionality of infrastructures, the land and water uses it sustains (Riquelme-Solar et al. 2015), as well as the landscape as a whole (Selman 2012). In this context, uncertainty may influence the location, type and form of interventions such as infrastructure. A better understanding of this influence is required to adequately prepare for spatial planning interventions in deltas.

1.2 An adaptive approach

One way in which it is proposed to handle uncertainty is by incorporating adaptiveness in planning (Walker et al. 2001; Kato & Ahern 2008). Attention for adaptiveness and adaptive approaches in planning is increasing (e.g., Koppenjan & Klijn 2004; Pahl-Wostl et al. 2007; Rauws 2015), starting with the growing awareness that interlinked human-nature systems such as those found in deltas confront planners and water managers alike with the dynamic behaviour of contextual variables. This increases uncertainty about the effect of their interventions (Milly et al. 2008; de Roo & Silva 2010; Islam & Susskind 2012; Rauws 2015) and long-term investment decisions (Albrechts 2004; van der Vlist et al. 2015). Adaptiveness in planning finds its *raison d'être* in a general understanding of uncertainty. For most, adaptiveness holds the promise of accounting for some generally understood but often unspecified conception of uncertainty. It is also true that conceptual diffusion exists concerning what adaptiveness entails exactly.

To understand the merits and possible drawbacks of adaptiveness, the scholarly contributions to thinking about adaptiveness since the early 1970s can offer some first pointers. The opportunities adaptiveness offers can be illustrated by the argument made by Cooper et al. (1971). They argue, in the context of mobility planning, that adaptive models for urban planning 'permit flexible and continuous responses to

dynamically changing urban conditions, including citizen attitudes and reactions, as well as to changing economics and technologies' (p. 397). Their work stood not on its own, but was embedded in advances in dynamic systems modelling and informed by the upcoming emphasis on participation among actors in managing and developing the living environment, examples being advocacy planning (Davidoff 1965) and citizen participation (Arnstein 1969). Adaptiveness was further developed in the decades thereafter, and since the seminal work of Holling et al. (1978) and Walters (1986), has been transposed into planning and governance studies (Lessard 1998; Walker et al. 2001; Kato & Ahern 2008; Chaffin et al. 2014; Karpouzoglou et al. 2016; Zedler 2017).

Adaptiveness holds the promise of accounting for uncertainty and change. This, however, seems to be more often based on mere hope than empirical evidence. Gregory et al. (2006: 434), for example, conclude: 'Adaptive management techniques are one of the principal tools proposed by environmental decision makers to provide flexible and responsive management approaches over time. However, the record of successful applications is surprisingly small.' For this thesis, this translates to the premise that the use of concepts pertaining to adaptiveness does affect reality but not necessarily in 'successful ways' (Allan & Curtis 2005; Gregory et al. 2006). Evidence from the literature suggests that the use of tools and approaches to advance adaptiveness takes place in a context with different knowledge arrangements and multiple rational ways to perceive uncertainty, which are influenced by and influence thinking about adaptiveness (Dewulf 2005; Brugnach et al. 2008; Janssen et al. 2014; Karpouzoglou et al. 2016). In this context, Green Nylen (2011) points to the extreme difficulty of operationalising aspects of adaptive management and Allan and Curtis (2005) point to the problems in regional adaptive management because of entrenched social norms and institutional patterns. One might argue that reality is affected by the discourse about adaptiveness in different ways, each of which might be differently assessed depending on one's perspective (MacIntyre 1988; Davy 2008). For example, interventions in water systems developed using the adaptation pathways tool have already influenced deliberations relating to long-term planning for the IJsselmeer: for some stakeholders, for the worse, and for others for the better (RIZA 2003; Reeder & Ranger 2011; Haasnoot et al. 2013; DP 2014). So, in this context of growing criticism about the ability of adaptiveness to handle uncertainty, this thesis contributes to knowledge about the influence of adaptiveness on how planners handle uncertainty.

Before describing how uncertainty and adaptiveness are studied, it should be noted that adaptiveness is an ambiguous concept. Adaptiveness is for example linked to 'management', 'capacity' and 'planning'. Moreover, there is a seemingly but often undetailed or unclear connection between uncertainty on the one hand and adaptiveness advocated in approaches, tools and planning processes on the other. Also, while some authors do not want to take a normative stance on the ability of adaptiveness to deal with uncertainty (e.g., Giezen et al. 2015), this position is (although often unmentioned) assumed by advocates of adaptiveness (e.g., Folke et al. 2005; Gupta et al. 2010; Giordano 2012; Islam & Susskind 2012). In this context, and for the reasons addressed above, this thesis will further advance knowledge about the relationship between uncertainty and adaptiveness in spatial planning.

1.3 Objective and research questions

The objective of this study is threefold. First, to study uncertainty in the context of planning for interventions and long-term spatial transformations. Second, to obtain insight into adaptiveness and query it as to the promise it holds to help planners decide about interventions amid uncertainty. Third, to further study adaptiveness in particular planning practices related to deltas and long-term spatial interventions. The objective of this study is expressed in the following research question:

> **What differentiation of uncertainty helps planners to decide about interventions in delta areas and to what extent does adaptiveness contribute to handle this uncertainty?**

By addressing this question, this research contributes to the growing awareness of uncertainty and clarifies the concepts of adaptiveness and uncertainty in spatial planning. This research offers insight into what uncertainty entails with respect to the different conceptualisations of adaptiveness available to planners who need to intervene in deltas. The research was set up to explore and connect insight into uncertainty with current knowledge about interventions in deltas based on adaptiveness.

1.4 Research approach

The research approach is based on a mix of methods and finds its origin in an interpretative research perspective (Hesse-Biber 2010; Yanow & Schwartz-Shea 2014). Interpretative research builds on interpreting and understanding meaning assigned to text, figures, objects and experiences. The research in this thesis starts by assuming a reality independent from interpretation, which can be approached and understood through meaning-making mechanisms (Farthing 2016). This contradicts with some interpretative researchers, who adhere to constructivism and reject an independent reality free from interpretation (e.g., Yanow 1993; Allmendinger 2009; Creswell 2014). This epistemological position allows for the exploration and comprehension of different perspectives on what uncertainty might mean in the context of planning.

The research approach is divided into two main parts, reflected in the structure of the thesis. The first part is a theoretical exploration of the two concepts studied in this thesis: uncertainty and adaptiveness. This part intends to offer an understanding of both concepts to enable their further study and application in planning practices. To explore these concepts, I executed two reviews. To study uncertainty, I chose to conduct a critical review (Grant & Booth 2009) of planning literature and studies in environmental risk and climate uncertainty. In contrast to, for example, a formal systematic review, a critical review intends to 'evaluate conceptual contributions to embody existing or derive new theory' (Grant & Booth 2009: 94). I intend to offer a new understanding of the possibilities or impossibilities of handling uncertainty in spatial planning. To study adaptiveness, I conducted a qualitative systematic review to address the advancement of this concept within a broad understanding of spatial planning, in other words, pertaining to interventions in the environment in its broadest sense. A qualitative systematic review intends to appraise and synthesise studies to create a thematic analysis of the subject area and is as transparent as possible in reporting methods and findings, although it does not provide the rigorousness of systematic reviews or meta-analyses (Pettigrew & Roberts 2006; Sandelowski 2008; Grant & Booth 2009; Berrang Ford et al. 2015). The analytical methods of the review are a content analysis of the articles (Hsieh & Shannon 2005) and subsequently a domain analysis of the identified themes (Borgatti 1999) to discover main trends and elements related to adaptiveness. Here, the tension

between objectivists and constructivists comes vividly to mind: do we 'find' a path or 'construct' a path. I choose for 'discover' as an in-between: a path may already exist but may also require creativity on the part of the path-taker.

The second part of this thesis is based on case study research and engages more directly with empirical data and planning practice. A case in this thesis refers to a specific exemplar of a planning practice. The research approach taken here is embedded in an interpretative perspective and offers two comparative case studies and one independent in-depth case study (Schwartz-Shea & Yanow 2012). Comparative case study research (Engeli & Rothmayr Allison 2014; Farthing 2016) builds on the awareness of cases as singular phenomena that are studied within their context to achieve a deeper insight into how this specific situation evolved (Byrne 2013; Thomas 2011). By comparing multiple cases, more general insights and lessons for other cases might be distilled, although still with caution and awareness of their context-dependency. The cases were studied through interviews, focus groups and policy documents, which were analysed by reading, rereading, coding and building case narratives (Silverman 2006; Cresswell 2014). In doing so, I was informed by process tracing methodology to study case patterns (Beach & Pedersen 2013). The emphasis in this thesis is on advancing plausible, reliable and transparent arguments for the claims I make (Schwartz-Shea & Yanow 2012). These arguments and claims originate from meaning-making during each of the traditional research steps (formulation of a question, hypothesis, data collection, analysis, dissemination, subsequent iteration). The cases are built inductively, therefore through iterative steps, to qualitatively study the empirical events and experiences insightful to build the arguments and discover mechanism and patterns. This sometimes demands a further fine-tuning of questions or needs additional data or to repeat parts of the analysis (Beach & Pedersen 2013). This iterative process was structured based on the theoretical part of this thesis. Each of the next chapters has a methods section in which the specificities of the methods used can be found.

The following three exponents of planning practice are included as cases: planning approaches, planning tools and planning processes, which are the three exponents of spatial planning of particular interest in this thesis. The planning approaches studied in this thesis are the water diplomacy framework (Islam & Susskind 2012), originating in

the United States, and adaptive delta management (van Rhee 2012), originating in the Netherlands. A comparative analysis was conducted of, on the one hand, the water diplomacy framework and, on the other, adaptive delta management. While widely diverging in style, background and emphasis, both approaches claim to deliver policy in the context of water management by advancing adaptiveness for situations in which uncertainty is present. As planning tools, adaptation pathways (Haasnoot et al. 2013) are studied in four planning situations: strategic planning for water management in the IJsselmeer area (the Netherlands), climate adaptation planning for the coastal zone of Ílhavo and Vagos (Portugal), urban redevelopment in a neighbourhood in the city of Prague (Czech Republic) and flood risk management for the area surrounding the city of Rotterdam (the Netherlands). This tool is used in adaptive delta management and claims to take uncertainties into account better than predict-and-control approaches by advancing adaptiveness in policies (Haasnoot et al. 2013; Walker et al. 2013; Kwakkel et al. 2015). The four applications are compared to study which design choices need to be considered when adjusting the tool for particular planning contexts in order to deliver adaptive policy. To study planning processes, one in-depth case study into the strategic planning process of the IJsselmeer area was chosen. This process took place in the context of the Delta Programme, which had the aim to propose coherent strategies up to 2100, created in a collaborative planning process. I traced uncertainty throughout the planning process to study the underlying discussions when planners want to develop long-term strategies and address uncertainty by means of adaptiveness through a multi-level, multi-actor process. The reasons for choosing these cases as exemplars of approaches, tools and processes are given in the methods sections of the respective chapters.

1.5 Structure of this thesis

The main body of this thesis consists of five papers written with different co-authors. In Chapter 2, the concept of uncertainty related to interventions in spatial planning is studied. In this chapter, I query several understandings of uncertainty that have taken root in the fields of study related to spatial planning, risk management and climate change, and synthesise these to argue for a characterisation of uncertainty that helps planners search for interventions amid uncertainty. Chapter 3 presents the results of the qualitative systematic

review of adaptiveness in the planning literature. The chapter outlines different forms of adaptiveness and offers further theorisation about the commonalities, differences and available elements within three different forms of adaptiveness, allowing planners to make a deliberate choice to structure their particular adaptive approach. Based on these first two chapters, I studied how uncertainty influences adaptiveness in spatial planning with particular attention for planning approaches, planning tools and planning processes. Chapter 4 focuses on uncertainty in planning approaches. Chapter 5 highlights an adaptive planning tool: adaptation pathways (e.g., Haasnoot et al. 2013). In Chapter 6, I return to the IJsselmeer area to study the planning process undertaken in the Delta Programme. In Chapter 7, I give my general conclusions and discuss them in light of the related scholarly debates, and conclude by addressing the societal relevance of this research and topics for future research.

2

Navigating amid uncertainty in spatial planning

This paper is published as: Zandvoort M, van der Vlist MJ, Klijn F & van den Brink A (2017) Navigating amid uncertainty in spatial planning. *Planning Theory* 1-21, Online First.


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Abstract

In view of the need to adapt to uncertain climate change through spatial interventions, this paper explores how spatial planners might navigate amid uncertainty. To draw out insights for planning, we examine planning frameworks which explicitly recognise uncertainty and uncertainty descriptions from studies in environmental risk and climate uncertainty. We build our case by addressing the implications of different characteristics of uncertainty and describe how planners can handle uncertainty based on the nature, level, and location of uncertainty. We argue that a plural-unequivocal characterisation of uncertainty helps planners in their search for adequate and warranted interventions amid uncertainty.

Keywords

Uncertainty, ambiguity, spatial planning, climate change, long-term consequences, moral responsibility

2.1 Introduction

Spatial planners contribute to the organisation of the environment by preparing planning decisions and taking deliberate actions to develop places (Christensen 1985; Balducci et al. 2011). When taking decisions or preparing possible interventions, planners will always be confronted with uncertainty (Christensen 1985; Albrechts 2004; Balducci et al. 2011; Rauws et al. 2014; Lau 2015). Uncertainty is a particularly important consideration when assessing the potential long-term consequences of interventions in the environment (Connell 2009; Salet et al. 2013; van der Vlist et al. 2015; Walsh et al. 2015). Planners are also required to assess the impacts of climate change in order to design spatial interventions for climate adaptation, even though climate change can alter local environments in unpredictable ways. Moreover, these interventions, such as the construction and adaptation of infrastructure, can influence the location and layout of development for many decades, with possible unforeseen consequences for other spatial interventions or society (Graham & Marvin 2001). Altogether, this demands a coherent understanding of uncertainty to inform adequate planning interventions.

Contemporary planning theory considers uncertainty as part of complexity thinking (e.g., de Roo & Silva 2010; Innes & Booher 2010; Batty 2013). However, planning theorists have described uncertainty in many different ways (e.g., Gunder 2008; Abbott 2009; Bertolini 2010; Hillier 2010; Balducci et al. 2011; Abbott 2012; Hillier 2013; Salet et al. 2013; Rauws et al. 2014; Lau 2015), which allows for a variety of interpretations. These differences between interpretations give rise to three issues. Firstly, where planners only partially understand uncertainty their interventions may be redundant or deficient. Secondly, if planners act with a poor understanding of uncertainty, decisions and interventions may turn out to be maladaptive. Thirdly, the normative implications of structuring development for decades under conditions of uncertainty include a moral responsibility: decisions and interventions in response to uncertainty may be unjust, or lead to injustice. These issues can be illustrated by the example of building a dyke for protection against flooding in the face of uncertain climate change. The dyke may be built too high or low, in the wrong place or way, or with unjust consequences for flood safety.

We argue that to deal adequately with specific uncertainties, spatial planners should understand the differences between uncertainties. The aim of this chapter is to explore perspectives for handling uncertainty in spatial planning. To gain insight into the adequacy of planning interventions when confronted with uncertainty, we set out to answer the question: 'What differentiation of uncertainty offers insight into adequate and warranted planning interventions?' We structure our chapter into three parts: first, how uncertainties can be differentiated; second, how these relate to planning; and third, what insights can be derived from such a differentiation for handling uncertainty in spatial planning, for both adequate and warranted interventions. We aim to contribute to the subject of uncertainty in planning and to the development of a theory on the adequacy of interventions in relation to uncertainty. Moreover, we investigate some of the ethical considerations of handling uncertainty.

In the next section we examine four theoretical frameworks in which uncertainty has an important role. These frameworks were developed by Abbott (2005, 2009), Christensen (1985), Friend and Hickling (2005), and Islam and Susskind (2012). In the following section we describe three characteristics of uncertainty based on recent conceptualisations of uncertainty in studies pertaining to climate change uncertainty and environmental risk (building on e.g. Walker et al. 2003; Brugnach et al. 2008; Kwakkel et al. 2010b; Skinner et al. 2014; van den Hoek et al. 2014a). As these studies propose characterisations of uncertainty for the purpose of better handling long-term but as yet unknown environmental changes, they may offer insights into how to handle uncertainty in spatial planning. Then, in the main body of the chapter, we connect planning with uncertainty conceptualisations, first by articulating what we mean by 'planning' and then by building on the three characteristics of uncertainty (nature, level and location). We explore the characteristics of uncertainty to gain insights into handling perspectives for planning. Lastly, we synthesise these insights to determine what theoretical footholds the three characteristics of uncertainty offer to help planners navigate amid uncertainty.

2.2 Uncertainty frameworks in planning

Uncertainty frameworks in planning theory have evolved over several decades. A widely used framework is the one developed by Christensen (1985), which was also used by Balducci et al. (2011) and referred to by many others (e.g., Alfasi & Portugali 2004; Abbott 2005; Gunder 2008). A similar framework is the one used by Stacey (2007) and Islam and Susskind (2012). Another influential framework was proposed to assess uncertainty in the strategic choice approach (Friend & Jessop 1969; Friend 1993; Friend & Hickling 2005). This framework was further developed by Abbott (2005, 2009, 2012), who added some components to the characterisation of uncertainty in the strategic choice approach. We base our discussion of these four frameworks on a review of the literature on uncertainty and planning and on citations and alterations of the discussed works.

Christensen (1985) links the variables 'knowledge' and 'agreement' to two types of uncertainty, uncertainty about means and uncertainty about ends, in a matrix to obtain four planning situations. Planning problems can be mapped according to these four situations. There is an implied value judgement that the best situation is achieved when there is agreement and sufficient knowledge to make a decision (Bertolini 2010). Regarding uncertainty about means and uncertainty about ends in planning Christensen (1985: 63) states: 'By matching planning processes to problem characteristics, planning offers a chance to overcome, or at least reduce, uncertainty.' Uncertainty about means can be overcome by gaining more knowledge or initiating a learning process; agreement is necessary to overcome uncertainty about ends.

In the context of the strategic choice approach, Friend and Jessop (1969), Friend (1993) and Friend and Hickling (2005), describe three types, or 'areas', of uncertainty and link these to three 'structuring principles' for planning. Uncertainties relate to a planning problem and the planning process must be informed by ex-ante assessment of prevalent areas of uncertainty. Friend (1993) reviews the three areas of uncertainty and discusses how these areas influence planning. The first area is 'uncertainty in the working environment', which calls for deeper investigation. The second area, 'uncertainty about related choices', demands wider collaboration. The third area is 'uncertainty about guiding values', which indicates that objectives are not yet clear enough. Based on these areas, the planner must learn 'to manage

uncertainty in a strategic way. This means considering carefully which areas of uncertainty are most significant in any particular planning context and what possible forms of actions might be initiated in response' (Friend 1993: 1).

Both frameworks are used and adapted by others, most elaborately by Abbott (2005, 2009, 2012). Abbott (2005) synthesised the frameworks of Christensen (1985) and Friend (1993) into one framework with environmental uncertainty and social or planning-process uncertainty as two overlapping dimensions and five distinct 'natures' of uncertainty (chance, external uncertainty, causal uncertainty, organisational uncertainty and value uncertainty) as subdivisions (Figure 2.1).

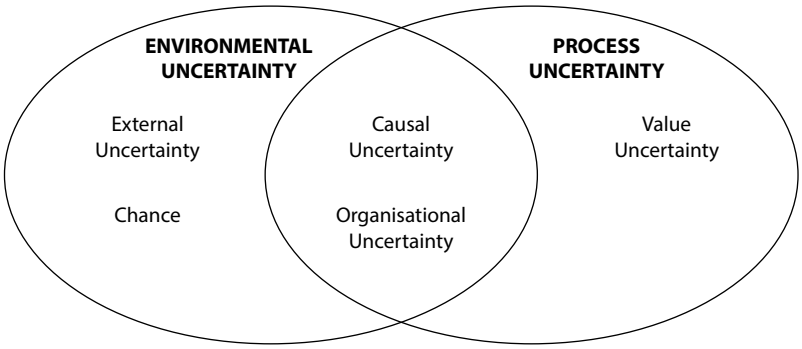


Figure 2.1. Abbott's (2005) framework: two overlapping dimensions with five 'natures' of uncertainty.

Although Abbott acknowledged that distinct uncertainties have different implications for planning, he did not further address these, except for stating that '[d]ifferent planning theories can thus provide guidance on how to understand and manage different dimensions of uncertainty' (Abbott 2005: 248). The framework used by Islam and Susskind (2012), adapted from Stacey (2007), bears strong similarities to the framework of Christensen (1985), but differs in three main ways. First, the variables have been changed from binary variables (either knowledge or no knowledge; either agreement or not) to ratio-scaled, gradual variables. Second, the framework has been altered from a means–end dichotomy to an agreement–uncertainty dichotomy, thereby overcoming the difficult relationship between means and ends (e.g. Simon, 1969). Third, uncertainty is connected to the complexity of a planning situation. Adapting the framework in such a way allows the complexity of the planning problem to be characterised according to the amount of uncertainty and disagreement (cf. means and ends

in the matrix of Christensen (1985) and facts and values in Simon (1969)). More disagreement and more uncertainty indicate greater complexity. As Islam and Susskind (2012) show, a planning problem or situation can be positioned on a scale from simple situations with little disagreement and/or uncertainty via complicated situations to complex planning situations with much disagreement, large uncertainty or both (see Figure 2.2).

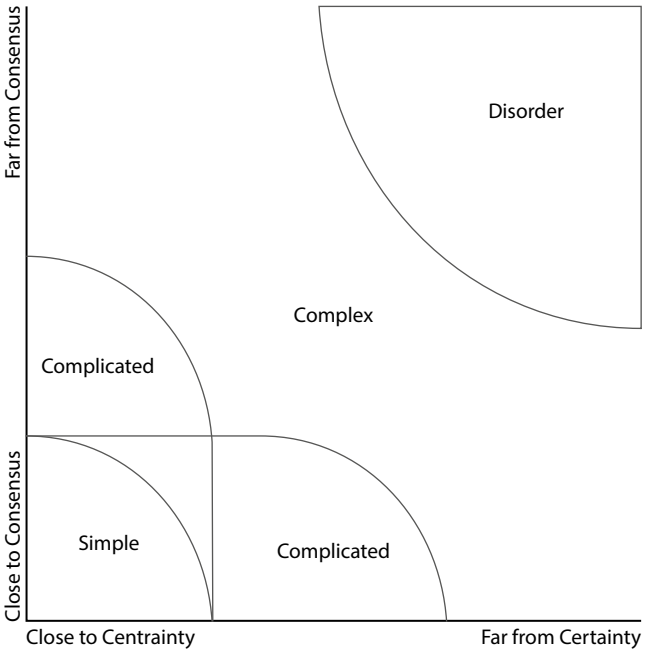


Figure 2.2. Islam and Susskind's (2012) framework: consensus and uncertainty add up to complex and disorderly planning situations (Stacey 2007).

In the four frameworks, the uncertainty debate revolves around how to deal with uncertainty (Christensen 1985; Islam & Susskind 2012) or uncertainties (Friend 1993; Abbott 2005) in planning. One insight from the conceptualisation of uncertainties in the frameworks is that the coupling between what uncertainty is and what uncertainty entails for planning is coloured by the planning paradigm within which uncertainty is defined. For example, Christensen (1985) uses the differences between uncertainty about means and ends to classify prototypical planning processes, such as rational planning (when everything is clear) and a bargaining process (when only ends are uncertain). Each of the frameworks makes assumptions about what planning is, how this affects their ontological position and how uncertainty is used to assess the adequacy and justification of

planning interventions. We argue that a detailed understanding of uncertainty could surpass differences between rational-comprehensive, incremental and communicative, relational planning (Christensen 1985), but reject the ontology-free ideal in which planners can choose the uncertainty and planning definitions as they like. We now turn to how we can better understand uncertainty in planning by examining how it is characterised in risk- and climate studies.

2.3 Characteristics of uncertainty in risk- and climate studies

In risk and climate studies, uncertainty is categorised in many different ways (e.g., van Asselt & Rotmans 1997; van Asselt 2000; Walker et al. 2003; Kwakkel et al. 2010b; Skinner et al. 2014; van den Hoek et al. 2014a). These studies show a rapid evolution in the conceptualisation of uncertainty over the past two decades. Skinner et al. (2014) reviewed characterisations of uncertainty in environmental risk studies and concluded that even in one scientific domain terminology is inconsistent and sometimes contradictory. Of the many characterisations identified, nature, level and location are used by a range of reviews and studies to understand uncertainty (Walker et al. 2003; Brugnach et al. 2008; van der Keur et al. 2008; Kwakkel et al. 2010b; Skinner et al. 2014; van den Hoek et al. 2014a). We examine these characteristics to identify what uncertainty might entail for planning.

2.3.1 The nature of uncertainty

The nature of uncertainty relates to the question of why a phenomenon is uncertain. Kwakkel et al. (2010b) distinguish three natures of uncertainty: ontic, epistemic and ambiguous uncertainty. Ontic uncertainty is also referred to as variability, stochastic uncertainty, aleatory uncertainty, random uncertainty, fundamental uncertainty or chance (Walker et al. 2003; Skinner et al. 2014; Rauws 2015). Ontic uncertainty arises from variability in a phenomenon and is inherently unpredictable and irreducible, even if systems could be better understood over time. The origins of ontic uncertainty are the unpredictable and chaotic dynamics of physical, economic, political and cultural phenomena and human behaviour (Walker et al. 2003). An example is the future discharge of a river, which can never be predicted

a month ahead due to the inherent chaotic, non-linear behaviour of the water system (Milly et al. 2008).

Epistemic uncertainty is the incompleteness or imperfection of knowledge, or inexactness (error) (Hofer 1996; Walker et al. 2003). The origin of epistemic uncertainty is a lack of data, poor quality of data, or insufficient techniques to measure parameters that may be relevant for the decision or policy at hand. Several statistical measures exist to indicate the quality of quantitative data. For example, Funtowicz and Ravetz (1990) introduced the notion of pedigree in qualitative data to 'systematically assess the imperfection in the knowledge base, thereby providing an indication of the degree to which uncertainty may be reducible' (cited in Walker et al. 2003: 13). The main difference between ontic and epistemic uncertainty is that ontic uncertainty cannot be reduced, while epistemic uncertainty can, namely by increasing the amount or quality of knowledge or reducing error. An example is the failure of a river dyke. The mechanisms of failure are well understood and, thus, the susceptibility of the dyke to failure at any location could be determined. It is, however, too expensive to measure the strength of the dyke at each and every location along its length and during each possible combination of hydraulic loading and antecedent conditions, so water managers often accept a degree of epistemic uncertainty.

Ambiguity is a third and independent nature of uncertainty, as first proposed by Brugnach et al. (2008). Kwakkel et al. (2010b: 310) define ambiguity as 'uncertainty arising from the simultaneous presence of multiple frames of reference about a certain phenomenon'. Ambiguity is seen as an irreducible uncertainty because of the many frames in society, which are not necessarily recognised. It is not about 'not knowing enough', but about 'knowing differently' (van den Hoek et al. 2014a). In the example of a possible failure of a dyke, ambiguity can arise from the existence of different perspectives on the acceptability of such failure, and hence different perspectives on the amount of investment required to either reduce epistemic uncertainty and/or build stronger dykes to prepare for higher water levels.

2.3.2 The level of uncertainty

The level of uncertainty refers to the degree of certainty that can be achieved in a given situation. Different levels of uncertainty can be

distinguished between full certainty and complete uncertainty or between knowing everything precisely and a total lack of knowledge (Walker et al. 2003). Kwakkel et al. (2010b) proposed to redefine the levels (Table 2.1) to indicate the possibility of quantifying uncertainty in terms of probabilities or likelihood of facts or events (Hofer 1996; Kwakkel et al. 2010b; Skinner et al. 2014).

Table 2.1. The four levels of uncertainty (Kwakkel et al. 2010b: 308-309).

Level of uncertainty	Description
Level 1 – Shallow uncertainty	Being able to enumerate multiple alternatives and provide probabilities.
Level 2 – Medium uncertainty	Being able to enumerate multiple alternatives and rank them in terms of perceived likelihood without being able to compare likelihoods of alternatives (ordinal).
Level 3 – Deep uncertainty	Being able to enumerate multiple alternatives without being able to rank them in terms of likelihood or plausibility.
Level 4 – Recognised ignorance	Being unable to enumerate multiple alternatives while admitting the possibility of being surprised.

2.3.3 The location of uncertainty

Locating uncertainty can originate from a modeller's perspective, in which the location is where an uncertainty manifests itself in a model (Walker et al. 2003), or from a general risk assessment perspective, in which it is 'where the uncertainty occurs within an assessment' (Skinner et al. 2014: 3). Based on these definitions, the location of uncertainty includes, among others, the modelled system (and its boundaries), input data, the model itself (both in representing the real world and in parameters) and the accumulated uncertainty in the outcomes of a model.

Instead of location, some use the 'source' of uncertainty in a similar fashion. For example, van der Keur et al. (2008) redefined the location of uncertainty as the source of uncertainty based on three 'subsystems' (ecological, social and technical) and distinguished different sources (including data, the model, boundary conditions) of uncertainty for each of these subsystems (van der Keur et al. 2008). Both source and location describe where uncertainty can be located, depending on the question 'what is uncertain?'

2.4 Relating planning to the characteristics of uncertainty

The characterisation of uncertainty by nature, level and location, as described above, differs from the four uncertainty frameworks in planning and offers additional insights for dealing with uncertainty. However, the possibilities for dealing with uncertainty through planning interventions are influenced by the particularities of an individual's planning perspective (Christensen 1985). Therefore, we first elaborate on the kind of ontological position and related perspective on planning that could match the characteristics of uncertainty.

We argue that an understanding of planning should be consistent with the ontological perspective taken. Here, we adopt a perspective in which we acknowledge that the world behaves in complex, intricate ways beyond our grasp (DeLanda 2006; de Roo & Silva 2010). In addition, we claim that at least some elements are knowable, without neglecting the intricate ways in which physical interactions and interpretations make reality too complex to grasp (Bhaskar 1998; DeLanda 2006; Harman 2008). We assert the existence of poly-rationality and poly-epistemology (Davy 2008), which makes knowledge both object-dependent and subject-dependent. The former implies that there is just one knowable world and that maladaptive planning is possible and possibly dangerous for human existence; the latter implies that there are multiple rationalities for interpreting the complex world and acting accordingly.

This ontological position allows for a plural-unequivocal understanding of uncertainty, which is necessary to embrace the three characteristics of uncertainty: nature, level, and location. Taking this position can help us to transcend different understandings of uncertainty (Christensen 1985) derived from the rational (e.g. Walker et al. 2003) and relational perspectives (e.g. Brugnach et al. 2008; Islam & Susskind 2012; van den Hoek et al. 2014a) and construct a coherent frame of understanding that acknowledges both the plurality of uncertainty and its unequivocal implications for adequate and just interventions.

We build on the understanding that planning is primarily a practice (Alexander 2015) shaped by planners who constantly navigate amid different paradoxes (Savini et al. 2015). Planners build on knowledge to navigate planning practices through multiple, connected ways of knowing (Davoudi 2015). For our purpose, planning can thus be

seen as a vehicle planners use to turn their knowledge into adequate interventions in particular situations (e.g., van der Vlist 1998; Allmendinger 2009; Alexander 2015). We see this as an activity that predominantly takes place within public institutions. We argue that, in accordance with our ontological perspective, the performance of planning and planners can be assessed against general, universal claims about uncertainty, which need to be specified for situated planning practices (Campbell 2006; Alexander 2015; Savini et al. 2015). In this view, we propose that distinct characteristics of uncertainty provide planners with a rationale for investigating the adequacy and justification of their interventions.

We connect uncertainty to planning via its guiding facet and its developmental facet. In the guiding facet of planning, planners produce legitimating discourses. In the developmental facet of planning, planners search for regulatory mechanisms for interventions (van der Vlist 1998; Olssen 1999; Davoudi 2015). Based on these premises, we relate the three characteristics of uncertainty to what can be known and what can be done in planning. Ontic uncertainty is an unknowable phenomenon, which implies that planning interventions necessarily take place in uncertainty. Epistemic uncertainty can be known, and thus implies that planners could reduce uncertainty by increasing or correcting current knowledge. Ambiguity arises from situations in which actors have different knowledge and perceptions, which implies that planners should search for a single way of knowing. Each of these claims builds on the idea that one can handle uncertainty in adequate ways, justified by the relevant premises concerning the type of uncertainty involved. The level and location of uncertainty can also be described for both facets of planning. All this is illustrated in table 2.2.

Table 2.2. A plural-unequivocal analysis of uncertainty related to the guiding and developmental facets of planning.

Planning	**Nature**			**Level**	**Location**
	Ontic	**Epistemic**	**Ambiguity**		
What can be known (guiding facet)	Unknowable phenomena up to a specific level	Knowable phenomena up to a specific level	Differently (un)known	Degree of certainty to which a phenomenon can be known	Knowledge about where a phenomenon can become manifest
Prescriptive to what can be done (developmental facet)	Intervening in uncertainty	Enlarging or correcting current knowledge	Search for one way of knowing	Specify what can be done regarding the measurability of phenomena	Specify what can be done regarding the possible location where uncertainty manifests itself

This analysis is still very abstract and needs to be specified in more detail to obtain an answer to our research question about what insight this differentiation of uncertainty offers for making adequate and warranted planning interventions. Such specification might be found in what each of the characteristics of uncertainty implies for the possible interventions planners make. Moreover, each of the characteristics holds some normative implications for warranted courses of action. We explore these topics in the following sections.

2.4.1 What are the implications of the ontic and epistemic natures of uncertainty for planning?

The nature of uncertainty has far reaching implications for planning, since it describes the possibility or impossibility of reducing uncertainty. Based on the distinction between ontic and epistemic natures, planners could ask whether or not there is room for reducing uncertainty and what type of knowledge could deliver more insight into uncertainty and what possible and warranted actions could be taken, despite the uncertainty.

Ontic uncertainty is by definition irreducible. If ontic uncertainty is encountered, for example the unknown effect of climate change on the future discharge of a river, planners have to act under uncertainty, which implies that they must accept the risks involved. Most planning actions taken to deal with ontic uncertainty will probably be designed to make the object of planning able to withstand or adjust to how the uncertain phenomenon might unfold. In such situations planners could opt to enhance the robust, adaptive or flexible properties of the object. For example, in response to uncertain future river discharges, the dykes could be strengthened or otherwise adapted to make them more robust (Klijn et al. 2012a) or flexible (Scholtes & de Neufville 2011).

Epistemic uncertainty can by definition be reduced by gaining more knowledge or conducting directed experiments. In this sense epistemic uncertainty is similar to 'uncertainties in the working environment', which need deeper investigation, in the strategic choice approach (Friend 1993). Planners confronted with epistemic uncertainty may respond by making plans that are adaptive or flexible (Kato & Ahern 2008). Adaptive planning builds on the ability to alter the development path laid out in plans (Balducci et al. 2011) as new evidence arises, the

predictability of a phenomenon increases or as the future unfolds (Kato & Ahern 2008; Rauws et al. 2014). Of course, responses to uncertainty being reducible or irreducible are not mutually exclusive. As well as taking time to measure river discharges to increase knowledge with more specifications or details, the inclusion of robustness or flexibility in the object of planning might also be deemed appropriate. Investing in such robust or flexible properties to handle epistemic uncertainty can, however, lead to maladaptation or overinvestment (van de Riet 2003). This could be avoided by first investing in the knowledge base. Knowing the difference between ontic or epistemic uncertainty and the implications for what can be done allows judgements to be made about an adequate course of action.

There are also several normative issues pertaining to ontic and epistemic uncertainties. Being uncertain and being able or unable to reduce uncertainty defines the responsibility of planners to act (or not), and in which way. This bears a strong resemblance to the precautionary principle in environmental ethics (O'Riordan & Cameron 1994; Gardiner et al. 2011; Munthe 2011). If planners do not know what the effects of an action are going to be, they should not do it to avoid possible damage. However, if they do know that a harmful change or outcome is likely, they could be considered to have a moral responsibility to find out what might happen and what could be done to reduce harm, based on their personal moral principles, or those of their planning institute or society in general (Basta 2014). Uncertainty determines what the type and extent of precautionary action might be, although the level and location of uncertainty are just as important in determining appropriate (precautionary) action.

Whether or not planners can be held accountable for inadequate or inappropriate action depends on whether or not they are able to obtain the knowledge required to act (epistemic versus ontic uncertainty). In the face of ontic uncertainty, precaution might be the just choice. In the face of epistemic uncertainty, acting to reduce uncertainty to better guide actions might do more justice to the situation at hand. In both instances, the planner (or planning institution) is morally responsible for their actions or inaction, which can be assessed against the uncertainty at hand (Fischer & Ravizza 1998). There is therefore a strong imperative to know the distinction between ontic and epistemic uncertainty for judging planning decisions and addressing planners' accountability for the type and extent of actions taken amid uncertainty.

2.4.2 Frames, ambiguity and disagreement in addressing uncertainty in planning

Two issues need to be resolved regarding ambiguity in planning. The first is the relation between ambiguity and disagreement and the second is the relation between ambiguity and value, means and choice uncertainty. In addition, the nature of ambiguity itself challenges conceptualisations of uncertainty since it arises from the existence of different frames, as does uncertainty. We elaborate on these issues and address the connection between ambiguity and planning by introducing discursive uncertainty as pertinent to all discussions of uncertainty in planning.

The first issue in need of clarification is the relation between disagreement in planning frameworks and ambiguity as a separate nature of uncertainty. Ambiguity is a form of uncertainty arising from different frames in society (Dewulf et al. 2005; Brugnach et al. 2008). Disagreement is the outcome of colliding frames, values or positions among actors involved in a planning process, which can lead to uncertainty about the planning process or its outcomes (Susskind et al. 1999). This problem relates to how a frame is defined, which can be done in at least two different ways. As a time-slice based concept, the frame is defined as a 'cognitive representation', but when historically situated, the frame is seen as an 'interactional co-construction' (Dewulf et al. 2005; Brugnach et al. 2008). When disagreement is related to the perception of frames as interactional co-constructions, it can be seen as the absence of a unanimously accepted and clear understanding. Ambiguity can be seen as the mere existence of different cognitive frames pertaining to an issue. While disagreement and ambiguity result from the same multiplicity of frames (as cognitive representations) in society (Brugnach et al. 2008; Kwakkel et al. 2010b), the difference is between planning as a situated practice, in which a multiplicity of frames results in disagreement, and the contextual situation, in which the same multiplicity of frames results in ambiguous uncertainty (Abbott 2005). Ambiguous uncertainty is, by definition, irreducible from the perspective of the situated planning practice, whereas disagreement can be dealt with in a planning process (Susskind & Field 1996; Innes & Booher 2010). One of the possible interventions for resolving disagreement, and to some extent ambiguous uncertainty where it can be drawn into the planning situation, is to align frames in a consensus-building process or to reframe – that is, to transform the

collective understanding of the planning problem, data, information or the scope of the process – through interactional co-construction or joint fact-finding (Susskind & Field 1996; Abbott 2005; Brugnach et al. 2008; Schenk et al. 2016).

The second issue that needs attention are the categories identified in planning frameworks: value uncertainty, means uncertainty and choice uncertainty (Abbott 2005; Friend & Hickling 2005; Islam & Susskind 2012). The distinction between uncertainty about values and choices (about means) can be useful when determining the aim of a consensus-building process (Susskind & Field 1996). The concept of guiding values from the strategic choice approach (Friend & Hickling 2005) corresponds to differences between values that underlie frames, while choice uncertainty refers to uncertainty about the appropriate or desirable choices or means, due to different frames. Choice uncertainty can also be epistemic in nature, or partly so, if there is insufficient knowledge about the effects of a choice. So, value and means uncertainty can both be related to ambiguity, but means uncertainty can also be related to epistemic uncertainty.

An important feature of ambiguity is the existence of frames or multiple rationalities, which also pertain to what uncertainty, planning and just action are (Davy 2008). We propose a planning perspective that enables uncertainty to be seen as a plural-unequivocal concept, but this is just one heuristic for understanding uncertainty. In planning, uncertainty is discursively constructed, often with differences between actors' cognitive representations of reality (Dewulf 2005; Hillier 2013). There can, for example, be disagreement between actors about an uncertainty being ontic or epistemic, or being a level 2 or 3 uncertainty. This can be termed discursive uncertainty: uncertainty arising from disagreement or being uncertain about the uncertainty of phenomena. Discursive uncertainty affects actors' perceptions of appropriate action. Moreover, the discursive practice of interactional co-construction and aligning frames can lead to agreements with wrong assumptions about the characteristics of uncertainty. When planners intend to align alternate representations of uncertainty, awareness of the possible discursive uncertainty could be helpful in elaborating different uncertainty discourses.

Ambiguity can provide insight for planning, for example on the representation of different frames and values among stakeholders

in planning processes. Here, as Vanessa Watson (2003) argues, the danger of underestimating differences arises when 'planners assume a shared rationality where it does not exist' (p. 403). This implies several normative-procedural choices. First, who should be represented to include or avoid the exclusion of 'frames' in the co-construction of understanding pertaining to uncertainties. Second, if co-construction or reframing is identified as an adequate intervention, issues arise pertaining to equal access of actors to the process, fairness in processes of inclusion or exclusion, and respect for differences regarding uncertainty or other issues not pertaining to the actual planning issue. Also, for effective co-construction or reframing, discussing the appropriate level of reframing needed to cope with uncertainty can be important to do justice to multiple frames (does the issue concern reframing of values, means, actions, or of uncertainty itself?). This requires that actors accept the reduction of a multiplicity of frames to a collective perception of reality for the planning issue at hand.

Normative issues also pertain to the distributive and non-distributive effects of choices and means. Uncertainty might hamper timely choices or implementation of proper means, resulting in injustice to currently disadvantaged groups or future generations. The intergenerational aspect is one of the main moral issues debated in climate change ethics (Gardiner 2006; Gardiner et al. 2011). While ontic and epistemic uncertainty are considered relevant to ethical considerations about climate change, ambiguity receives less attention, although it can offer a different perspective. In discussing uncertainty about choices and means, different cognitive representations of uncertainty (what we described as discursive uncertainty) about the solutions for an issue affects the adequate handling of uncertainty. Instead of discussing the effect of ontic or epistemic uncertainty on interventions, ambiguity challenges the underlying representations of reality and offers a different set of arguments and solutions related to co-construction and aligning frames.

2.4.3 Level of uncertainty in planning and its connection with risk

The level of uncertainty specifies possible ways of dealing with uncertainty regarding the timing and use of planning interventions. The level of uncertainty is only a descriptor for ontic and epistemic uncertainties, which may both be present in an uncertain phenomenon

at a specific moment (cf. Walker et al. 2003). While ambiguity could be expressed in levels, this is probably a futile exercise as probability ranking of different frames does not make much sense. A better option may be to make a distinction between unanimous clarity and total confusion (Brugnach et al. 2008). However, ambiguity can give rise to discursive uncertainty, in which there is a debate about the level at which an uncertain phenomenon can be specified.

The level of uncertainty is strongly connected to the concept of risk. According to Knight (1921: 20), risk is 'measureable uncertainty', equivalent to levels 1 and 2 (Table 2.1), immeasurable uncertainty is represented by levels 3 and 4. In planning, risk is often described in terms of the probability of an event and its impact or consequences, which can be further specified according to the exposure to the event and vulnerability to its impacts (Renn 2008; Klijn et al. 2012a). Risk management approaches that can be used to deal with uncertainty levels 1 and 2 include probabilistic and deterministic approaches and statistical-based assessment approaches, such as real options analysis (Scholtes & de Neufville 2011).

Level 3 uncertainty can be linked to pathway approaches and scenario planning (Haasnoot et al. 2013). Level 4 can be linked to those uncertainties that we do not know (the 'known unknowns'), in which planning needs to be open to surprises or 'black swans' (Taleb 2001; Kwakkel et al. 2010b). It is this level 4, ontic uncertainty that has led to demands for openness, reflexivity, responsiveness and experimental practices in planning (Rauws et al. 2014; Ansaloni & Tedeschi 2016). The link between uncertainty and risk can become a key issue in translating knowledge about uncertainty into action, because both action and inaction can, but do not necessarily, result in risk-taking activities. The level of uncertainty determines in more detail which approaches and solutions are suitable under conditions of uncertainty.

The level is an important concept to help planners adequately handle uncertainty. The levels are conceived of as a continuum, from fully certain about a phenomenon at one end to totally uncertain at the other (Walker et al. 2003). For planners, decisions on when and how to act are made easier by knowing about the extremes and dynamics in the degree of uncertainty over time (Islam & Susskind 2012). In addition, the size of uncertainty can be helpful in describing the behaviour of uncertainty over time and in comparing different uncertainties. The

total size of uncertainty about a problem may consist of the sum of many different small uncertainties or one large uncertainty, but for the sake of clarity, when we refer to the size of uncertainty we mean the size of one uncertain phenomenon. The size of uncertainty can help to describe the behaviour of uncertainty over time, and can help to compare different uncertainties relative to one another. If the size of uncertainty is expected to decrease over time, planners would be advised to wait until there is less uncertainty before acting. If it remains the same or might increase, taking action now could be better than waiting for future change. The size of uncertainty is vital in several approaches to dealing with uncertainty, such as options analysis, scenario planning and pathways approaches (Scholtes & de Neufville 2011; Haasnoot et al. 2013). The size of uncertainty is also often a major issue in public and scientific debate, a highly topical example being the climate change debate (Ledanowsky et al. 2014).

The level of uncertainty also has a normative aspect, mainly concerning the substantive issues of justice (Davy 1997). Whereas risk always focuses on negative consequences, uncertainty introduces a positive, 'upward' connotation. This neutral direction of decisional relevance adds the possibility of enabling just distributions in time and space (Savini et al. 2015). Moreover, risk ethics can inform up to the second level of uncertainty (usually regarding only the probabilities of negative consequences and the effects of hazardous events) about what is the proper extent of precautionary action (or inaction) and what is the optimal way to proceed with regard to the distribution of the burden of injustice (e.g., Davy 1997; van Asselt & Vos 2006; Munthe 2011; Basta 2014).

In addition to the information provided by the ontic nature of uncertainty on the distributional effects of acting (or not acting), the level of uncertainty could throw light on the fairness of the outcomes of possible interventions. We think an added benefit of uncertainty is that it shifts the perspective from risk-based decisions, which aim to minimise negative effects, to a substantive justice perspective in which the aim is to find the optimum balance of positive and negative effects (e.g., Davy 1997). This presumes the existence of an optimal solution, or at least proportional differences in the fairness of interventions and predefined categories for apprehending reality to avoid ambiguity or discursive uncertainty regarding the planning issue.

2.4.4 Locating uncertainty

The location of uncertainty can provide further information on the source of uncertainty and where best to act. Current descriptions of the location of uncertainty are, however, not suitable for planning. While the nature and level of uncertainty are generic descriptions, the location of uncertainty is more specific to the domain of interest and is often context-dependent (Funtowicz & Ravetz 1990; Skinner et al. 2014). Current descriptions are based on modelling studies, identifying the modelled system, its context and technical aspects within a modelling study as possible locations (Walker et al. 2003; Kwakkel et al. 2010b). Van den Hoek et al. (2014a) has used a systems perspective to locate uncertainty and assess the cascading of uncertainty between different subsystems.

We propose to take a simplified socio-physical system as a minimal heuristic to query the location of uncertainty relevant to spatial planning (van der Vlist 1998; Healey 2007). As a minimum, uncertainty can then be located within the field of interaction between social (cultural, political, economic, etc.) and physical dimensions. Locating uncertainty is identifying where in such a system uncertainty is present, which depends on the specific planning context. In this conceptualisation, uncertainty concerning the social system relates to, among others, human activities, roles and cultural patterns. Physical uncertainty concerns the patterns and behaviour of the environmental systems. The socio-physical system forms a first subdivision to provide information for locating uncertainty and responding to uncertainty at the most adequate place. In some cases, uncertainty can cascade through causal relationships between subsystems (van den Hoek et al. 2014a). For example, the uncertain effects of climate change may induce planners to permit (legal) flexibility in land use to enable flood management interventions at a later date (Tasan-Kok 2008), which in turn creates uncertainty for farmers if they want to take land-based investment decisions. Both the location of uncertainty and the geographical scale change, while the effects and related risks of (handling) uncertainty are transferred to other actors in society.

This example also illustrates an important normative implication of the location of uncertainty. The location of an uncertainty relates to who bears responsibility for acting (or not) on a particular uncertainty, and the possibilities for deliberately altering the externalities of an uncertain

phenomenon. The location of an uncertainty is often not singular. In the example above, the uncertain effects of climate change are multifarious, which can make it difficult to determine the related responsibility to act, although locating uncertainty at least brings into the open the issue of who should probably bear responsibility and suggest who might be responsible for climate change adaptation if its impacts are not yet clear (Mees et al. 2012; Thompson & Bedik-Keymer 2012; Nalau et al. 2015). A second, related normative element pertains to the deliberate transfer of externalities of uncertainty to others. This transfer can be assessed for fairness. Is it fair to transfer these externalities, as in the example, from a state actor to a set of private actors? Without wanting to go into the ethical debate about distributional versus procedural assessment of this question (cf. Fischer & Ravizza 1998), it might be worth pursuing a just transfer of externalities of acting amid uncertainty.

From the three characteristics of uncertainty and the different insights each offers for what can be known and what can be done we can derive different types of interventions appropriate for handling uncertainty in planning and identify the normative implications of such interventions. These are summarised in table 2.3. This offers a heuristic framework for navigating amid uncertainty in planning, with pointers for dealing with each of the distinct natures of uncertainty and specifications based on the level and location of uncertainty.

Table 2.3. Possible interventions and normative implications for navigating amid uncertainty for the three characteristics of uncertainty.

Planning	Nature			Level	Location
	Ontic	Epistemic	Ambiguity		
What can be known (guiding facet)	Unknowable phenomena up to a specific level	Knowable phenomena up to a specific level	Differently (un)known	Degree of certainty to which a phenomenon can be known	Knowledge about where a phenomenon can become manifest
Prescriptive to what can be done (developmental facet)	Intervening in uncertainty	Enlarging or correcting current knowledge	Search for one way of knowing	Specify what can be done regarding the measurability of phenomena	Specify what can be done regarding the possible location where uncertainty manifests itself
Possible interventions	Primarily aimed at the object of planning practice (e.g. adaptive, robust or flexible objects and institutes)	Primarily aimed at the trajectory of plans and planning (e.g. adaptive, robust or flexible plans/ planning)	Primarily aimed at co-construction of knowledge and frame alignment	Risk management, scenario planning, and remaining reflexive and open to self-organising and emergent properties	Pertaining to geographical or institutional scale for adequate interventions
Normative implications	Are the effects of (not) intervening just, based on current knowledge about uncertainty? To what extent does not knowing determine the type and extent of precautionary actions?	Does improved/altered knowledge lead to more just interventions? Could the planner have known more, and hence be responsible for not or wrongly acting?	Is knowledge acceptable for all relevant frames in the particular planning situation? Are procedures for co-construction fairly inclusive?	Does the level pertain to fair outcomes of interventions? Can interventions lead to fairer results over time (intergenerational)? Fairer over space (intra-generational)? Is there an optimal solution to strive for in essentially unjust situations?	Does (non)intervention amid uncertainty about locality and scale do justice to distributive and non-distributive principles? Who bears responsibility for handling uncertainty in specific localities? Is deliberate transfer of the effect of uncertainty just?
Meta-ethical considerations	Presumption of best and fairest solution? Presumption of predefined categories to apprehend reality?				

2.5 Navigating amid uncertainty in planning

There is a close connection between what is uncertain, what can be known and what can be done. The three characteristics of uncertainty inform this connection and could offer insights into how planners can navigate amid uncertainty. Existing planning frameworks do not provide a coherent enough understanding of uncertainty to inform adequate ways of handling the different characteristics of uncertainty (Christensen 1985; Friend 1993; Abbott 2005; Islam & Susskind 2012). Moreover, planning methods are tailored only to specific uncertainties (Lempert & Groves 2010; Haasnoot et al. 2013; Walker et al. 2013) and while communicative planning tools effectively address ambiguity, they neglect other uncertainties (Innes & Booher 2010). Effective integration of uncertainties can be hampered by a relational-constructivist vision of uncertainty, for example about climate change, because this can become subject to negotiation and consensus-building processes, which may lead to maladaptation. Our contribution aims to amend these shortcomings. An understanding of what can be known about uncertainty can enable planners to make decisions about adequate planning interventions and take into account their normative implications. This can lead to interventions amid uncertainty and inform the normative implications for acting (or not) according to the distinct characteristics of uncertainty. In situations where planners are confronted with a world known in different ways, they can either strive to bring about a consensus on one way of knowing or accept incompatible ways of knowing, as long as this permits adequate spatial interventions. Further specifying the degree to which the world is uncertain, and where phenomena can become manifest, could aid navigation between ontic, epistemic and ambiguous uncertainty and the level and location of uncertainties.

Our conceptualisation of uncertainty in planning also raises some normative implications. Should planners strive for one way of knowing? Should they try to reduce uncertainty? This depends on the particularities of each planning situation. In contending that planning must be conceived as something specific, defined by its complex context and the behaviour of actors and planners, also makes an exploration of possibilities for handling uncertainty an interpretative and contextually embedded endeavour. With this in mind, each of the characteristics offers insight into what can be known and what adequate and just interventions might entail. Together, this offers a heuristic for navigating amid uncertainty.

2.6 Conclusion

We have presented a plural-unequivocal understanding of uncertainty which we argue offers pointers for manoeuvring planning processes through issues of uncertainty. Drawing on planning as a situated practice of navigating, we set out to re-examine the concept of uncertainty by distinguishing between different types of uncertainty and how they might inform planning as a situated practice. Although uncertainty has enjoyed a reasonable degree of attention in planning studies, we conclude that our exploration contributes to a fuller description of the possible types of planning interventions when confronted with uncertainty.

The normative implications of a plural-unequivocal understanding of uncertainty are still only highly schematic, and how planners can deal with uncertainty should be further explored. By viewing uncertainty as a plural-unequivocal concept we have identified different characteristics of uncertainty and concomitant ways of being uncertain, and diverging ways of knowing. By investigating the implications for the guiding and developmental character of planning, we were able to draw out insights for planning interventions and summarise them. These provide pointers for discussing how to handle uncertainty in situated planning practices.

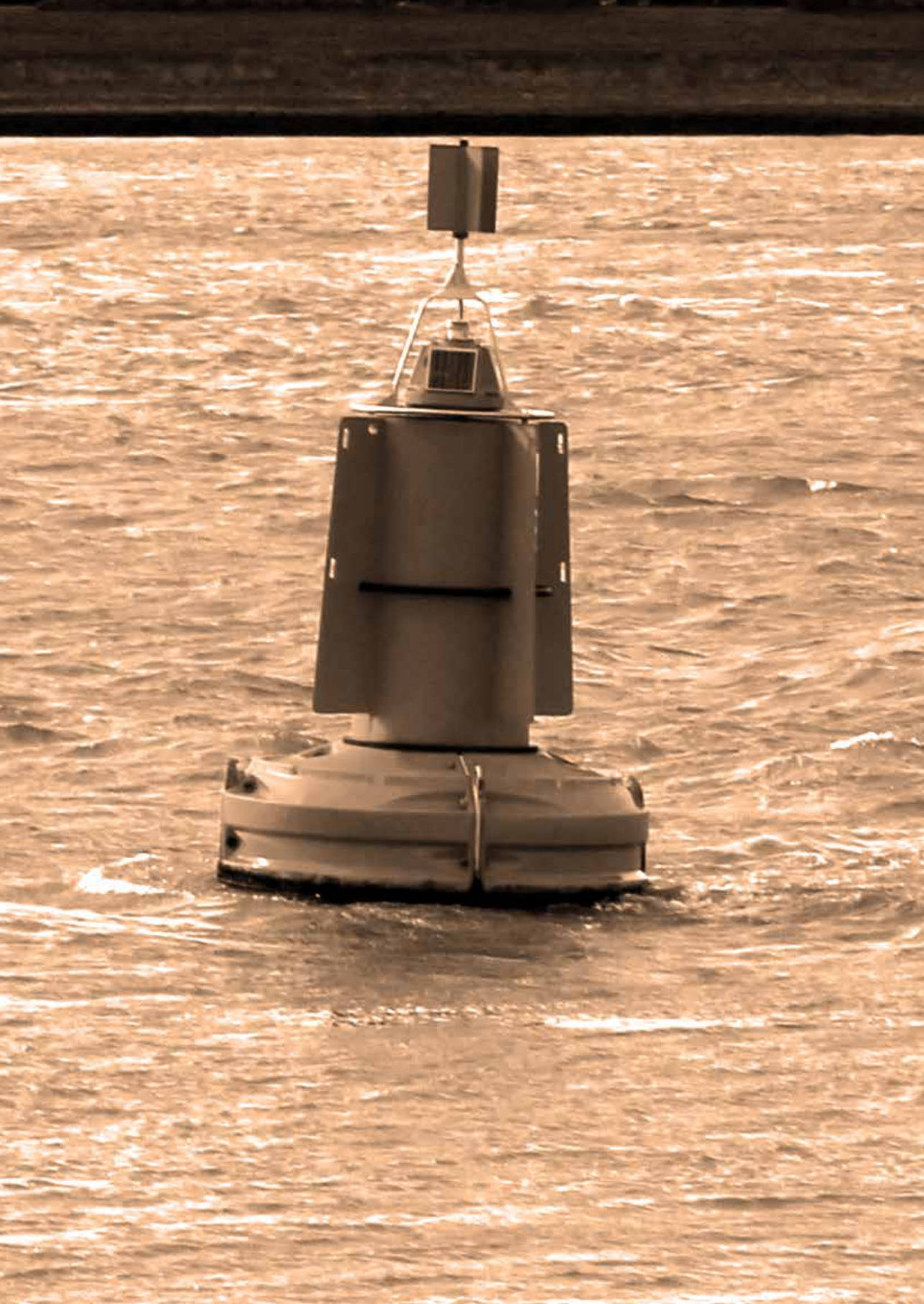
The normative questions we raised from our examination of a plurality of unequivocal uncertainties need to be discussed further, any answers will depend on the rational or moral framework within which they are examined (MacIntyre 1988; Davy 2008). This challenges the planner, and the role of morality in planning processes, because the unequivocal implications of uncertainty for the adequacy of actions (a dyke can still fail, causing flooding and deaths) needs to be accounted for. Planners and planning institutes may be held morally and legally accountable for failing to take adequate action amid uncertainty. Planners cannot circumvent this responsibility. Essentially, they need to act in proportion to uncertainty and bear the consequences of their actions. It is our hope that this exploration contributes to a better understanding of uncertainty in planning and aids the further structuring of spatial interventions to avert the consequences of climate change and other uncertain developments. The types of interventions and their normative implications discussed here, although in need of further exploration, offer pointers to planners to help them justify the proportionality of their actions and navigate amid uncertainty.

3

What's adaptive to what?

Defining and using the concept of adaptiveness in planning

This chapter has been submitted as: Zandvoort M & Willems JJ. What's adaptive to what? Defining and using the concept of adaptiveness in planning. *Journal of Planning Literature.*



Abstract

Adaptiveness is proposed to deal with uncertainty and change in planning, but there is diversity in how adaptiveness is defined and used. After a qualitative systematic review, we conclude that there are three ways: adaptive management intends to reduce uncertainty about how systems respond to interventions, adaptive capacity enables systems to adapt to changing, but uncertain conditions and adaptive planning aims to handle irreducible uncertainty about future change. We conclude that various components – goals, assessment protocols, monitoring schemes – are available to implement adaptiveness, but their use should be appropriate regarding particular assumptions about uncertainty that underlie the domains of adaptiveness.

Keywords

Adaptive management, adaptive capacity, adaptive planning, uncertainty, change

3.1 Introduction

In planning, adaptiveness is increasingly proposed to deal with uncertainty and change. For example, adaptiveness refers to such concepts as adaptive management (Holling 1978; Walters 1986; Warmink et al. 2017), adaptive governance (Folke et al. 2005; Pahl-Wostl 2007), adaptive capacity (Pahl-Wostl 2009; Giezen et al. 2015), adaptive approaches to planning (Busscher et al. 2013; Walker et al. 2013; Rauws 2017) and to planning as being adaptive itself (Kato & Ahern 2008). The use of the adjective adaptive is, thus, diverse.

Diversity about what adaptive means and why adaptiveness is brought in to planning can complicate the operationalisation of the concept for particular planning practices. These complications may raise doubts about the stated ability of adaptiveness to deal with uncertainty and change. Insight into what adaptiveness entails can help to comprehend the diverse definitions and uses of the concept for particular planning practices. Outlining the possible components of an adaptive approach offers direction for planners who want to use adaptiveness to deal with uncertainty and change. When the underlying premises of adaptiveness are clear, planners can arrange components into an approach suitable for the uncertainties and change encountered in their particular planning practice.

We focus on the planning of physical space in its widest sense, (including environmental, conservation, marine, strategic, regional, spatial, and land use planning) (cf. Alexander 2015). In this context, we see planning as an activity linked to 'deliberate efforts to manage and develop place qualities and to pay attention to spatial connectivities' (Hillier & Healey 2010: 4). Each planning practice – which can have a local, regional or larger geographic scale – has distinct characteristics due to the particular spatial connectivities of where it takes place, and for this, planners need to devise their approach.

Each time they intervene, planners encounter multiple uncertainties and different drivers of change particular to the intervention and where that intervention happens. We start from the premise that the relationship between uncertainty and different sorts of change and adaptiveness may explain the diversity in defining and using adaptiveness. Multiple types of uncertainty exist (see Chapter 2), for example related to social systems, environmental systems, human

actions or a combination of those phenomena. Accordingly, the concept of adaptiveness may have different meanings dependent on the type of uncertainty. The relationship between adaptiveness and uncertainty is, thus, far from straight-forward.

This chapter therefore aims to study the relation between adaptiveness and uncertainty in planning, define what adaptiveness is and identify the components proposed to design adaptive approaches in planning. Our research question is 'What is the relation between adaptiveness and uncertainty in planning and which components are proposed to operationalize adaptiveness?' To answer this question, we first describe how we conducted a qualitative systematic review of the planning literature. Then, we offer a coherent overview of what adaptive refers to (and why), based on the connection with uncertainty. In addition, we give an overview of the different components an adaptive approach can include and offer conceptual clarity on their congruent use in planning practice. Lastly, we discuss our findings and present the conclusions.

3.2 Methods

We performed a qualitative systematic literature review. Review studies come in a variety of types (Grant & Booth 2009), and a qualitative systematic review is based on the transparent selection and analysis of a clearly delineated set of scientific articles intended to uncover constructs underlying a certain concept (Grant & Booth 2009). In our case, this entails the concept of adaptiveness: what it is, where it is directed at and which components support or underlie its use. Already intensively applied in medical studies (e.g., Evans & Kowanko 1999), (qualitative) systematic reviews are now increasingly used in planning-related studies to obtain insight into specific constructs or idioms and to map the existing state-of-the-art of concepts (e.g., Biesbroek et al. 2013; Karpouzoglou et al. 2016; Pettigrew & Roberts 2006).

We collected articles from Scopus, the largest online database of peer-reviewed scientific articles, through the use of a Boolean expression (Table 3.1) (Casimir & Tobi 2011). We cross-checked the resulting database with Google Scholar and Web of Science. However, using Google Scholar, we received too much non-scientific and obscure material to allow for systematic analysis and in Web of Science, a random sample of 20 articles did not gave additional data. Therefore,

we used the database derived through Scopus. Using our keywords, we intended to obtain a large enough sample from the literature to identify the main uses of adaptiveness. This yielded a relevant number of articles related to a broad interpretation of spatial or environmental planning (e.g., marine planning, resources planning, land use planning and regional planning, but excluded stochastic planning, medical planning and robotics planning). We considered that at least 50 full text articles would be necessary for a stand-alone review, with a maximum of around 100 to maintain manageability. For example, Biesbroek et al. (2013) reviewed 81 full text articles; Casimir and Tobi (2011) 58; Karpouzoglou et al. (2016) 60; and Ronteltrap et al. (2011) 107. We chose to focus on planning and excluded articles related to adaptive governance, since this would double the number of articles – indicating a small overlap between adaptiveness in planning and governance – and for which systematic reviews were recently executed (e.g., Chaffin et al. 2014; Karpouzoglou et al. 2016). Based on our research question and a maximum of 500 abstracts for each search, we tested a dozen Boolean expressions using the first 20 abstracts (sorted by relevance). The final Boolean expression (Table 3.1) led to our sample of peer-reviewed research or review articles (N=325), based on the occurrence of either 'adaptive' and 'plan*' in the title of the article and 'planning' in the title, abstract or keywords. Keywords we also tested for 'chang*', 'uncertain*' and combinations with the aforementioned different types of planning to see if this would sufficiently specify our search, but it did not. For example, we did not include a Boolean operator for 'spatial' or 'environment' because this limited the number of articles drastically due to the different fields of practice (land use planning, marine planning, etc.). We focussed on articles and reviews (excluding book chapters, conference articles, etc.) and limited the search to articles in English. Our last search was executed in October 2015.

After deleting doubles (N=4), we scanned the abstracts to identify the relevance for the review. Articles dealing with some type of decision-oriented process outside of spatial or environmentally related planning were excluded. These were categorised under technical articles (e.g., in industrial planning, linguistics, path planning, process planning and robotics) (N=147), medical articles (e.g., treatment planning or radiology) (N=85) and a remainder category (e.g., articles in psychology or geology) (N=5). This left N=84 relevant articles for our analysis. All full articles were retrieved via the authors' home institution library or by contacting the authors. Based on reading the full articles, we deleted

some more articles (N=7). Four turned out to be technical articles, and three did fit the aforementioned exclusion criteria, but were not excluded in Scopus. This left 77 full articles for analysis (Appendix A).

Table 3.1. Boolean expression to select a sample of the literature through Scopus

Block	Search Term	Demarcation
Object	planning	Title, abstract, keywords
Dependent	adaptive AND plan*	Title only
Types of documents		Articles, review papers
Included languages		English

For further analysis, all 77 articles were entered into Atlas.ti (version 7.5), a qualitative data analysis software tool. Both authors coded a random 10% of the full articles (N=8) to obtain a classification (i.e. a list of family codes). In addition to descriptive codes (e.g., year of publication or journal), we created family codes after the three questions of Smit et al. (1999), modified as:

1. What is adaptive?
2. Adaptive to what?
3. What are the components of adaptiveness?

To create additional family codes, the third question on components of adaptiveness was coded a second time in which codes emerged during the analysis of the articles (for example, the family of codes 'learning' includes the codes 'collaborative learning', 'social learning', 'reflective learning'). The coding of the 77 full articles was done by the first author, based on the family codes. This coding led to quotations for further analysis, which were analysed through content analysis and domain analysis (e.g., Casimir & Tobi 2011). The second author cross-checked the coding to guarantee for consistent interpretation of the data and contributed to the further analysis of the data.

3.3 Definitions and use of adaptiveness in planning

The articles that were analysed were found to come from a variety of planning domains (Figure 3.1a), with an emphasis on conservation and forest planning (N=13 & N=6) and urban and spatial planning (N=8 & N=6). The publication date of the articles varied from 1971 to 2015, with the number of articles increasing after 2005 and very rapidly after 2011 (Figure 3.1b).

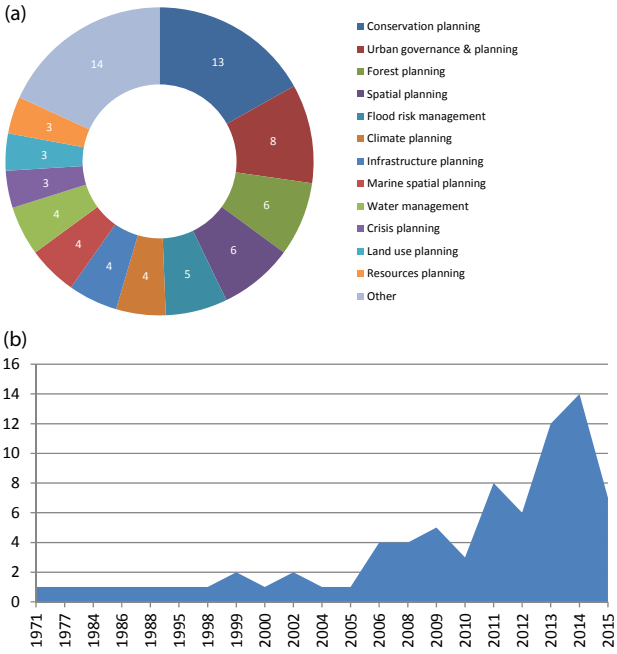


Figure 3.1. (a) Types of planning occurring three times or more; 'other' contains domains of planning as diverse as heritage planning, military planning and tourism planning; **(b)** distribution of the 77 papers based on year of publication, showing an steady increase since 2005.

3.3.1 What is adaptive?

Most articles provide insight into what is meant by adaptiveness, although not all articles provide a clear description. For example, Birkmann et al. (2014) use adaptiveness in their article to refer to various issues: adaptive spatial planning, adaptive urban governance, adaptive capacities, adaptive approaches and adaptive planning theory. This indicates that a more systematic categorisation of adaptiveness may increase its specific operationalization. We found three distinctly different, but related domains from our analysis to describe what is considered adaptive, which we refer to as adaptive management (N=31), adaptive capacity (N=14) and adaptive planning (N=32) (Figure 3.2).

The first domain of adaptiveness is about planning practices which are closely related to adaptive management as originally conceptualised (cf. Holling 1978; Walters 1986) or with some slight adaptations. In this conceptualisation, adaptive management is an approach to deal with uncertainties in ecosystem dynamics through trial and error and by deliberately designed experiments and recurrent interventions

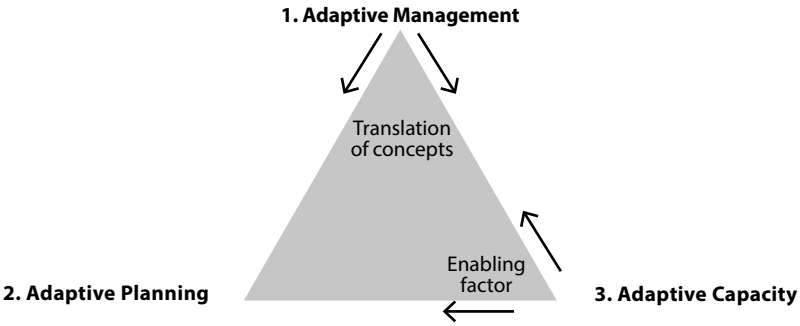


Figure 3.2. The mutual interlinkages between the domains adaptive management, adaptive planning and adaptive capacity.

applying the insights derived from these experiments. For example, some discuss adaptive management of ecosystems such as forests (e.g., Hoogstra-Klein & Burger 2013; Smith 2013) or protected nature areas (e.g., Almstedt & Reed 2013; Gormley et al. 2015). Some are related to risk management, such as flood risk management (e.g., Lacerda et al. 2014) or disaster recovery (e.g., Berke et al. 2014; Potter et al. 2013).

The second domain of adaptiveness specifically indicates the capacity of a system to adapt by itself, often in relation to climate change adaptation (e.g., van den Brink et al. 2014; Kruse & Putz 2014), or a complex systems approach (e.g., Bovaird 2008; Giezen et al. 2015). This set of literature offers a different perspective on what is adaptive. Adaptive capacity enhances systems to respond to uncertain change and sudden adverse events. Adaptive capacity is described in a variety of ways, for example, as the 'ability of actors to act according to plan' (van den Brink et al. 2014: 984) and the 'ability or potential of a system to respond successfully to (climate) variability and change' (Kruse & Putz 2014: 2621). It includes generic abilities 'to adapt' (Innes & Booher 1999: 417), 'to adapt to and shape change' (Saavedra & Budd 2009: 246) and 'to adapt to change' (Higgins & Duane 2008: 147). Other authors use very specific utterances. For example, the 'ability to change mode, trip chain, share rides and carry out activities at closer destinations including at home' (Watcharasukarn et al. 2012: 349). Planners can use adaptive capacity to increase the capacity of a system to sustain itself. The adaptive capacity of societies can, in particular, be enhanced through institutional structures, social learning and knowledge exchange (Bovaird 2008; van den Brink et al. 2014; Butler et al. 2015). Adaptive capacity relates to concepts such as vulnerability and resilience (Hill et al. 2010; Dale et al. 2015). It relies on the self-organisation of complex systems such as a city or the development of an infrastructure network

(Bovaird 2008; Giezen et al. 2015). Moreover, the capacity of planning (institutions) or stakeholders to transform themselves under changing conditions is argued to be pivotal for enhancing adaptive capacity (Barton 2013; Hetz & Bruns 2014; Butler et al. 2015).

The third domain of adaptiveness highlights it as a method or approach or directs attention to planning instruments, such as strategies, plans or designs, with an underlying shift towards a long-term, future-oriented perspective (e.g., Walkerden 2006; Renn & Klinke 2013). Often, these articles build on adaptive management theory and practice and translate this to planning (oftentimes as 'adaptive management planning'). Adaptive planning is distinctly different in that planners take a long-term, future-oriented and anticipatory perspective, in contrast to adaptive management, which emphasises short-term actions in a daily or yearly management context, and adaptive capacity, which focuses on enhancing systems to respond to uncertain change. Operationalizing adaptive planning approaches often takes place with specific practices in mind, such as conservation planning or land use planning. For example, Leadbeter (2013) discusses principles of adaptive planning in the context of the reuse of heritage places for new functions. Walkerden (2006) discusses the use of adaptive planning in the context of collaborative planning projects. Kato and Ahern (2008) apply adaptive planning to landscape planning.

3.3.2 Adaptive to what?

On the most abstract level, our analysis shows that the reason for planners to bring in adaptiveness is either uncertainty or change. Some of the articles are very specific, e.g., when dealing with uncertainty about travel demand in the coming 10 years (Kwakkel et al. 2010a); others remains very general, e.g., when referring to 'conditions of change and uncertainty' (Almstedt & Reed 2013) and 'changing needs and conditions' (Berke et al. 2014). Sometimes, the type of change is clearly specified. For example, Barton (2013: 1918) distinguishes between gradual and episodic climate change to specify the impact of different sorts of change.

A main reason for the attention to uncertainty and change in planning is the inherently dynamic environment wherein planners undertake their activities (e.g., Lessard 1998; Mills et al. 2015). Planners cannot

fully know how their interventions will affect the environment or to what extent interventions may be useful. Additionally, planners need to account for the unpredictable ways in which environmental conditions can change. We found that the uncertainty this brings to planning is a justification to conceptualise planning as adaptive.

After acknowledging uncertainty and change as general justifications for adaptiveness, we further analysed how they relate to the three domains of adaptiveness. Two concepts in particular relate to handling uncertainty: learning and coping. In adaptive management, we found the conception of uncertainty as reducible through learning the effects of interventions. New insights can be derived from experiments, pilot projects or trial and error. The resulting lessons learned need to be accommodated in plans and policy, which become increasingly better tailored and optimised to the planning issue and its circumstances (Kato & Ahern 2008). We depicted this in figure 3.3a as an ongoing process in which – at each moment in time – uncertainty about current conditions is factored into the planned system through trial and error. In multiple articles, this practice of trial and error is critiqued (e.g., Gregory et al. 2006; Moore & Hockings 2013; but see Mance et al. 2014). A major critique is that planning issues need more directed efforts to systematically learn (e.g., Hoogstra-Klein & Burger 2013; Köppel et al. 2014). The underlying argument is that trial-and-error learning is not adequate for the long-term orientation inherent in planning issues. Instead, planners make interventions that will shape the environment for decades to come and thus need to look into the future to be prepared for uncertain change, as depicted in figure 3.3b (Moore & Conroy 2006).

Coping is the second concept we found to be particularly related to handling uncertainty and change through adaptiveness. Planners need to have a coping strategy, because circumstances and conditions can develop in uncertain ways. They can enable a system or their strategies to cope with uncertainty about the direction, speed or magnitude of change in two ways. First, planners can incorporate constant iteration to adjust to continuously altering circumstances, for example, by redrafting or reissuing planning (elements) or plans, called prestoring (Alterman 1988) or prototyping (Mills et al. 2015) of plans. Second, they can increase a system's capacity to adapt to (or cope with) altered circumstances linked to resilience (Bovaird 2008; van den Brink et al. 2014; Butler et al. 2015). Coping is enabled with an external, outward-

looking orientation regarding current conditions, a characteristic of adaptive planning. Coping is also enabled with an internal orientation regarding the acceptability of the effects of change on the performance of a system, a justification for adaptive capacity. This latter orientation which underlies adaptive capacity, thus, also allows coping with ambiguity about how a system should perform (Figure 3.3c).

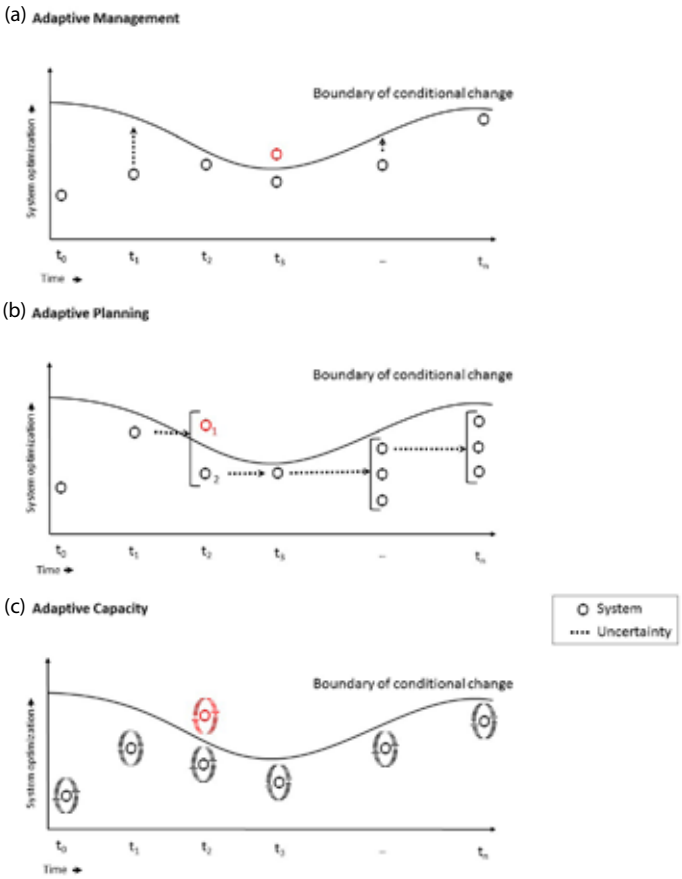


Figure 3.3. (a) The relationship of adaptive management with change and uncertainty; **(b)** The relationship of adaptive planning with change and uncertainty; **(c)** The relationship of adaptive capacity with change and uncertainty.

3.3.3 Components to arrange adaptiveness in planning

Our review reveals that the three domains of adaptiveness use the same terms, yet their operationalisations differ regarding uncertainty and change and how planners should handle these. We analysed the articles as to the components proposed to incorporate adaptiveness in planning. These can be divided into components to create or enhance adaptiveness, such as flexibility and path dependency, and components

that allow for the operationalisation of adaptiveness, such as planning instruments and monitoring schemes for continuous re-evaluation.

Creating or enhancing adaptiveness.

A central component for adaptiveness is flexibility. We found flexibility to switch between options, or use them now or later, to be essential. Flexibility is created by addressing multiple options in a plan, using prestored plans (generic plans which can be updated if changed conditions allow it) and making relevant knowledge accessible and reusable (Alterman 1988). For example, Berke et al. (2014: 317) address possibilities to promote flexibility: 'by supporting alternative courses of action, including allowing for adjustments in land use regulations, the design and location of public facilities, and building relocation schemes.' Some even claim that flexibility, through alternatives and available contingency plans, is the general idea underlying adaptive planning (Catto & Parewick 2008). The dominant argument in the articles is that flexibility should be developed to effectuate adaptiveness in general and in the domain of adaptive planning in particular.

Flexibility is connected to the concepts of lock-in and path dependency, used in the three domains of adaptiveness. Planning practices are historical and context-dependent and are a result of past planning activities. Hetz and Bruns (2014) argue that locked-in situations relate to path dependency on a specific technical, physical or institutional path. Such paths determine the future direction of planning because they restrict interventions. Planners who want to overcome lock-in on a path can use each of the three domains of adaptiveness. Adaptive planning is argued to show what lock-in and path dependency exists and offers a way out through physical interventions, institutional options or by challenging existing knowledge (Innes & Booher 1999; Halleux et al. 2012). Bovaird (2008: 324), for example, argues: '[A]s changes in a CAS [complex adaptive system] are path-dependent, any agent which succeeds in triggering changes in line with its own needs and priorities may be able to achieve system-wide changes particularly favourable to its own purposes.' Adaptive planning intends to map out possible directions to overcome path dependency and trigger change. Adaptive management helps to overcome path dependency by experimentation and learning through trial and error, required to handle the unpredictable effects of interventions to overcome lock-ins (Bovaird 2008).

To overcome path dependency and determine where flexibility might be found, planners should outline their goals (Wilhere 2002; Berke et al. 2014). Goals are deemed sufficient to determine flexibility if they are quantifiable and measurable (Kwakkel et al. 2010a), although qualitative goals are suitable as a starting point for guidance of the process towards more adaptiveness (Leskinen et al. 2009). For the attainment of goals amid uncertainty, adaptiveness builds on intermediate adjustments (Catto & Parewick 2008; Caves et al. 2013). This means that a strategy to attain goals might be adjusted, while the final destination can be more or less defined (although some room is left for adjusting goals) (Lessard 1998). The final destination can be expressed through one specific goal or a set of interlinked goals (Wilhere 2002; Leskinen et al. 2009). Caves et al. (2013) propose to set nested goals to reconcile the need for measurable objectives under unknown future conditions.

Specific goals for adaptiveness should reflect values of stakeholders who are affected by a strategy, if possible through consensus of stakeholder preferences (Menzel & Buchecker 2013; Berke et al. 2014). In some cases, this consensus extends to the active participation in the development, execution and continuous monitoring of a plan (Lessard 1998; Innes & Booher 1999), or even by delivering the information to adjust a plan or the voluntary restriction of participants' economic gains (Butler et al. 2008). For these latter points, however, collective goal setting and establishing trust between disparate parties are pivotal components (Butler et al. 2008; Vella & Dale 2014). Adaptiveness, in such cases, is often coupled to collaborative management or participatory planning approaches, because '[n]either collaboration nor adaptive management provides a sufficient structure for addressing the externalities that drive uncontrollable and unpredictable change.' (Caves et al. 2013: 42). Therefore, '[c]ombining collaboration and adaptive management is viewed as a way of broadening the scope of information and options considered in decision cycles' (p. 43), which should instil accountability and shared learning which are important in enhancing adaptive capacity (van den Brink et al. 2014). Collaboration is specifically connected to questions of what to decide and how to trade off interests regarding the performance of the system. Collaboration engages with the allocation of responsibilities and the trade-off needed to determine strategies, despite different value judgements of stakeholders (Walkerden 2006).

Operationalising adaptiveness.

We found that adaptiveness can be operationalised through three main components: scenarios, pilots and experiments, and deliberate learning mechanisms. Scenarios of seen and unforeseen change are described by Berke et al. (2014: 311) as 'scenarios of multiple possible futures in which planners not only evaluate alternatives (…) but also possibilities that they may not fully control.' Scenario thinking is a key aspect of the evolution from adaptive management to adaptive planning, because scenarios connect trial and error and hypothesis testing in experiments to contingency planning based on the exploration of plausible futures (Kwakkel et al. 2010a; Caves et al. 2013). Scenarios guide the systematic reassessment of adaptiveness in an anticipatory fashion, and, with them, planners can estimate the uncertainty relevant for their interventions. Scenarios also help explore and map the direction for enhancing adaptive capacity in a planned system (Higgins & Duane 2008).

Pilots and experiments have an important role in operationalizing adaptiveness. Pilots and experiments are used to gain more knowledge to adjust plans and strategies. The main benefit of using pilots is that, if executed properly, they provide a safe testing environment for innovative, but often unproven, interventions (Ahern et al. 2014). Pilots and experiments are also suggested to set a baseline for future action (Dallmeier et al. 2002) and allow planners to iteratively develop local plans based on a temporary pilot plan (Butler et al. 2008). The premise of pilots is that they allow for a reduction of uncertainty. This reduction enables improvement of a plan or intervention in the future, allows for optimization of day-to-day management, or establishes an equilibrium between interventions and the system, for example, a maximum sustainable yield (e.g., Butler et al. 2008; Leskinen et al. 2009).

Pilots and experiments are forms of deliberate learning mechanisms. Through the articles we found that, for adaptiveness, planners need to not only connect knowledge to action, but also (conversely) to connect action to knowledge. Planners can take, according to Hoogstra-Klein and Burger (2013: 710), an iterative, 'planned approach to reliable [sic] learn about how to improve management practices over time in the face of risk and uncertainty.' Mapping the different styles of learning, we found six styles of learning which either account for continuity or use learning mechanisms as a joint effort (Figure 3.4). According to Innes and Booher (1999), planners should strive to incorporate both sorts

of learning in their activities, if they want to build consensus among stakeholders. We found that, especially in the context of forward-looking adaptive planning, achieving and measuring learning remains a more theoretical discussion than an empirically-based practice.

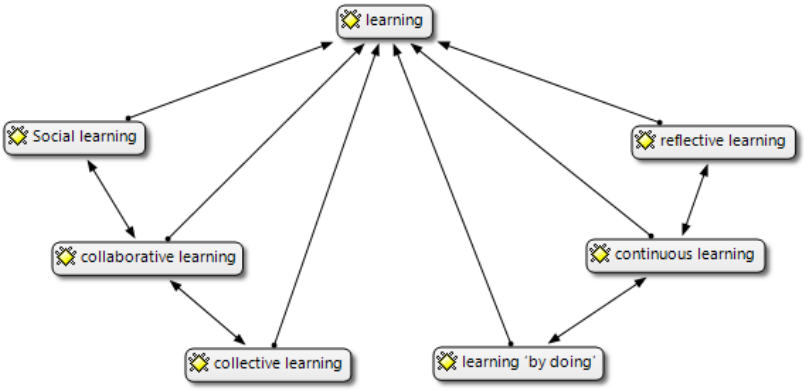


Figure 3.4. Six types of learning emphasising either the mutual effort necessary to learn in planning contexts and learning to account for continuity in and through learning.

Deliberate and Constant Re-evaluation to Adapt.

We found a strong emphasis on constant and deliberate re-evaluation as part of adaptiveness, based on reflexive feedback for which indicators of change, monitoring schemes and assessment protocols are needed. Re-evaluation builds on the notion of reflexive feedback loops. Almost all articles mention some type of feedback connecting adaptiveness with initial actions. In adaptive capacity, such feedback relates to the feedback loops inherent in systems, which necessitate constant adjustment (feedback from the system to the plan and back), while feedback in adaptive management and adaptive planning is essential to inform consecutive plans. Feedback is not only linked to learning, but also to definitions of indicators (indicating thresholds and tipping-, turning- or trigger points), a monitoring system and assessment protocols.

Indicators of change – which indicate that a threshold or turning-, trigger- or tipping points for a particular driver of change is at hand – form a prerequisite for re-evaluation. Quantitative and measurable goals can help to define precise indicators. Such indicators are also necessary to know when to act. As Bovaird (2008: 335) explains:

> '[C]hanging the "rules of the game" is not an everyday affair. It is only likely to be possible at specific junctures, and in conjunction with other players. The moments at which this is possible – the "policy

turning points" within the trajectory of punctuated equilibria – occur only occasionally.'

In adaptive planning, indicators of change help with preparing for the anticipation of thresholds and taking action against adverse change (Berke et al. 2014). When using adaptive management for natural resources, planners use thresholds to signify moments when an ecological balance tips into unsustainable dynamics. Identifying such thresholds through, for example, pilots and avoid their crossing helps planners to sustain the dynamic balance of a system (cf. maximum sustainable yield). In adaptive capacity, tipping points relate to the performance of the system and can be avoided by enlarging the capacity to adapt.

If planners want to know if a threshold or trigger point is approaching, they need to monitor conditions. Monitoring helps planners in situation matching, in which a plan is pre-stored for a later moment (Alterman 1988), to track outcomes of deliberate learning through pilots and experiments (Berke et al. 2014) and offers them insight into whether the conditions to sustain collaboration are maintained (Butler et al. 2015). Monitoring also allows for continuous learning so planners know when and how to adjust their interventions. Monitoring schemes come in a variety of forms. For example, Ahern et al. (2014) operationalise monitoring through an ecosystem services toolbox that contains quantifiable measures. Dallmeier et al. (2002) operationalise monitoring through a protocol which addresses everything from sampling design to reporting. Kwakkel et al. (2010a) build on threshold values and propose monitoring in the form of contingency planning. Their threshold values are identified according to vulnerabilities and opportunities, and crossing these thresholds can trigger different actions: defensive actions, capitalizing actions, corrective actions and reassessment actions. These actions allow planners to either defend against the encountered change or try to capitalize it by taking advantage of the occurring change. In response to specific triggers, planners might correct their course of action or undertake a full reassessment of their goals.

Assessment protocols are a viable way to account for several strains put on information and continuous assessment. In assessment protocols, planners can define when and how to adjust plans and decision processes (Leskinen 2009), based on the timely arrival of monitoring

results at the decision-making level and the definition of appropriate indicators to alter a course of action (Kato & Ahern 2008; Eberhard et al. 2009). Schultz and Nie (2012) discuss the relation between triggers, monitoring, assessment and feedback and conclude that enforceability of adaptiveness is very difficult when assessment protocols or feedback mechanisms are unspecific or unclear.

3.4 Relations between Components and Domains of Adaptiveness

Each of the found components is more or less prevalent among adaptive management, adaptive capacity and adaptive planning. Adaptive management articles show a clear awareness of the operational side of being adaptive, pertaining to how to be adaptive and the specific use of experiments and monitoring. Articles about adaptive capacity are generic about adaptiveness and its enhancement. Strengthening adaptive capacity is an inherently subjective task and depends on the capacity planners exactly aim at. Within the broad conceptualization of adaptive capacity, specifically learning and the institutional context, are often mentioned. The institutional context, including the participation of institutional actors, is important to meet fair governance criteria (responsive and accountable policy, equity, protection of basic rights and legitimate policy processes) and to deal with social justice dilemmas (Almstedt & Reed 2013; van den Brink et al. 2014).

Adaptive planning emphasises decisions and interventions. One key element incorporated in the design of adaptive plans and policies are scenarios to test and delineate hypotheses and goals for monitoring and learning. The adaptive planning literature neglects some practical issues about components developed for adaptive management. Telling in this regard are triggers and thresholds. These are in adaptive management often based on environmental systems' working and in planning are more broadly defined and often unclear. The use of hedging, corrective actions, reprogramming, repurposing, revising and updating plans can in such instances be difficult (e.g., Lessard 1998; Kwakkel et al. 2010a; Ahern et al. 2014).

Despite the differences, the components have value in each of the domains. Moreover, several issues are emphasised across the literature: the need for cross-scale and multi-level interactions and the specific

role of the government or other actors who advance adaptiveness. First, the scalar and multi-level interdependency in environmental systems demands interaction across levels and between actors. This relates to the aim of being adaptive: handling uncertainty and change. Uncertainty and change partly arise due to scalar interlinkages in environmental systems, which need to be addressed to effectively manage and plan for systems in an adaptive way, or need to be brought into play to enhance the adaptive capacity of a system.

Planners who want to advance adaptiveness and do so effectively need some specific capabilities. We found that planners need commitment, leadership and willingness to act. For effective adaptiveness, commitment of lead actors (a leader figure, organisation or government institute) striving for adaptiveness is deemed pivotal, and high commitment and dedication of stakeholders is considered a necessity (Walkerden 2006; Caves et al. 2013). Commitment is needed to 'steer (…) outputs towards outcomes' (Mills et al. 2015: 57). Stakeholders can enhance adaptiveness through commitment to a first set of actions and to continuous learning (Giordano 2012). Altogether, commitment from lead organizations needs to be sustained over prolonged periods of time to steer the planning process towards goals (Fontaine 2011; Mills et al. 2015). To sustain commitment, leadership is necessary (Almstedt & Reed 2013; Menzel & Buchecker 2013). Van den Brink et al. (2014) set out three possible styles of leadership: visionary leadership to hold the long timeframe of environmental planning in view, entrepreneurial leadership for effective brokerage of deals and gaining resources, and leadership to build and sustain coalitions. Willingness of lead planners to act is indicated as a prerequisite to advance adaptiveness. This includes willingness 'to try new initiatives in an experimental mode' (Reed 1999: 351), 'to find a win/win situation and an ability to let go of predetermined preferences' (Giezen et al. 2015: 13), 'to act on knowledge gained' (Almstedt & Reed 2013: 666) and 'to accept reasonable failure' (Kato & Ahern 2008: 555). Lastly, for effective adaptiveness, planners need to pay attention to the principles of good governance. Multiple articles point to the principles of good governance in relation to fair and just action on behalf of all stakeholders (e.g., van Buuren et al. 2013; van den Brink et al. 2014). The role of planners for such conduct is not to be underestimated when effectuating adaptive plans and policies (Godden & Kung 2011; Mills et al. 2015).

3.5 Discussion

The diversity in the use and justification for bringing adaptiveness into planning can complicate the operationalisation of the concept for particular planning practices. In recent decades, scholars engaged with the development of adaptiveness in the wider context of planning to deal with uncertainty and change (Lessard 1998; Kato & Ahern 2008; Swanson et al. 2010; Walker et al. 2013), but these were often directed at a particular way of operationalising adaptiveness, while numerous studies allow for conceptual diffusion. In addition to these studies, we reviewed existing studies to offer insight into what adaptiveness entails and its relation with uncertainty across the planning literature. Additionally, we outlined the components of an adaptive approach.

Arranging different components into an adequate approach to deal with uncertainty is of great concern for planners. Due to the uptake of adaptiveness across planning studies, the question 'what is adaptive to what?' can no longer be answered concisely. Instead, we showed that at least three particular answers can be given, based on adaptive management, adaptive capacity and adaptive planning. The conception of uncertainty underlying each, distinguishes them, although they remain partly complementary. Holling's (1978) adaptive management is predominantly based on deduction and trial and error. The underlying epistemological perspective of adaptive management significantly differs from the domain of adaptive capacity, which is based on a relational epistemology (e.g., Innes & Booher 1999; Innes & Booher 2010; Hoogstra-Klein & Burger 2013; Davoudi 2015). Although communicative and relational-based planning schools have each adopted adaptive management and do relate this to the experimental and learning-based model of adaptiveness, their presumptions about uncertainty and knowledge differ (Innes & Booher 2010). This affects adaptiveness because designs of adaptive management and adaptive planning rely on monitoring indicators of change and testing hypotheses to deduct knowledge (Reed 1999; Hermans et al. 2012). In contrast, in a relational epistemology, the underlying reasons to strive for adaptiveness – change and uncertainty – are a main reason to reject deduction and a monothetic use of indicators, which imply unchanging goals and stable conditions. This rejection problematizes monitoring and continuous evaluation of (spatial) plans (Rae & Wong 2012) and can lead to difficulties in determining or judging corrective actions due to unclear indicators, undefined performance criteria or ambiguous

mandates (Reed 1999; Green Nylen 2011). When taking these premises underlying adaptiveness into account, planners can arrange components into an adequate approach to handle the uncertainties and change encountered in their particular planning practice.

In addition to this point, almost all articles have a normative implication: to be adaptive is good, and with more experiments and data, decisions and planning can be enhanced and improved. We do not disagree with this underlying normativity of adaptiveness in planning per se, but in accordance with Allan and Curtis (2005), we want to point to the dangers of uncritically adopting this position. The literature we reviewed shows that learning (Menzel & Buchecker 2013), monitoring (Schultz & Nie 2012), and establishing clear thresholds for altering plans or course (Green Nylen 2011) are hardly incorporated in adaptive management policies (Gregory et al. 2006). In addition, their operationalisation can also bring legitimacy problems (van Buuren et al. 2013). Accordingly, there is a chance that the cure is worse than the disease.

The results of this review are sensitive to our interpretation. In most of the discussed articles, there was no direct claim about a specific domain or epistemological perspective. By undertaking a qualitative systematic review, we aimed at being transparent about the choices we made and the way we interpreted the articles. The coding process was set up in such a way that both authors cross-checked each other's interpretation to create a sound image. The sample (77 articles) is another methodological issue. The articles were relevant for planning in a general sense, based on the chosen Boolean expression, but the review could be extended if issues of climate adaptation or governance and policymaking were also addressed. The diverging use of adaptiveness in planning was shown with this sample, but insights about devising and delivering environmental planning interventions might have been missed (e.g., Folke et al. 2005; Islam & Susskind 2012). We chose to take this approach because it would lead to an overarching perspective on the relation between adaptiveness and uncertainty, insight into definitions of adaptiveness and understanding of the available components to bring adaptiveness into particular planning practices.

3.6 Conclusions

We aimed to study the relation between adaptiveness and uncertainty in planning, define what adaptiveness is and identify the components proposed to design adaptive approaches in planning. Our research question was 'What is the relation between adaptiveness and uncertainty in planning and which components are proposed to operationalize adaptiveness?' Based on a qualitative systematic review of the planning literature, we offered a coherent overview of what adaptive refers to (and why), based on the connection with uncertainty.

We defined adaptiveness in three domains:

1. Adaptive management to reduce uncertainty about how systems respond to interventions.
2. Adaptive capacity to enable systems to adapt to changing and uncertain conditions.
3. Adaptive planning to handle irreducible uncertainty about future change.

Particular assumptions about uncertainty and change underlie these domains, and the literature is unclear about what this means for applying adaptiveness in particular planning practices. Assumptions about uncertainty can explain some of the diversity in definitions and use of adaptiveness throughout the literature. Components to operationalize adaptiveness are clear goals, flexibility, scenarios, experiments and pilots, and re-evaluation of options based on continuous monitoring and deliberate assessment protocols that have clearly defined indicators for thresholds of change. We conclude that the uncertainty with which planners are confronted is a viable entry point to arrange these components into appropriate approaches for operationalizing adaptiveness in their specific planning practices.

Although adaptiveness clearly gained traction in planning studies, most conceptualizations and operationalisations are still closely tied to the seminal work of Holling (1978) and colleagues. Future research should expand adaptiveness more firmly in planning, but overcoming the dichotomy between deductive and relational epistemologies is therefore essential. The lack of clear empirical evidence for the working of adaptiveness in planning (Allan & Curtis 2005; Gregory et al. 2006) also requires more deliberate reflection on adaptiveness in planning. The components identified from the three different domains

of adaptiveness may support planners in the congruent design of adaptive management schemes, give pointers to enhance adaptive capacity and create and test adaptive planning approaches for particular planning practices.

4

Handling uncertainty through adaptiveness in planning approaches

Comparing adaptive delta management and the water diplomacy framework

This chapter is published as: Zandvoort M, van der Vlist MJ, van den Brink A (2017) Handling uncertainty through adaptiveness in planning approaches: Comparing adaptive delta management and the water diplomacy framework. *Journal of Environmental Policy and Planning,* Online First

Abstract

Planners and water managers seek to be adaptive to handle uncertainty through the use of planning approaches. In this chapter, we study what type of adaptiveness is proposed and how this may be operationalized in planning approaches to adequately handle different uncertainties. We took a comparative case study approach to study two planning approaches: the water diplomacy framework (WDF) and adaptive delta management (ADM). We found that the approaches differ in their conceptualization of uncertainty and show that different types of adaptiveness are used in the approaches. While WDF builds on collaborative adaptive management as a set of on-going adjustments and continuous learning to handle uncertainty, ADM deliberately attempts to anticipate future adaptations through a set of tools which allows for seizing opportunities and avoiding lock-in and lock-out mechanisms. We conclude that neither of the approaches is fully able to account for different uncertainties. Both approaches may benefit from specific insights in what uncertainty and adaptiveness entail for the development of water management plans.

Keywords

Adaptiveness, uncertainty, planning approaches, environmental planning, water management

4.1. Introduction

Planners and water managers seek to be adaptive to handle change and uncertainty in spatial and environmental planning (Kwakkel et al. 2010a). Handling uncertainty grows in importance due to the need to deal with climate change, characterized by the prevalence of long-term, stochastic uncertainty about its impacts (Lempert et al. 2004). Planners and water managers can strive for adaptiveness in three ways. First, by adaptively managing resources through focused experiments and closely monitoring change (Walters 1986; Caves et al. 2013). Second, by increasing the adaptive capacity of institutions and deliberate learning from past experiments (van den Brink et al. 2014). A third possibility is to iteratively take decisions and create room for future adjustments to cope with as yet uncertain change when planning for interventions in the physical environment (Kato & Ahern 2008).

How adaptiveness is used and specified for environmental planning practices and policy-making depends on assumptions about uncertainty. These assumptions influence how information is dealt with (Martens & van Weelden 2014) and which type of adaptiveness is adequate to handle specific uncertainties (Chapter 3). The adequacy of adaptiveness foremost depends on the nature of uncertainty with which planners and water managers are confronted (Walker et al. 2003; Brugnach et al. 2008). Uncertainty can be of an ontic nature (in case of chaotic system behaviour), epistemic nature (in case of a lack of current knowledge) or ambiguous nature (in case of diverging frames or perspectives) (Walker et al. 2003; Brugnach et al. 2008; Kwakkel et al. 2010b). In the context of planning problems, ambiguity relates but is not similar to disagreement (Brugnach et al. 2008). The difference relates to how 'frame' is defined: either as a cognitive representation or as an interactional co-construction (Dewulf et al. 2005). We see ambiguity as originating from the existence of different cognitive representations pertaining to an issue, which we distinguish from disagreement as this pertains to the temporary absence of an unanimously accepted frame of understanding of an issue or its adequate handling (Chapter 2). This distinction helps to identify an adequate course of action to mitigate both 'types' of ambiguity: either seeking co-construction, including different frames and hedging against the influence of frames on planning or conflict resolution and frame alignment in a particular situation. Ontic uncertainty, due to the chaotic behaviour of a water system, is best tackled by adaptiveness in the system itself.

Ambiguity is best dealt with (but not necessarily resolved) by adequate representation of different frames and values throughout an adaptive learning process and appropriate mechanisms to resolve disagreements (Brugnach et al. 2008; Chapter 2). To put it simply, increasing the height of a dyke will not solve ambiguity among stakeholders, while building consensus will not diminish uncertainty about future water discharges.

When planners intend to handle uncertainty they may rely on planning approaches which make use of adaptiveness. We conceptualize planning approaches as combined sets of tools in a coherent framework which planners can use to structure planning processes and deal with multifaceted planning situations, akin to policy packages (Howlett et al. 2015) and portfolios of tools (Aerts et al. 2008).

Multiple planning approaches are developed to handle uncertainty, especially in practices involved with planning in river deltas and other water systems (e.g., Lempert et al. 2004; Berke & Lyles 2013). Here, we intentionally focus on planning approaches which originate from the messy day-to-day practice of planning. In such practices, complex water problems arise which are characterized by different uncertainties that need to be accounted for simultaneously. To get a coherent approach for multifaceted situations with complex problems, multiple uncertainties need to be addressed. We argue that when the resulting approaches do not offer insight in the consequences of different uncertainties, the congruent handling of uncertainty can become problematic. Moreover, it is yet unknown if approaches are adequate to handle different uncertainties when developing policy and what type of adaptiveness is expected to do so.

In this chapter, we study what type of adaptiveness is proposed and how this is operationalized in planning approaches to handle different uncertainties. Our research question is: 'How is adaptiveness operationalized in planning approaches to handle uncertainty in complex water problems?' We start from the premise that analysis of planning approaches may offer insight in how adaptiveness can be operationalized to handle different uncertainties, specified as to the three natures described above. The structure of our chapter is as follows. We first outline our research approach. Second, we describe the studied planning approaches in general, the uncertainties they address and their specification and use of adaptiveness. Third, we compare the approaches

to see how adaptiveness is embedded in the approaches to handle uncertainty. Lastly, we discuss our findings and offer our conclusions.

4.2. Methods

To answer our research question we took a comparative case study approach (Engeli & Rothmayr Allison 2014). A major advantage of comparative case studies is that they allow for a tailored analytic strategy to explore poorly understood phenomena by answering how and why questions (Meyer 2001). We chose to compare not more than two approaches to allow for in-depth insight in the mechanisms involved in operationalizing adaptiveness to handle uncertainty. We sought for two similar approaches developed in different contexts because we assumed that the context may determine the use of concepts such as adaptiveness and uncertainty. To make this possible our case study design needed to adequately specify the analytical use of the comparison and the principles on which this is based (Hyett et al. 2014).

There are multiple planning approaches, tools and instruments available for specific practices and contexts. Some examples are listed in table 4.1. We distinguish planning approaches from tools and instruments because approaches can be seen as comprehensive packages of tools and instruments. We selected two planning approaches, adaptive delta management (ADM) (van Rhee 2012) and the water diplomacy framework (WDF) (Islam & Susskind 2012; Susskind & Islam 2012) for several reasons (Table 4.2). First, they were both developed to deal with complex problems and uncertainty by providing a comprehensive planning approach with explicit use of adaptiveness. An additional reason to study these approaches is their origin in the messy practice of day-to-day planning. They originate from the audacious attempt of practitioners to get a grip on situations wherein environmental issues, fraught with uncertainty, interrelate with conflicts between values and stakes. Finally, both approaches are fully described and supported by a scholarly body of knowledge which forms their underlying rationality.

Our analytical focus was on the guidelines which offer the formal description of both approaches (Islam & Susskind 2012; van Rhee 2012). We deliberately chose to focus on the formal descriptions because we wanted to study their operationalization and not application. Study of the operationalization of approaches is necessary for choosing

Table 4.1. Different planning approaches, tools and instruments.

Planning approaches	Tools	Instruments
Adaptive Delta Management	Adaptation pathways	Covenants
GeoDesign	Cost-benefit analysis	Rules
Integrated Water Resources Management	Joint-fact finding	Standards
Strategic Choice approach	Multi-criteria analysis	Subsidies
Water Diplomacy	Real options analysis	Taxes
	Robust decision making	
	Scenario planning	

Table 4.2. Case selection criteria and scores for 5 planning approaches.

Approach	Complex problems	Comprehensive description	Adaptiveness	Practitioner based	Scholarly embedded	Context
Adaptive Delta Management	v	vv	v	v	v	Netherlands
GeoDesign	v	v	x	x	v	U.S.
Integrated Water Resources Management	v	~	x	~	v	United Nations
Strategic Choice approach	v	v	x	x	v	Great Britain
Water Diplomacy	v	v	v	~	v	U.S.

approaches and to study if successful applications are due to or despite the operationalization of an approach. We assumed that adaptiveness is used to handle uncertainty and were interested in two major elements: their relation in the formal operationalization and the contextual influence on this relationship (Figure 4.1). Our analysis included the following six steps (Table 4.3). We started with studying the formal descriptions to get a sense of the general themes related to uncertainty and adaptiveness in the approaches. Our next step was contextual immersion. We derived contextual data via citations in the guidelines and via conversations with the main authors of both approaches. To broaden our contextual insight, the water diplomacy workshop, held each year in Cambridge (MA), was visited. Also, several open interviews (Appendix B) were conducted with the authors of the approaches to query their background and context, whereby uncertainty and operationalization of adaptiveness were discussed. We also held interviews with first users of ADM in the context of the Dutch Delta Programme, a multi-level governmental programme to develop water management strategies in which ADM was developed.

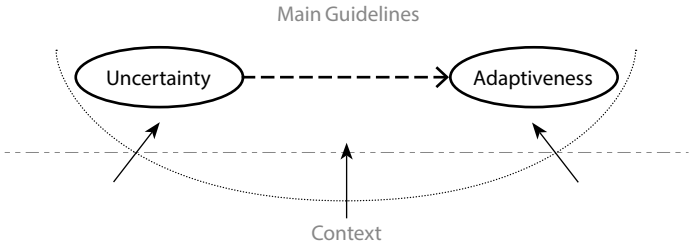


Figure 4.1. Conceptual framework

Table 4.3. The used analytic strategy (Ayres et al. 2003)

Steps	Strategy	Analytic focus	Product
1	Analytic immersion in both approaches	Within each main guideline	Sense of the general themes related to uncertainty and adaptiveness
2	Contextual immersion in both approaches	Open conversations with developers of both approaches; contextual material (scholarly and non-scholarly)	Sense of the general history and broader (scholarly) context of both approaches
3	Immersion in each approach	Within each main guideline (Atlas.ti)	Identification of significant statements and themes (codes) related to uncertainty and adaptiveness
4	Comparison of statements	Across main guidelines (Atlas.ti)	Identification of commonalities and differences
5	Reconnection of established themes	Within formal descriptions and in check with contextual immersion	Corroborate identified themes to ascertain fidelity to the approaches' context
6	Testing themes	Compare identified themes with general themes in the research question	Comparison of the material based on the found uncertainties; use of adaptiveness

Steps three and four in our research strategy were built on interpreting the main guidelines of both approaches in a sense-making process (Ayres et al. 2003; Schwartz-Shea & Yanow 2012). We first immersed ourselves in the main guidelines. We used the programme Atlas.ti. to interpret the text and search for linkages between themes and variables. We looked at how uncertainty and adaptiveness are described in the approaches and identified statements and variables related to our research question. We undertook three formal coding sessions of the guidelines until the main themes (uncertainty, adaptiveness, their relation, context) were saturated with sub-variables and all occurrences in the formal descriptions were accounted for (Appendix C). Next, we compared the underlying statements to identify commonalities and differences. In our fifth step, we reconnected to the context of the approaches to corroborate the identified themes and ascertain their fidelity. Our sixth and final step was to reflect on these findings by comparing both approaches in the context of the different natures of uncertainty and the specification and use of adaptiveness.

4.3. Results

We draw on the conceptual insights in the nature of uncertainty and distinct types of adaptiveness to elaborate how the approaches describe uncertainty and operationalize adaptiveness to deliver the outcomes they promise. First, we describe the water diplomacy framework (WDF), then adaptive delta management (ADM) to pinpoint their distinct characteristics. We illustrate WDF with the example of water management in the Sacramento-San Joaquin river delta and ADM with the example of replacing hydraulic structures in the Meuse river. Second, we compare the approaches and describe the found commonalities and differences.

4.3.1 Water Diplomacy Framework.

WDF (Islam & Susskind 2012; Susskind & Islam 2012) combines insights from complexity sciences, consensus building approaches and negotiation theory. It is developed to overcome problems associated with integrated water resources management (IWRM) by building on continually evolving systems due to open boundaries and including the latest developments in negotiation theory, based on seeking mutual gains for multiple stakeholders. Water system boundaries are claimed to be set in IWRM. Assuming set boundaries leads to perceive allocation as a win-lose situation. WDF seeks a transition towards an open, networked management of water resources. In most cases such open boundaries lead to the impossibility of optimizing water allocation because of uncertainty and variability.

An open network-perspective reframes water systems as networks crossing science, policy and political fields. Water networks span across the boundaries of societal and natural processes, both influenced by and influencing the political domain. Water networks also cross different scales (e.g. spatial, temporal, jurisdictional, institutional) and within each scale they may cross different levels (Islam & Susskind 2012: 49). Due to the open and interconnected perspective on networks across scales and levels, problems tend to be complex. WDF assumes that focussing on problems arising due to the complexity of water networks, dynamic and open systems allow for searching flexibility in values and stakes of actors. A network view enables actors to perceive water as a flexible resource which allows for win-win water resource

allocation and mutual gains. Such mutual gains thinking is developed since the 1970s as a reflection on negotiating agreements (Fischer & Ury 1981; Margerum 2011).

The general rules WDF offers elaborate on the configuration and development of water systems, but the major emphasis is on how to steer collaborative processes to desired end-results. WDF equips planners to design a collaborative scheme among stakeholders to manage water networks and argues that system perspectives always depend on the values and views of stakeholders. This emphasis originates from the insight that there is 'no agreement on the data that needed to be collected or how projections regarding future demand should be made [and] fundamental disagreement about (...) appropriate allocation formula' (Islam & Susskind 2012: 12). WDF thus starts from the premise of conflict in need of mediation and agreement. When mediating and seeking agreement WDF builds on diplomacy, for which it emphasises as a starting point the establishment of good relations and skills of the planner to deal with conflict situations.

The development of the California bay-delta programme illustrates this approach (Islam & Susskind 2012). The Sacramento-San Joaquin river delta, discharging in the San Francisco Bay (hence the acronym bay-delta) is a fragile, ecosystem while also the storeroom for water throughout California (Kallis et al. 2009). In the bay-delta, conflict arose since the 1940s about the diversion of water to particular users (Lacan & Resh 2016). A conflict arising due to fundamentally opposite uses and complexity of the system (Kallis et al. 2009). The conflict was resolved with the development of a programme for which the stakeholders (State and federal agencies and over 30 different represented stakeholder groups) worked out a mutually advantageous solution based on the principles underlying WDF.

Uncertainty and handling mechanisms

WDF acknowledges that uncertainty remains a challenge in all water management efforts. Uncertainty is conceptualised in WDF based on the insight that water networks behave in unpredictable, and hence uncertain ways. This opposes the notion of forecasting in contemporary water management (Kiang et al. 2011). Related to the reasonably far forecasting of water supplies, WDF instead 'assumes that the supply and quality of water are more unpredictable than that (and becoming even

more so, for example, because of a changing climate)' (Islam & Susskind 2012: 272). Consequently, WDF argues that uncertainty must explicitly be addressed in water network characterization.

On a meta-level water networks are characterized by the use of a diagnostic framework which builds on two variables: the amount of uncertainty and the amount of disagreement. These variables determine if water networks and associated problems are simple (small uncertainty, low disagreement), complicated (either high uncertainty or large disagreement) or complex (high uncertainty and large disagreement). The diagnostic framework implies that planners or water managers can plot uncertainty on a scale to determine the complexity of a water situation (with the other determinant being disagreement) (Islam & Susskind 2012: 91). From this perspective it is clear that setting up the Californian bay-delta programme was undertaken in a particularly complex situation with high disagreement and multiple contrasting uncertainties (Lacan & Resh 2016).

In contrast to this diagnostic framework, addressing uncertainty is made subject to the perspective of actors who convene to address a problem. Joint fact-finding should allow for mutual agreement concerning the amount of uncertainty and ways to proceed, but not necessarily solve uncertainty nor disagreement. This is derived from the complexity of water problems due to which 'we cannot talk about finding optimal or engineered solutions unless a great many non-objective assumptions are imposed' (Islam & Susskind 2012: 8). Such non-objective assumptions undermine the credibility of water managers when they claim sole reliance on scientific or technical judgements. The amount of disagreement may very well be about uncertainty or scientific certainty. This makes uncertainty and the depending diagnostic of a water network highly subjective. Before uncertainty can be addressed by WDF it should be discursively constructed, which allows for disagreement about what uncertainty is and how it should be handled.

The tension between conceptualizing uncertainty as a variable for determining the character of a water network (simple, complicated, complex), while being subject to the perspective of stakeholders, becomes visible in the role of the planner. To characterize a network, which the planner has to do before deciding about the appropriate management strategy, the planner has to identify the amount of uncertainty and disagreement. When stakeholders convene,

uncertainty depends on frames of reference or the 'Weltanschauung' of involved actors and is subject to consensus among the convened group of stakeholders. WDF does not indicate ambiguity as a separate aspect of water problems. Instead, it emphasises sufficient representation of different societal frames when convening stakeholders. The consensus reached after thorough selection of stakeholders allows for incorporation of ambiguity as much as possible due to co-construction of knowledge within the process. WDF is consequent in equipping planners to take on a neutral, mediating role and managing processes, but by doing so uncertainty is strongly embedded in the agreement/disagreement continuum. Thus, the approach does not equip planners to systematically choose between management strategies for specific types of problems or networks. This is part of the consensus-seeking process, such as the process in the bay-delta example. WDF hoovers between a meta-level analysis of what a network might be and equipping planners to handle complex water networks, through open-ended interpretation of problems and provision of guidance on the procedure to develop strategies. Where does this leave planners who need tools to handle uncertainty? For this, WDF proposes collaborative adaptive management.

Adaptiveness

WDF argues for 'new tools (...) required to model emerging water concerns' (Islam & Susskind 2012: 273). These tools include collaborative decision-making and joint fact-finding, combined in collaborative adaptive management (CAM). The use of CAM is proposed in order to allow for the recalibration of policies and plans and to ensure the possibility of mid-course corrections of such policies and plans, based on what WDF typifies as 'careful' monitoring (Islam & Susskind 2012: 202). CAM is embedded in an adaptive learning orientation which 'takes advantage of the unexpected' (Islam & Susskind 2012: 16), contrasting corrective actions through monitored change.

Adaptiveness is connected to changes on the certainty-uncertainty continuum and is tightly connected to flexibility: 'Any strategy can only be optimum under certain conditions, and when those conditions change, the strategy may no longer be ideal. To survive an organization needs to be flexible and adaptive. Flexible adaptation also requires new connections and new ways of seeing things' (Islam & Susskind 2012: 68). A new way of seeing things is the reconceptualization of systems

into networks where different nodes are in constant interplay. Planners can influence such nodes to resolve disagreement by creating more value than previously perceived. The negotiation turns the problem from a zero-sum game into a non-zero sum or win-win situation. This may be done by finding the best way to interact and adapt to other players in a network to juggle conflicting constraints and achieve the best possible outcome, feasible in the network's circumstances. To do so, WDF argues that adaptive learning (in contrast to adaptive management) is necessary. Adaptive learning intents the long-term co-production of explicit and tacit water knowledge. In this coproduction, the role of planners is to recognise and understand cross-scale and cross-level dynamics to ensure management of complex networks. This management is a long-term effort based on contingent agreement which should incorporate adaptive management principles, but which is reactive to occurring change. WDF is strongly normative about the adaptiveness strived for. One of the core assumptions of WDF is: 'the management of water networks *ought* to be adaptive and negotiated using a "non-zero-sum" approach' (Islam & Susskind 2012: 10; our emphasis). Adaptiveness is, thus, central to the approach.

The adaptive management scheme in the bay-delta is often praised as a successful exemplar of adaptive management (Kallis et al. 2009). This particular scheme enabled the stakeholders to manage currently uncertain future change by adapting to changing circumstances when they occur (Vlieg & Zandvoort 2013). Adaptive management refers in this case to increasing site-specific information to propose informed adjustments, for example by monitoring effects of interventions on biological parameters. Such adaptive management, as also proposed in the WDF is reactive to uncertain change, instead of forward-looking.

Outcomes

WDF promises specific outcomes or products when the approach is congruently adopted by planners. WDF claims to develop agreements which are fair, efficient and wise. These three characteristics are emphasised because: 'Unless agreements are viewed as fair (by those affected), efficient (by those who have to pay for them), and wise (by those with the expertise to judge), one or more parties, even if they reluctantly sign an agreement, will look for opportunities to reopen negotiations or to "get even" later' (Islam & Susskind 2012: 135). These agreements, and the approach to come to agreement in the first place,

are not embedded in an institutional context. The approach deliberately 'rejects the unquestioned authority of hierarchical governance structures' (Islam & Susskind 2012: XII), making its position highly critical regarding existing authority structures, without offering steps to transition from existing governance structures towards the proposed situation of on-going diplomacy. It also does not offer insight in transfer options to different planning cultures or governance settings.

WDF offers not only agreements about specific interventions or resource allocations. To handle uncertainty and allow for contingent steps, sensitivity to initial configurations is just as important. Therefore, 'the parties [in an agreement] may specify what will happen if various future events occur. Final agreements should also include dispute resolution provisions indicating how parties who fear that something has gone wrong are expected to proceed' (Islam & Susskind 2012: 147). Thus, agreements set initial steps to proceed in specific water systems, and rules for contingent steps based on believable forecasts and decisions about how to handle data gaps and interpretative differences. With such agreements, WDF claims to offer the necessary flexibility, based on adaptive learning and continuous adjustments, which should make long-term planning irrelevant.

4.3.2 Adaptive Delta Management.

Adaptive delta management (ADM) (van Rhee 2012) combines insights from scenario planning to explore future developments (Haasnoot et al. 2012), flexibility studies in economic and engineering studies (Scholtes & de Neufville 2011) and the concept of 'mainstreaming' developed in climate adaptation studies (Gersonius et al. 2016). ADM is developed to better handle uncertainty in the complex context of managing water in the Netherlands. Planners are equipped to solve complex water problems and are offered tools to handle future uncertainties (van Rhee 2012). The approach aids strategy-making with elements such as the construction of pathways, formal assessment of flexibility and scanning possible options to keep open. It also aims at combining investment and policy agendas of stakeholders.

ADM originated in the politically perceived necessity to integrate and enhance the core values solidarity, flexibility and sustainability for water management in the Netherlands (Ministry of I&M 2009). Enhancement

of these values was connected to fit ADM in the historically developed institutional setting, planning culture and the set of tools in use. The integration of the above mentioned domains of insight (e.g. scenario planning, flexibility, mainstreaming) reflect the three core values. Solidarity (which explicitly relates to intergenerational and intra-generational justice) is embedded in systematically mapping the externalities of choices. The mode of working which enhances flexibility is to anticipate future change in a transparent way through adaptation pathways (Haasnoot et al. 2012). Adaptation pathways is a tool with which planners can combine a portfolio of measures to assess their timely use under different scenarios. Sustainability relates to the mainstreaming of agendas through involvement of companies and inhabitants affected by choices and to the integration of spatial quality into strategy-formulation (Ministry of I&M 2009: 263-266).

ADM embraces a system-perspective and emphasises the implications for monitoring and optimizing a system relative to what are perceived unchangeable goals for safety and fresh water supply. Its premise is that the natural system is complex and dynamic, but society's goal setting is not. Consequently, the approach builds on a notion of different trajectories or pathways which a developing water system might follow in the future and follows several steps to create strategies. Strategies consist of 'goals, related measures and one or more development trajectories' (van Rhee 2012: 18) assuming that clear goals can be determined to design subsequent measures and development trajectories. Moreover, ADM builds on a contextual understanding of complex water systems and only very implicitly indicates the agency of water managers and planners to alter course.

ADM can be illustrated by the case of replacing seven interlinked hydraulic structures in the river Meuse (van Rhee 2012). During the 1920s the Meuse was canalised by building shipping locks and moveable weirs to improve its functionality for transport, drainage and flood prevention (Disco & van Vleuten 2002). In the coming decades, the structures need replacement, reason to reconsider them in the broader functionality of the river (van der Vlist et al. 2015). Determining their future use is, however, a complex problem. Regional water uses are adapted to the historic configuration of the river and future functionality depends on where and how structures are designed. ADM intends to offer insight in how to deal with uncertainty in such complex water problems.

Uncertainty and handling mechanisms

Uncertainty in ADM is described by using the scheme of Courtney et al. (1997) and distinguishes four types of uncertainty. ADM aims to tackle uncertainty about the future as described by Courtney et al.'s (1997) type two, which is uncertainty with a limited and distinct set of possible outcomes and type three which is uncertainty within a bandwidth when looking further in time (van Rhee 2012: 26).

Uncertainty is not only explicitly characterized, it is also described at multiple places in the planning approach. Enhancing flexibility, for example, builds on the idea that uncertainty diminishes over time. Moreover, uncertainty is described for different types of unknown developments to which one might want to be flexible. The approach stresses that uncertainty has to be made as explicit as possible to choose the most appropriate tool to handle it. Pertaining to the nature of uncertainty, ADM primarily relates to ontic, irreducible uncertainty. ADM indicates the presence of ontic uncertainty in climate change and socio-demographic change. An understanding of these types of change will always be incomplete and predictability will always falter. Coping with such change is, however, possible by waiting, since the uncertainty at this moment might diminish over time. In the Meuse example, the current strategy is to renovate the weirs for some years to monitor changes to better predict (but still not fully) how for example climate change may impact river discharges.

The key connection between handling uncertainty and adaptiveness are tipping points (Kwadijk et al. 2010). These moments in time are described as tipping points 'because going on in the current fashion becomes too expensive, technically impossible or societally unacceptable' (van Rhee 2012: 18). Tipping points indicate an expiration date at which a policy or measure is deemed not feasible anymore and translate uncertainty into questions of timing. When planners connect alternate policy strategies to scenarios of future change, tipping points can make uncertainty explicit. This offers an advantage since tipping points can be made measurable more easily compared to scenarios. Multiple uncertain variables can, thus, be compared and offer a time frame in which expiration dates will fall: 'What are the first and last moments at which a measure or strategy does not suffice anymore and, thus, additional measures need to be taken?' (van Rhee 2012: 24).

In the Meuse, the seven weirs which manage the water level each have different tipping points with specific uncertainty about when these are reached (van der Vlist et al. 2015). Timing depends on deterioration of the structures and the effects of climate change on river discharges, but also on the demand for shipping and fresh water use along the river banks. While there are complications to determine the exact tipping points (van der Vlist et al. 2015), first use of ADM informed the particular timing of necessary replacements and the possible alternative replacement strategies regarding societal demands (van Rhee 2012).

Adaptiveness

Adaptiveness in ADM intends to ameliorate the lack of predictive capacity and uncertainty about how the future unfolds. Adaptiveness helps to take adequate measures. Adequate measures are taken at the precise moment when they are needed for their ameliorating effects. To do so planners need to be flexible in time (that is to be able to postpone or advance measures) and assess measures to the wider physical and institutional context. Adequacy relates to the avoidance of lock-in or lock-out situations or a deliberate and transparent choice to get into such a situation. ADM equips planners to take short-term decisions and interventions only in light of their possible long-term impact on the system.

Building on the concept of tipping points, possible trajectories or adaptation pathways (Haasnoot et al. 2012) are made applicable for achieving medium and long-term societal goals. These trajectories are projected under different scenarios and their adequacy regarding possible but uncertain change. Strategies in ADM can be developed on different scales which has implications for the contribution of adaptiveness to handle uncertainty. On a project level, for example an investment decision for a weir, adaptiveness is enhanced through knowing the costs and benefits with respect to scenarios of future change. This allows for seizing option value for long-term developments. For the weirs in the Meuse, an option value is the possible buy-in of additional headway to handle future draught. Such option values create adaptiveness to handle currently unknown future change. On a strategic or regional spatial scale, ADM addresses the possibility to keep options open and seize opportunities for flexibility by coupling multiple stakes. An important function is to gain insight in

the possibilities to alter course if a tipping point for the current policy strategy comes close.

In addition to uncertainty, a reason for adaptiveness may be to couple agendas of stakeholders. Adaptiveness offers the opportunity to couple strategies with agendas, by alternating the decision about the use and timing of measures to seize short-term opportunities or to strategically wait until coupling might become advantageous (van Rhee 2012: 35). For the Meuse, combining a weir with a bridge might create synergy. Planners may gain synergy, but need to avoid unnecessary interdependencies between agendas. This can be done by, for example, cost benefit analysis of measures both independently and combined to see if measures can be executed separately without losing the advantage of coupling agendas.

ADM uses two types of adaptiveness. First, adaptiveness with regard to lock-in/lock-out mechanisms and the coupling of short-term interventions with long-term consequences and, second, to enable planners to enhance adaptive capacity of the managed system, by enlarging decision-space and enabling flexibility. These are tightly interwoven because the first type of adaptiveness enables and creates the second. Thus, there is an intricate relationship between different types of adaptiveness (i.e. adaptive planning and adaptive capacity) underlying ADM.

In the Meuse, ADM enabled planners to handle uncertainty about replacement based on the functionality of individual structures and in relation to key nodes in the water network. For each structure prevalent uncertainties and their interdependencies on a network level were determined (van Rhee 2012). This enabled planners to relate functionality-dependent choices (for example retaining the river for transport or not) to uncertainties for specific structures. It did not, however, abate ambiguity due to for example the choice about prioritizing specific functions of hydraulic structures over others.

Outcomes

ADM develops 'covenants for first and subsequent decisions' (van Rhee 2012: viii). The emphasis is put on first decisions 'which take into account conceivable future decisions; the art of leaving decision-space open for later choices and to maintain or increase flexibility of the water- and

spatial system' (van Rhee 2012: 5). These are embedded in strategies for water management and institutionally embedded in monitoring and yearly updated planning programmes. ADM's outcome is a set of pathways which aid decision-makers in optimal timing and phasing of measures with respect to uncertain drivers of change. ADM 'leads to a composite strategy, or a set of alternative strategies with intermediate possibilities for revisions' (van Rhee 2012: 14.) Within such a composite strategy, four types of measures are distinguished: measures which are (still) effective as (parts of) the current strategy, measures that are part of an improved strategy, measures that are profitable through coupling to other agendas and are optimized regarding their timing, and measures to keep options open for future choices or different strategic directions. The outcomes are not only these measures based on societal consensus as to their desirability, ADM also equips planners to assess the effectiveness of measures and determine the best possible strategy in light of different scenarios.

4.3.3.Comparing the two approaches.

WDF and ADM both start from the insight that predictability about the future is impossible due to the interlinked character of water systems. Linkages exist across different spatial and organizational scales, different stakes and values and non-linear causality of actions. A second common starting point is the difficult handling of uncertainty as a result of this interlinked character of water systems. WDF presumes that modelling is fraught with uncertainty and variability which leads to the impossibility to optimize water allocations. In ADM, uncertain climate change and variability in weather and climatic extremes necessitates reassessment of measures. The outcomes of both approaches are also comparable. Where WDF develops 'agreements', ADM develops 'covenants' in which both opt for reaching agreement between multiple contending parties about water management issues. The way to come to these outcomes, however, differs.

The differences can be summarized as the coupling of uncertainty to claims about information and knowledge; the conceptualization of adaptiveness in each of the approaches and the description of the fit with institutional contexts in which adaptiveness needs to be embedded. We discuss these differences in more detail below.

Uncertainty, information and knowledge claims

WDF starts from the premise that knowledge is essentially contested and stakeholder involvement leads to the most optimal agreements for managing water networks. ADM positions the technical production of water management strategies first and starts from the premise that more stakeholder influence might hinder the construction of adequate strategies, because stakeholders lack detailed insight in the functioning of water systems. This premise neglects other types of knowledge such as tacit, local knowledge of inhabitants of a region. Knowledge that WDF explicitly engages with to develop win-win solutions.

As shown above, uncertainty is an important concept in both approaches, while they handle uncertainty differently. In WDF uncertainty is primarily an issue for meta-level decisions about what a water problem entails regarding its degree of complexity. Planners' decisions are based on uncertainty involved in the encountered type of problem and the related handling perspectives. Uncertainty as conceptualized in WDF cannot be resolved, but also not anticipated through specific interventions. Uncertainty arising out of stakeholder frames might be handled through joint fact-finding. Joint fact-finding is proposed to handle, not necessarily reduce uncertainty, and is about believability and mutual acceptance of information. This translates in contingency settlements which allow for renegotiating and adjusting agreements. ADM starts from the assumption that uncertainty sometimes can be resolved, or time will offer additional insight in currently uncertain issues. Sometimes uncertainty cannot be resolved. ADM assumes that some uncertainties demand different (timing of) measures than others and that not all measures are adequate. Therefore, ADM proposes to use expert groups to establish detailed insight in the adequacy of measures and to decide on issues of timing in the preparation phase of strategies. This role of expert knowledge does not align with WDF which emphasises the use of tacit knowledge and mutual fact-finding wherein all stakeholders are engaged.

Compared to ADM, WDF seems to be better equipped to deliver policy under uncertainty. ADM focusses on ontic uncertainty, but mostly neglects uncertainties with an epistemic or ambiguous character. WDF focusses on epistemic and ambiguous natures of uncertainty while ontic uncertainty is, to some extent, reactively handled by adaptive management principles. Adaptive management is, however, made subject to consensus, which may lead to inadequate solutions with

respect to ontic or epistemic uncertainty. Important to note is that, while ADM as approach lacks attention for ambiguity, ambiguity is dealt with in the Dutch institutional context in which ADM is proposed, even to the extent that this may hinder sufficient attention for the implications of ontic uncertainty. Externalizing ambiguity from ADM may produce outcomes perceived as illegitimate by some actors, especially when their frame of reference and tacit knowledge are not incorporated into the process. When confronted with complex problems both ambiguity and ontic uncertainty are in need of careful handling of planners. The two approaches do not offer specific safeguards to ensure such handling.

Adaptiveness to handle uncertainty

While WDF builds on a general conception of adaptive management to handle uncertainty, ADM anticipates future adaptations through a set of tools which allows for seizing opportunities and avoiding lock-in and lock-out. To handle uncertainty in WDF the notion that neither collaborative management nor adaptive management are fully suited to plan for networked situations led to the proposal for collaborative adaptive management (CAM) (Caves et al. 2013). CAM, however, neglects the dynamic nature of complex systems, resulting in ontic uncertainty. A statement such as 'CAM assumes that water network managers will never get everything right on the first try' (Islam & Susskind 2012: 202) and the language concerning CAM (i.e. calibration, experiments) indicate a perspective wherein searching for optimizing management solutions, such as a specific allocation of water rights, is essential. Optimization is, however, rejected by WDF (Islam & Susskind 2012: 8). This rejection is necessary because good relations and diplomatic skills, essential for finding mutual gains, do only thrive by not foreclosing the solution space.

An issue less developed in both approaches is how to account for adaptiveness. Both approaches build on on-going monitoring (for ADM building on tipping points and drivers of change; WDF by monitoring systems in negotiated agreements), but do not specify how this should be done. WDF sees monitoring as part of 'experiments' to recalibrate policies and reconsider long-term goals and objectives. Two issues are at stake. First, a perception of agreements as experiments may result in problems already identified for trial-and-error approaches (Moore & Hockings 2013). For example, not properly taking into

account the unforeseen effects of agreements can lock-in the system on an undesired development trajectory. ADM explicitly accounts for this issue of unforeseen effects by taking an anticipatory adaptive planning view, while WDF is partly embedded in adaptive management principles and on-going adjustments instead of planned headroom for unforeseen corrections of policy. Second, monitoring becomes problematic, since complex situations render mid-course corrections unpredictable. Both approaches do not specify which variables need to be monitored (if possible at all) to effectuate adaptiveness. Even if some insights about what variables need to be monitored might be available, the assessment of such efforts might necessitate calibration of agreements, rendering monitoring itself obsolete.

Institutional context for adaptiveness

Both approaches are created in a specific institutional context. WDF builds implicitly on aspects derived from the US institutional context. This may hinder application in other situations, because it may not immediately be clear how the approach fits with local perceptions on uncertainty and adaptiveness (and other aspects of the approach) and which institutional presumptions influence the approach. For example, the vision on long-term planning, which might be rendered obsolete according to WDF, may reflect the US context in which a strong libertarian political climate obstructs long-term planning endeavours and the availability of sufficient resources for such activities. Moreover, WDF 'rejects the unquestioned authority of hierarchical governance structures' (Islam & Susskind 2012: xii) even though WDF claims to offer a universally applicable approach for water problems. This necessitates the tailoring of the approach to assumptions and claims about specific institutional contexts, for example related to the outspokenness of stakeholders and democratic institutions for representation implied in the approach. ADM is explicitly linked to the Dutch context and elaborates on how the approach diverges from contemporary Dutch practice and on transition steps for implementing ADM. This offers transparency as to the practical implications of its situated implementation for other contexts as well. The Dutch context, however, is characterized by long-term planning efforts and an egalitarian organized institutional structure. This may need to be accounted for when transferring ADM to other situations.

One issue related to handling uncertainty is the inclusion of stakeholders. WDF proposes to resolve the influence of different knowledge claims and perceptions on uncertainty by stakeholder inclusion throughout planning processes. ADM proposes a funnelling approach in which three groups have different functions. A large stakeholder group with representation of all stakes needs to establish and accord the objectives, principal drivers of change to be discussed and possible options for a strategy. A small group of experts does in-depth research, synthesizes details, executes uncertainty and risk analysis and keeps the process on track to develop specific and adequate strategies. Decision-makers need to adopt a strategy into the formal decision-making processes. Thus, both approaches assume outspoken stakeholder groups and the institutionalization of deliberative principles.

ADM deliberately engages with how strategies become embedded in existing institutional structures. It does not claim any overhaul is needed per se. Instead ADM offers steps to integrate the approach into an existing situation. WDF does signal the case-dependency of planning water systems: 'Consequently, one needs to be cognizant of the applicability and limitations of a given framework while analyzing case studies to derive generalizable principles that can be applied in other regions, domains, and situations' (Islam & Susskind 2012: 31). Signalling case dependency does not lead to proposing specific steps for implementing the approach. Therefore, ADM seems to be more specific about its case dependency and institutional context which allows for seeing the fit and possible misfit with other contexts.

4.4. Discussion and conclusions

Owing to the difficulty of planning water situations fraught with unpredictability and uncertain change, the authors of the water diplomacy framework (WDF) and adaptive delta management (ADM) critique existing planning approaches as being not fully up to the task of handling complexity and uncertainty. Consequently, they developed planning approaches to get grip on such situations and to operationalize adaptiveness to handle uncertainty. Because we wanted to know what adaptiveness was used in planning approaches to handle uncertainty in complex water problems we compared these two approaches.

We found that the alternatives offered by WDF and ADM differ, even though both approaches propose to develop agreements and covenants after signalling that variability, uncertainty and non-linear causality problematize planning for water systems. While WDF advances collaborative adaptive management as a set of on-going adjustments and continuous learning, ADM attempts to anticipate uncertain change through its adaptive planning view. We found that different types of adaptiveness are used in the approaches. This reflects the diffuse understanding of adaptiveness in scientific literature divided among something to either reactively adapt to altering circumstances, experiment to optimize solutions or agreements and proactively adapt to possible change by deliberate anticipation. A possible explanation for the difference between the approaches might have to do with the signalled weak points of existing planning schemes. WDF focusses mainly on the lacking attention for stakeholder inclusion and negotiation, fitting with more reactive styles of adaptiveness. ADM elaborates on the insufficient inclusion of long-term uncertain consequences in planning decisions, better fitting with adaptiveness through deliberate, planned anticipation. Thus, both aim to ameliorate planning of water systems, but do so on different aspects, which is reflected in the type of adaptiveness they apply.

Our results show that the approaches differ in their conceptualization of uncertainty. In both approaches frameworks are offered for addressing multifaceted situations, but these frameworks do not account for the three different natures of uncertainty (ontic, epistemic, ambiguous). This result supports previous studies where is argued that elaboration of uncertainty characterised by its three natures simultaneously is as yet undeveloped (van den Hoek et al. 2014b). An implication of this may be that neither of the approaches congruently offers tools to handle all types of uncertainty associated with complex water problems. This can become problematic when planners want to address situations wherein uncertainties of different natures intermingle.

When contrasting the different types of uncertainty with the two frameworks, our results indicate that WDF offers a more coherent account of each of the three natures compared to ADM. However, in making adaptiveness subject to knowledge claims and consensus WDF opens up the possibility of inadequate solutions for specifically uncertainty with an ontic nature. In ADM the handling of ontic uncertainties is emphasised, while for congruently handling all

uncertainties with the approach, it is less suitable. ADM lacks attention for primarily the ambiguous nature of uncertainty and some elaboration of the interrelation between different uncertainties and the proposed role of adaptiveness.

Connected to this, both approaches should better scrutinize how to transfer them to other institutional settings. To implement them in existing situations requires additional insight in possible transitory steps to embed the approaches in existing legal frameworks and local planning cultures. More clearly than WDF, ADM is already embedded in an institutional context, which corroborates the conclusion of Dewulf and Termeer (2015: 768) that '[o]verall the current institutional context for ADM in the Netherlands is quite favourable'. A lack of attention for the possible fit and misfit of approaches with the institutional context seems to be an important omission to account for uncertainty, next to limited resources, high costs, long duration and large technical requirements for managing uncertainty (Woodruff & Stults 2016). Further study into the different design choices involved when using planning approaches and tools for handling complex situations fraught with uncertainty may alleviate some of these omissions.

Although this comparative analysis helps to identify how planners may use approaches to handle uncertainty by adaptiveness in the planning of water systems, a limitation is that we studied only two approaches based on their conceptualization of uncertainty and adaptiveness. Our study focused on the use of adaptiveness to handle uncertainty, not on the overarching operational design of the approaches or their fine-tuning in day-to-day planning practice. Each of these limitations offers themes for future research, whereof an important direction is to study approaches in empirical cases to draw out insight in the use of approaches to address uncertainties and propose adaptive interventions adequate for the consequences of prevalent uncertainties. This should, however, be studied alongside the way of operationalizing concepts into adequate planning approaches as such.

Adaptiveness to handle uncertainty is expected to garner increasing attention as the malign consequences of decisions under uncertainty become more prevalent. The attention and development of adequate planning approaches to account for adequate interventions and adaptiveness amid uncertainty will probably only increase due to uncertain climate change. Our results suggest that planning approaches

such as WDF and ADM can enable the handling of uncertainty through adaptiveness, but need to be improved based on specific insights in what adaptiveness and uncertainty entail for the development of water management plans.

5

Adaptation pathways in planning for uncertain climate change

Applications in Portugal, the Czech Republic and the Netherlands

This chapter is published as: Zandvoort M, Campos IS, Vizinho A, Penha-Lopes G, Krkoška Lorencová E, van der Brugge R, van der Vlist MJ, van den Brink A & Jeuken ABM. (2017) Adaptation pathways in planning for uncertain climate change: applications in Portugal, the Czech Republic and the Netherlands. *Environmental Science & Policy* 78, 18-26.

Abstract

Adaptation pathways are developed to design adaptive policies to handle climate change uncertainty. Use of this tool varies across planning practices and adaptation challenges and adjusting the tool to particular practices can foster its adequate use. To gain insight into the use of adaptation pathways, we compared four initiatives (one each in Portugal and the Czech Republic and two in the Netherlands) with regard to design choices made. We found six design choices which need to be considered when adjusting adaptation pathways. Design choices about the geographic scale, inclusion of sectors, the generation and delineation of adaptation options, specification of possible pathways, the related performance metrics and the type of assessment are interdependent, but they are also influenced by contextual aspects. Analysis of the institutional diversity, planning culture and framing shows that the use of adaptation pathways is flexible enough to be adjusted for diverging planning practices. However, the tool is best suited to deliver local adaptation solutions, and adequate use depends on consensus about the adaptation problem, setting objective thresholds and determining uncertainty about future change. We conclude that understanding the customised use of tools for local planning practices is essential for adaptive policy design.

Keywords

Planning tools, policy-making, design choices, climate adaptation, uncertainty, adaptation pathways.

5.1 Introduction

Climate change is full of uncertainty, therefore adaptation should entail a portfolio of response options (Pielke 1998; Henstra 2016). To prepare climate adaptation policy, adaptive planning tools address these uncertainties by assessing different proposed responses. The adaptation pathways approach (Haasnoot et al. 2012; Haasnoot et al. 2013) is a promising adaptive planning tool. In addition to traditional scenario analysis tools, in which the impact of different climate scenarios and possible responses are assessed (van Vliet & Kok 2015), adaptation pathways start analysis with the possible extension over time of feasible options under climate change. Additionally, the tool aids in studying if and how current portfolios of responses can be diversified through adaption measures. Adaptation pathways claim to support policy-making by offering five contributions:

1. using objective-based thresholds;
2. handling uncertainty in principal drivers;
3. structuring a wealth of adaptation options;
4. pointing out possible lock-ins; and
5. incorporating multiple stakeholder preferences (Haasnoot et al. 2012).

In planning processes, planners and policymakers need to make choices about issues, such as the demarcation of the system, the geographic scale at which adaptation responses are assessed, specification of adaption measures and the necessity and possibility of quantifying the effects of interventions. These choices will influence the contributions and outcomes of using the adaptation pathway tool. A clearer understanding of how these design choices are made and their consequences will enable planners to better operationalize them for their particular planning practices. Better choices and operationalization of tools can improve the quality and effectiveness of adaptive policies. Moreover, planners may want to know the possible pitfalls of any tool. Such knowledge can increase the quality of the process and enhance usefulness and legitimacy of the developed adaptation responses.

We start from the premise that design choices about the use of adaptation pathways determine the process after a specific direction is chosen. These can be conceptualized as boundary choices which structure how a planning process will unfold (Karstens 2009; Van

Broekhoven et al. 2015). When choosing the design of an adaptation pathway, planners are confronted with dilemmas concerning the benefits and downsides of particular choices. Analysis of the use of one specific tool in different planning practices can contribute to studies comparing various policy tools or adaptation policies across multiple contexts (e.g., Bubeck et al. 2015; Eikelboom & Janssen 2017). Studying applications of adaptation pathways in different situations offers the opportunity to learn how the tool was used and which choices were made to adjust it to diverging circumstances. Moreover, such analysis can offer insight in the adequacy of the tool to deliver the five claimed contributions in different adaptation planning practices.

Our main objective is to study the use of the tool in different planning practices to gain an understanding of the design choices available to planners. Additionally, we want to gain insight into their consequences and the relation of choices to specific adaptation practices. We answer two related questions: 'Which choices structure the use of adaptation pathways in different adaptation planning practices?' and 'To what extent is the customised use of adaptation pathways in different planning practices adequate?' To this end we studied four applications of adaptation pathways (one each in Portugal and the Czech Republic and two in the Netherlands) and compared the processes of how users (e.g. planners, facilitators, policy-makers) of the tool chose a particular design of pathway and how the tools were used during specific planning processes. In the next section, we outline our research approach. Following this, we describe which design choices determined the use of the adaptation pathways in the four cases and outline why planners made particular choices. In the fourth section, we reflect on the design choices and contextual aspects which influenced which choice was made. Lastly, we discuss our findings in light of the use of adaptive planning tools for climate adaptation and present our conclusions.

5.2 Research approach

Key ingredients of the adaptation pathways are to identify adaptation tipping points (Kwadijk et al. 2010), to explore possible pathways and to monitor critical developments that start from the premise that policy responses have an expiration date. An adaptation tipping point is reached when the magnitude of external change is such that a policy

response no longer meets its objectives. The ineffectiveness of a policy response will depend on how the future develops and can be assessed through scenario studies. Tipping points can be assessed to gain insight into the opportunity to appropriately adapt, postpone or antedate a response when new information about changing conditions is gained (van der Vlist et al. 2015).

The aim of adaptation pathways is to select a set of policy responses by timing and sequencing different response options in light of one or more drivers of future change (Haasnoot et al. 2013). Planners generally do this in several steps, which results in a sequence of policy responses over time to achieve a set of pre-specified objectives under uncertain changing conditions (Haasnoot et al. 2012). For the purpose of communication, pathways can be depicted as a map showing different interconnected paths (Figure 5.1). Planners can assess paths regarding different time horizons and scenarios using multi-criteria scorecards or cost-benefit analysis techniques (Haasnoot et al. 2013).

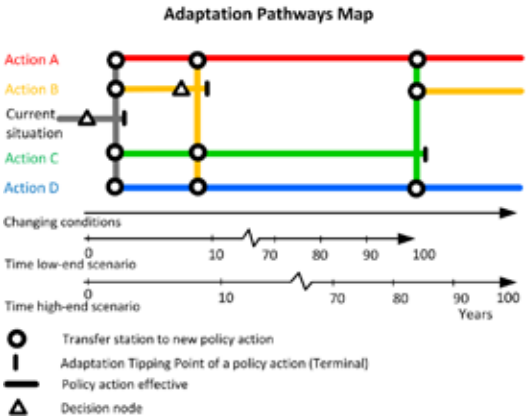


Figure 5.1. Adaptation pathways depicted in their original conceptualisation with four different actions and adaptation tipping points and scenarios on the x-axis (Haasnoot et al. 2013).

Planners need to take four steps to create an adaptation pathways map. These are related to four of the contributions mentioned in the introduction:

- Set the objectives, performance metrics and related threshold values. This contributes to using objective based thresholds.
- Assess adaptation tipping points for the current policy or management situation, based on thresholds under different scenarios. This contributes to the handling of uncertainty in drivers of change.

- Explore and select policy responses and assess their adaptation tipping points. This supports the structuring of a wealth of options.
- Combine the different responses into combinations of alternative pathways which can be assessed on costs and benefits and multiple criteria to enable the selection of a preferred path. This helps highlight possible lock-ins.

The fifth contribution, incorporating multiple stakeholder preferences, is not embedded in a specific step but relevant for each of the four steps.

When an adaptation pathways map is created, planners need a monitoring system to collect information for early warning signals (triggers) to alter, or adjust (i.e. advance or postpone) policy responses. In each of the steps, design choices have to be made which are of profound importance for the use of adaptation pathways, but those choices are not set by the tool itself. Instead, users assess their specific situations, which determines to a large extent the effectiveness of the tool and the quality of its outcomes. The contribution of each step depends on the design choices of planners regarding the operationalization of each step in their particular situation.

We approached the use of adaptation pathways through the aforementioned steps and explored these steps for possible design choices and contextual variables that determined the outcome of these choices in the four cases. We carried out a comparative case study of applications of the pathways in four planning processes to develop policies to adapt to climate change (Farthing 2016). Our cases differ regarding their planning objective, scope, amount of participation and planning culture. The cases were part of the European research project Bottom-up climate Adaptation Strategies towards a sustainable Europe (BASE) (BASE 2016). In this project, 22 case studies across Europe were conducted to gather insight into sector-specific adaptation activities and to examine interactions across multiple policy levels. For this, planners used multiple adaptation analysis methods in which they received training through workshops.

We used four of these case studies for our comparison: the Ílhavo and Vagos Coast in Portugal, Prague in the Czech Republic and IJsselmeer and Rotterdam in the Netherlands. In each of these cases, planners used adaptation pathways to assess climate adaptation responses, but

for different types of climate impacts. Moreover, we chose these cases because they have distinctly different planning objectives and scopes (both spatially and in adaptation responses) and a different emphasis on participation within BASE. Lastly, in the design of the study, the planners in the cases went through each of the four steps described above.

We took a comparative approach in which the planners in each of the cases were trained to use the adaptation pathways and apply them in their specific case studies. Subsequently, during the planning process, the experimental application of pathways was observed and reflected upon as the cases progressed through the different steps of the adaptation pathways. Each of the cases has a distinct methodology, data collection and analysis. The Ílhavo and Vagos Coast case was based on participatory action research, spatial modelling and interviews; the Prague case on spatial analysis, and additional interviews and a workshop; the IJsselmeer case on focus groups and interviews; and Rotterdam on action research, interviews and spatial and economic assessments. The results of these studies were separately documented for each case (BASE 2016). These case documents were analysed to identify a list of questions for a comparative analysis. Based on these questions and written data, the first author conducted reflective interviews with the case study planners about their use of the tool and choices during the process. We used these reflections to create case narratives, describing the use of pathways, the justification of different methodical steps in the cases, the aspects that may influence why a choice was made and which consequences this may have for the outcomes. These case narratives were crosschecked with the BASE case documents and the case study planners and, lastly, compared to derive insights into the main commonalities and differences in how choices were made during the application of the adaptation pathways.

5.3 Adaptation pathways in four cases

In this section we first give a general description of the location, context and identified adaptation problem for each case. Then, we describe the application of adaptation pathways, the different steps taken and the design choices made in the four cases.

5.3.1 Water resource management in the IJsselmeer

The IJsselmeer is an estuary that was dammed and separated from the Wadden Sea in the 1930s and comprises 1100 km^2 of water. The IJsselmeer is managed for flood safety and to supply of fresh water. Adaptation was deemed pivotal due to altered discharge from the IJssel river (a tributary of the Rhine river), sea levels rising and an increasing prevalence of drought. The Delta Programme IJsselmeer was run from 2010 to 2014 to study the possible policy actions for climate change adaptation in the water system (DP 2014). This programme was a multi-level and cross-governmental programme to develop a nation-wide strategy and six regional strategies for long-term flood risk and water resources management. Policy-makers developed long-term water resource management strategies for the IJsselmeer's water level and water usage in the regions along the lake.

Adaptation pathways were used to address the cost-effectiveness of preliminary policy options, to assess possible options and to communicate these with (non-governmental) partners. The objectives were to sustain long-term flood safety and the regional water supply. Planners set the performance metrics for the drivers of change, which were sea level rise and altered discharge of the IJssel river, both related to minimum and maximum water levels of the lake. For flooding, the threshold is a maximum water level, while for water supply a minimum water level determines the additional buffer size of the lake. The national Delta Programme centrally determined the stressors and surrounding uncertainty in four scenarios.

The planners determined options based on the primary choices of adjusting the water level, affecting the area along the lake, or maintaining current water levels, both affecting the discharge regime into the Wadden Sea. They based adaptation tipping points on alterations of the water level under projections for low and high sea level rises in 2100 and were also informed by studies executed for the different regions around the lake. The simplicity of the performance metrics and thresholds, both related to specific water level alterations, allowed for quantitative assessment of current and alternative strategies under increasing sea level rise and assumptions about water inflow.

By means of the pathways, planners evaluated possible options and stakeholder preferences. In doing so, they considered packages of

technical and governance measures. According to the planners, the preliminary conceptualisation of paths was less useful, because the large number of options rendered them unhelpful for communicating and progressing to the final policy decisions. Moreover, stakeholders had difficulty understanding the pathway maps (see chapter 6). They perceived a large number of options as irrelevant due to the physical characteristics of the management problem. The final path consists of more flexible yearly water level management in the short term and building pumping capacity to drain the lake on the longer term (after 2050) (DP 2014). According to the planners, this reflects a preference for flexibility, since the other main strategy (increasing water levels) would need major investments in dyke reinforcements and alterations of regional drainage capacity (BASE 2016).

5.3.2 Coastal management in Ílhavo and Vagos, Portugal

On the west coast of Portugal, the highly vulnerable stretch of low-lying dune barrier (~20 km) belonging to the municipalities of Ílhavo and Vagos is particularly exposed to coastal erosion, storm surges and flood risks (Alves et al. 2011; Dias et al. 2014). Aware of the role and conflicts of different actors in the co-construction and implementation of coastal adaptation policy, planners integrated the use of the adaptation pathways in a broader participatory approach based on the Scenario Workshop method (Schmidt-Thomé & Klein 2013; Campos et al. 2016). This method included three stages (i.e. critique, vision and action-plan) over two full-day workshops (held one month apart) and was complemented by risk assessment studies, a multi-criteria analysis, and a cost-benefit analysis. The objective for the case was to find consensus on a set of policy options and develop an adaptation action-plan for the future.

The facilitating team structured the adaptation measures, conducted a multi-criteria study based on the adaptation options chosen during the first workshop and designed a set of possible adaptation pathways. There were no predefined explicit objectives, although in the first workshop two objectives were defined: retaining flood safety and supporting the local economy by retaining a sandy beach. These objectives were not predetermined, but participants recognised the flood safety objective as enabling a healthy coastline, a precondition for other economic objectives. The planners asked participants to choose

their preferred adaptation pathways or design their own pathways by combining predefined pathways based on their tacit knowledge of the area. The planners informed participants with printed versions of potential adaptation pathways and results of a multi-criteria analysis. Five sub-groups worked out the specific issues for five sub-stretches of the coastal area with distinct geographical characteristics. This resulted in five pathway maps, one for each sub-stretch of the coastline, hand-designed by participants and based on the potential for adaptation. In consultation with the participants of the workshop, these pathways were aggregated into one set of final pathways applicable to the whole coastal zone of Ílhavo and Vagos. This was possible due to the similarity of the measures and the adaptation tipping-points across the five interdependent sub-regions (BASE 2016; Campos et al. 2016).

The main stressors were coastal erosion and overtopping, potentially accelerated by sea level rise. Uncertainty in this stressor did not play a large role, since the tipping points were defined for the worst case scenario (RCP 8.5 and 100 year flood). Adaptation tipping points were determined based on spatially modelling coastal erosion and overtopping, fitted to the regional circumstances and climate scenarios. The derived measurable objective is restoring and maintaining a safe coast for which erosion needs to be mitigated. Although multiple paths were brought to the attention of stakeholders, the workshop participants (e.g. farmers, inhabitants, fishermen and the mayors of the municipalities) placed emphasis on technical options (e.g. sand nourishment or groynes) and discarded legal or spatial options (e.g. expropriation of farmers for flood protection); because these solutions may be expensive and only able to postpone tipping points for the local situation.

5.3.3 Managing the urban heat island effect in Prague, Czech Republic

In Prague, adaptation pathways were used to explore solutions for the urban heat island (UHI) effect in the city district Prague six. In this district, several developments are taking place, including construction of administrative buildings and planned renovation of the neighbourhood near the Czech Technical University's campus. The planned developments include building on current green space and replacing parks with office buildings. The effects of the proposed

redevelopment and the possibilities to lower the UHI effect were the main impetus for the study (BASE 2016).

Climate projections for the coming 30 years in the Czech Republic show increases in the number of tropical days and nights compared to the period between 1961 and 2012. A similar trend for the number of heatwaves is predicted (Štěpánek et al. 2016). The UHI potential for the climate projections and the effects of ameliorating measures were assessed with an urban heat mapping tool, based on climatic factors with the UHI potential based on current and future land use. The performance metric was the UHI potential of interventions. The urban heat mapping tool was used by planners to quantify UHI potential of different land uses on a 10-point scale and they determined that a UHI value of six would be so severe that it was chosen as an adaptation tipping point for changes in land surface. Then, planners distinguished adaptation tipping points based on percentages of ameliorating land uses by UHI. By including changes in urban land use, the pathways show the relative effect of different measures on the UHI and the impact of urban plans on future UHI effects. Policy makers indicated that while the types of measures were deemed less applicable for direct adaptation policy interventions, the intention and conceptualisation of the pathways were interesting and useful to adapt urban development plans. During a participatory seminar in Prague, stakeholders prioritized UHI and risk of heatwaves as the main climate related impacts. The use of the UHI tool in combination with pathways and mapping of stakeholder preferences was, however, difficult because more information was needed concerning different land uses, specific measures (the effect of green roofs versus a pond versus a park, etc.) and their ameliorating effect on UHI.

5.3.4 Flood risk management in Rotterdam

Rotterdam is located in the Rhine-Meuse delta and is flood-prone due to peak river discharges and storm surges, which will increase due to climate change (Jeuken et al. 2015). Planners used adaptation pathways in the context of the Delta Programme Rijnmond-Drechtsteden, with the objective to provide region-wide strategies for long-term flood risk management. Planners conceptualized adaptation pathways as 'development paths' indicating the timely order of decisions and envisioned them as a tool to assess costs and benefits of different

adaptation strategies and to inform the participatory process. The objective to reduce flood risk was considerably elaborated based on exactly determined water levels. In addition to these objectives, planners added the analysis of economic effects on assets, inhabitants of the area and the harbour-based economy to understand the wider impacts of flood risk reduction measures. The planners used intermediate pathways for sub-areas and economically informed pathways during strategy formulation. According to an interviewee, these pathways showed clear optimal policy approaches and timing of when adaptation tipping points may occur. This was also due to a few quantifiable tipping points that included one dominant threshold for determining options and which coincided with the expected technical lifetime of the Maeslant storm surge barrier (BASE 2016).

Though they assess policy options and their timely effects in the face of drivers of change, the final pathways proposed by the Delta Programme are very general and lack details about tipping points and transfer options (DP 2014). According to an interviewee, this was due to the shift in objective and performance metrics from height and associated water levels to the strength of the dykes, which depends more on the duration of high water levels instead of the most extreme levels (BASE 2016). This changed the set of options and the valuation of possible solutions, because an additional performance metric was included. The underlying discussion is that for height, options include building higher dykes, lowering the water level through altering the river bed or closing the delta on the seaward side.

Due to the regional scale and the long time horizon of the Delta Programme, intensive discussions about the objectives and desirable strategies took place, involving stakeholders groups and all levels of government. At the start, the process reflected different perspectives (i.e. a nature-friendly open estuary versus a closed system with barriers). In the end, one path was chosen, as the decision-makers discarded alternative paths that remain options for the long term. This choice came about due to the geographical diversity of the area, with the problem shifting from the west side were the height of the dykes is an issue, to the east, were strength of the dykes is an issue. Moreover, the complexity of the institutional setting led to deferments on foreclosing options such as river bed alterations or dyke reinforcements.

5.4 Comparison

When reflecting on the cases and comparing them, two aspects are pertinent. The design choices which are chosen and the external factors that influence these choices. Each of the four cases has taken the steps which make up the adaptation pathways tool. As evidenced in the four descriptions above, there are large differences between the cases as to how the planners undertook each of the four steps (Table 5.1).

Table 5.1. The choices made in each case for the four steps of the adaptation pathways.

Steps	Set objectives, performance metrics, threshold values	Assess tipping points under different scenarios	Select policy responses and assess tipping points	Combine responses in alternative pathways & assess impacts
IJsselmeer, Netherlands	Sustaining long-term water supply and flood risk safety	Lake's water levels, specified in cm	Participation of experts and policymakers	2D hydraulic model
Ílhavo and Vagos Coast, Portugal	Sustaining the ability to protect coastal areas under influence of sea level rise, increasing erosion and flood risk	General effects on coast, unspecified threshold values	Participation of experts and stakeholders	Scenario Workshop/Multi-criteria analysis
Prague, Czech Republic	Sustainability of measures to decrease urban heat	Urban heat, specified threshold values in % urban heat potential	Expert-based	GIS mapping, urban heat tool
Rotterdam, Netherlands	Supporting on-going flood risk management	Water levels, costs or damage; End of lifetime of storm surge barrier	Participation of experts and policymakers	2D hydraulic model, cost-effectiveness analysis

From the cases, we found that planners can design adaptation pathways in different ways. The geographic scale on which pathways are formulated ranges from a small coastal stretch (Ílhavo and Vagos) to a large delta area with different land uses and drivers of change (Rotterdam). Planners also deliberately chose the number of sectors to be involved in the planning process, leading to more or less integrated sets of pathways (IJsselmeer and Prague, respectively). Planners in each of the four cases chose how much participation to allow or deliberately organise in order to generate and delineate options. In the Prague case, participation was almost absent while – on the other end of the spectrum – participation was deliberately organised in the Portuguese case. This influences two other design choices: the specification of pathways and the related performance metrics and threshold values. Planners can choose generic paths without clear thresholds or

specification of detailed paths and objective thresholds. For example, planners reduced the IJsselmeer pathways to the most decisive paths but made specific and contained detailed thresholds, while planners in the Rotterdam case only chose several generic paths without clear thresholds or performance metrics (DP 2014). The sixth choice we found to be decisive for the design of pathways and their implementation is the way of assessing them. In the cases studied, these ranged from GIS mapping (Prague) to hydraulic models (IJsselmeer) to cost-effectiveness (Rotterdam) to participative assessment (Ílhavo and Vagos).

We found these six design choices to be decisive when using and embedding the pathways within the particular adaptation planning processes. But this raises a second important issue, namely to what extent the choices made in each of the cases were adequate to achieve the advantages claimed by the adaptation pathways tool. This depended strongly on how choices were made. We found that, in no case, were the involved design choices made independently. Each choice influenced other choices. For example, the geographic scale determines which sectors and stakeholders might be included in the process, which further determines the generation of options. Another example is the determination of specific pathways and indicators. These are influenced by the choice of how options are generated and delineated. In addition to such interdependencies between choices, we found that each of the individual design choices and the involved aspects were also structured by the context of the particular planning practice. When comparing the four cases, we found that three distinct but tightly interlinked aspects influenced how planners chose to design the adaptation pathways and their implementation. These aspects are the institutional diversity affecting a planning problem, the particular planning culture and the framing of objectives and uncertainty. We turn to these three influential aspects to assess whether the adaptation pathways delivered on their claimed contributions.

5.4.1 Institutional diversity

In the IJsselmeer case, the wealth of options generated during the process provoked much debate. This was partly due to the diversity of actors involved. Actors did not always accept the extreme climatic scenarios and the package of options initially proposed for the area. Some actors were suspected of actively thwarting the planning process,

making the use of the adaptation pathways difficult. According to the planners in this case, the hybrid top-down national and bottom-up regional planning process explains part of this difficulty. While main objectives and scenarios with related uncertainty were established in a top-down manner, helping national consistency, this approach lacked a shared problem-perception, leading actors to oppose them. According to the planners, the straightforward participative use of the pathways in the Ílhavo and Vagos case enabled the inclusion of a diverse set of visions on the coastal zone. The speed with which the workshop participants resorted to only physical options during the construction of pathways might explain the easy inclusion of diverse visions on the coast. Other aspects that led to easy inclusion were the use of scenario workshop methodology, which made clear what the question at hand was, the easy visualisation of the proposed adaptation pathways and skilled facilitation (Campos et al. 2016). In the Prague case, options were not discussed with different actors, so nothing meaningful can be said about the effects of institutional diversity in this case. In Rotterdam, institutional diversity led to a significant emphasis on the contribution of each of the options to local areas, while the pathways for the regional scale lacked choices between paths (DP 2014). Moreover, according to an interviewee, the vested interests and the power of the shipping industry made the harbour activities partly decisive for the strategies. According to the planners and reflected in the final pathways (DP 2014), the mismatch between geographic and institutional scales led to fuzzy thresholds, a large array of options and unclear institutional responsibilities for specific paths.

5.4.2 Planning culture

In the IJsselmeer case, discussing an unfavourable option (a strong increase of the water level) led to a heated debate. The decision makers discarded this option due to the strong preferences of stakeholders and the involved financial costs. This, as we discussed in a focus group, can be partly attributed to a planning culture which heavily relies on a perception of the manageability of the water level (Faludi 2005; Chapter 6). In Portugal's coastal planning culture, technical options and civil engineering are highly dominant (Schmidt et al. 2014). The pathways seem to sustain such a technical perception. According to the planners, other options (e.g. restrictive land use policies, legal prohibitions for coastal settlements or insurance options) were not extensively

considered. In this sense, chosen pathways can reinforce a dominant lock-in or challenge the dominant culture, if unfavourable options are considered. Prague's planning culture might be regarded as a major obstruction for public adaptation efforts, as was shown by Maier (2000). When the developer took over the area's developments, the power of the municipality to alter its course was rendered obsolete, because local government has a weak position in urban development (Spilková & Perlín 2010). This made the use of the tool redundant, because it was not introduced in the initial phases of the planning process. The acceptance of the information delivered by the pathways was, according to the local planner, low. Determining the exact effects of the functioning of the adaptation pathways in this context is difficult, because decision makers might react negatively for other reasons not queried in our case. In Rotterdam, an interviewee indicated that opting for specific geographic boundaries builds on the economic importance of the area but further exploration of this comment did not fit in the structure of our research. Past planning choices led to starting with these specific boundaries, which included an area with a large geographic diversity. This hindered the creation of a specific strategy for the whole area and negatively influenced the use of the pathways throughout the process, leading to unrefined pathways without clear thresholds.

5.4.3 Framing objectives and uncertainty

The Dutch parliament formulated the objectives for the IJsselmeer and Rotterdam cases, and they adjusted them for the IJsselmeer case during the process. This negated the possibility of several options, especially those pertaining to spatial measures. In Rotterdam, the objective to cope with water levels (associated with rare extremes) led to options which were later deemed redundant. Executed assessments showed a low relevance of this objective for the more important issue of dyke strength. Moreover, several options were already integrated in the objectives and problem statement. We observed that the continuous and prolonged debate led to constant reframing of objectives and thresholds for some of the regional scale options. This diminishes the prevention of lock-ins, although we observed that the pathways helped to think through the consequences of choices. This indicates that pathways work best with upfront agreement on what the objectives and solutions are.

In the Portuguese case, the framing of objectives influenced the considered options. When reflecting on the process we observed that the objectives (to protect populations and the beach and to prevent further erosion of the dune system and the connection between the sea and the lagoon) which could be translated into measures, already had a seaward focus and a spatial-technical connotation. In Prague, communication and framing of both the objectives and options were not a shared endeavour, rendering the advice to increase either green or blue space in the redevelopment project difficult. That Prague's policymakers judged the options as unrealistic might be due to the specific presentation of the options as percentages of land uses. This could be overcome by translating the availability of space into more specific measures (e.g. green roofs and parks). Another solution in the design of the pathways might be a collaborative framing of the objectives with decision makers to increase the acceptance of the resulting pathways, as was done in the Portuguese case.

Concerning uncertainty, all of the pathways show a small bandwidth of uncertainty in the scenarios. In the IJsselmeer case, uncertainty in sea level rise was framed as being clear and small (BASE 2016). The strategy could thus be reduced to two options, with the timing of the options being quite certain. Reflecting on the final set of pathways, they seemed to fall short of expectations of what the tool could offer regarding uncertainty: structuring a wealth of options and highlighting lock-ins. In the Ílhavo and Vagos case, some uncertainty remained about the effectiveness of options. After the scenario workshops, technical and cost-benefit analyses of the options in the final pathways clarified at least some uncertainty. The scenarios did not show much uncertainty, because erosion is an actual problem, and sea level rise was perceived as a certain, steady process. The adaptation pathways in Prague remained uncertain as to the effectiveness of the options, requiring further specification in terms of particular green and blue measures and their cooling effect. In Rotterdam, all options were left open until 2100 (DP 2014). This presupposes that the planners do not see uncertainty as affecting the adequateness of the interventions on the mid or long term (Chapter 2).

5.4.4 The contributions of adaptation pathways

The institutional diversity, planning culture and framing of objectives and uncertainty influenced the six design choices in each of the four cases. This influenced whether the adaptation pathways tool could deliver on its five claims and how planners could go about the design choices when using pathways in their local situation (Table 5.2). In general, the institutional diversity affected three contributions:

- the determination of objective thresholds,
- the generation and subsequent structuring of options,
- accounting for preferences during the process.

The use of adaptation pathways was hindered on a regional planning scale by the diversity of involved actors. In general, a higher institutional diversity was more problematic for delivering these three contributions. To cope with actor diversity and avoid unclear pathways, planners should make sure that actor preferences are represented in objectives before venturing into next steps. Thus, the tool can best be used from the start of the planning process onwards.

Planning cultures mainly affect the contribution of pathways to identify possible lock-ins and the generation and structuring of a wealth of options. Deeply engrained visions in planning cultures create a lock-in that should be accounted for when adaptive planning is brought forward. In order to establish objective thresholds and identify lock-ins, scales matter. The cases show that planning cultures can be challenged or sustained by pathways and that choices are strongly informed by default thinking of how things ought to be done in particular situations. None of the cases shows a strongly diverging trajectory or a transition towards different interventions (BASE 2016). The use of pathways in each of the four cases depended on how geographic boundaries were set. We found that adequate use of pathways is more feasible on a local planning scale and with options broadly addressing the physical or natural environment than options on a regional scale with distributed institutional networks and non-physical or non-natural drivers. To cope with diverse spatial characteristics and stakeholder preferences, sensible categorisation of different interventions and packages of similar projects and interventions, such as river widening or urban greening, may help develop strategies for larger geographical scales. To cope with a technical bias in planning culture, planners can include a high diversity of actors and set clear objectives allowing for non-

Table 5.2. The contributions of adaptation pathways in each of the four cases.

Contributions / Cases	Use objective based thresholds	Handle uncertainty in principle drivers	Structure a wealth of options	Identify possible lock-in	Incorporate multiple stakeholder preferences
IJsselmeer	Hybrid scales rendered objective thresholds difficult	Scenarios were not accepted by all actors	Debate due to a diversity of actors. Preferences and financial implications led to rejection of multiple options	An unfavourable option led to heated debate partly due to a perception of the manageability of the water level	Lack of a shared problem perception
Ílhavo and Vagos	Predetermined objectives led to (coarse) thresholds about which consensus existed	Succeeded due to scenario workshop methodology	A technical perception was dominant due to existing preferences within this set, structuring of options was effective	Pathways were used to uphold a lock-in/dominant culture but were fairly effective in showing the lock-ins	Straightforward inclusion led to open debate and consensus
Prague	A late introduction of the tool and weak role of local government made the tool redundant	The expert-based approach led to a fairly straightforward handling of uncertainty	Framing the objectives led to coarse options for the area and a lack of structuring effects between options	Information about lock-ins was not effective for redevelopment because it was not assessed by stakeholders	Incorporation was not considered Acceptance of information from the tool was low
Rotterdam	Mismatch between scales led to fuzzy thresholds and debate about objectives during the process	Unclear which uncertainty to handle led to reiteration of the pathways during the process, reducing their effectiveness	There were no clear thresholds set due to diverging scales embedded in the historic approach to the region	Past planning choices hindered informing about lock-in, due to negative effects	Economic stakes dominated. Institutional diversity and mismatch between scales led participation to be partly redundant
General	The different framing of objectives, partly due to the high diversity and a mismatch in scaling, rendered this contribution difficult.	Use of scenarios and the attention to uncertainty can render this a strong point, but stakeholder preferences can affect adequate handling of uncertainty.	Planning cultures determine the acceptability of options to a large extent, both before and during the structuring of a wealth of options.	Embedded preferences and institutional diversity can obstruct transitions between pathways. In all four cases this contribution was determined by the local planning culture.	Incorporation of stakeholder preferences is neither necessary nor done everywhere. Success depends on adequate incorporation through tools other than AP themselves.

technical interventions. This at least enables that the consequences of different choices are addressed.

Lastly, framing influenced all the claimed contributions of adaptive pathways, due to the perception of objective thresholds and uncertainty in drivers of change on which the tool builds. When combined with scenario workshop methods, planners can explicitly define the objectives and have an additional tool to align frames (Campos et al. 2016). Here, the general insight we found is that sufficient consensus is needed about the problem, the objective thresholds and uncertainty. Planners might consider paying attention and making time for the framing of objectives and the support of decision-makers. As for uncertainty, planners need to evaluate uncertainty and the flexibility or robustness for the pathways.

5.5 Discussion

Adaptation pathways reflect a way of considering uncertainty in long-term planning, characterized by integrating adaptiveness in a decision-making process. Pathways are also useful in structuring a portfolio of adaptation options in a visually attractive way. Our aim was to study the choices involved in using adaptation pathways in different planning practices. We studied the choices that determined the use of the tool in four cases from different adaptation planning practices in Portugal, the Czech Republic and the Netherlands. We compared how users (e.g. planners, facilitators and policymakers) chose a particular pathway design and how they used the tool during their planning processes.

We found six design choices which need to be considered when the adaptation pathways are adjusted to develop a portfolio of options for a specific adaptation problem. In each case different design choices were made, demonstrating a large methodological diversity in the use of the tool. Although such diversity is not problematic *per se*, we saw that diverse methods might influence the claimed contributions of the pathways. These contributions are objective-based thresholds, handling uncertainty, structuring a wealth of adaptation options, identifying possible lock-ins, and incorporating multiple stakeholder preferences. We showed that opting for a particular design in a way that deviates from the original conception of the pathways may indeed reduce the adequacy of the tool to deliver on these contributions.

None of the cases fully succeeded in delivering on the claimed contributions, although the Portuguese case was most successful in this respect. The contribution least achieved was the claim to identify lock-ins. The current study found that planning cultures and the institutional contexts lead to pathways that support lock-in on the already chosen development path, instead of highlighting them to adjust and respond to options accordingly. This finding is in agreement with Hetz and Bruns (2014) in their single case study of Johannesburg. We add to their found constraints from a process-judicative perspective by indicating constraints from other origins, embedded in particular planning cultures or institutional settings.

We found that a misfit between the tool and its use in local planning practices also affected the handling of uncertainty. Although somewhat successful, planners did not consider uncertainty systematically, although they did tailor a portfolio of options to particular drivers of change. However, our cases imply that the specific adaptation problem and uncertainty regarding drivers of change need to guide the specific use and adjustments of the adaptation pathways tool. This seems straightforward, but all four cases indicate this is a challenging endeavour due to the three contextual variables: the institutional diversity and related scale choices, the local planning culture and the framing of objectives and uncertainty. These findings implicate that the conclusion of Lawrence and Haasnoot (2017: 55) that 'contextual matters (…) provided a backdrop that helped enable the adoption of [adaptation pathways] for planning' is less straightforward. While contextual variables enable adoption of the tool, we found that they are also the most important hurdles to overcome in the adequate adjustment of the tool. Additionally to the study by Lawrence and Haasnoot (2017), we specified three contextual variables and showed how the institutional diversity, planning culture and framing influenced adjustment of the tool.

Our findings are consistent with Henstra (2016), who outlines that there are trade-offs in tool selection. We showed that even *after* selecting planning tools, design choices keep influencing the adequate use of tools. Additionally, policy transfer studies indicate that – in addition to the instrumental transfer of tools – planners can also benefit from adopting 'soft' ideas such as using the conceptualisation of pathways to handle uncertainty (Benson & Jordan 2011). We indeed found that in all four cases the application of adaptation pathways promoted a

trans-disciplinary learning process, important for enhancing adaptive capacity and a higher degree of institutional flexibility.

The case studies show that how adaptation pathways are designed and used is determined by how they are adjusted for local planning practices. To be adequate and to simplify their use, planners who want to use pathways need to define adaptation objectives clearly and decide who is ultimately responsible for enacting the resulting adaptive planning policies (Lawrence & Haasnoot 2017). As this study indicates, this might be problematic for adaptation pathways and similar tools, due to ambiguous institutional responsibilities for policy delivery in networked governance structures (Bannink & Ossenwaarde 2012; Hajer 2003). The shift to networked governance might very well hamper adequate use of tools. Actors can use tools to their advantage, for example in rallying support for adaptation solutions. However, this may too quickly focus on details instead of considering large scale, systemic transformation options. While more research is necessary into the effects of an unclear division of responsibilities for adaptation and commitments related to the use and outcomes of tools such as adaptation pathways (cf. Barton 2013; Mees et al. 2015), their combined use with the scenario workshop method appears to be a possible solution for this integration.

5.6 Conclusions

We have compared the use of adaptation pathways in four planning practices to find common design choices and conclude that purposefully deciding on six choices is imperative to ensure adequate use of the tool. Adaptation pathways as tool is flexible enough to be adjusted for diverging planning contexts. When adjusting tools, however, planners should match them to their particular situation and embed tool design in their local planning context to successfully harvest promised contributions. In our case studies, this was not an easy endeavour.

While this study focused on existing practices of adaptation pathways use, a promising avenue for future research would be to deliberately design and experiment with different adjustments of tools to test their adequacy in delivering adaptive planning policy for a range of adaptation problems and contexts. This may account for the six design choices and give further guidance for the uptake of adaptation

pathways and other adaptive planning tools. Another avenue for future application is to deliberately make tools more flexible to quickly adjust for different situated practices (e.g. easy incorporation of add-ons such as scenario workshop methodology and cost-benefit analysis). A last suggestion is to study the functioning of tools in their planning-institutional environment. Consistently embedding the use of policy design tools for climate change adaptation in relevant planning contexts is necessary, but issues of power, knowledge uptake and adequate transfer need to be accounted for.

6

Dealing with uncertainty in collaborative planning

Developing adaptive strategies for the IJsselmeer

This chapter has been resubmitted as: Zandvoort M, van der Brugge R, van der Vlist MJ, van den Brink A. Dealing with uncertainty in collaborative planning: Developing adaptive strategies for the IJsselmeer. *Journal of Environmental Planning and Management*.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Enkhuizerzand

Abstract

Adaptive strategies to deal with uncertainty in water management are often collaboratively developed. So far, however, little attention has been paid to the influence of collaboration on handling uncertainty. In this paper, we study how collaboration has influenced the handling of uncertainty through adaptive planning for water management strategies for the IJsselmeer area in the Netherlands. We show how a fixation on certainty, different perspectives among actors and unclear responsibilities between arenas affect the handling of uncertainty, and found that it is adversely affected by collaboration. The use of adaptive planning challenged current water uses and system functions, creating resistance from actors. We conclude that developing a shared problem perception and common understanding of uncertainties, and ensuring a clear demarcation between the water system, its societal functions and water usage, are necessary to make adaptive planning successful in handling uncertainty.

6.1 Introduction

Uncertainty is increasingly gaining attention in planning for water system management. The need to handle uncertainty is highlighted by a recognition of non-linearity (Milly et al. 2008), an acknowledgement of social complexity (Healey 2007) and the rapidly-increasing sophistication of models (Walker et al. 2003). Handling uncertainty is particularly important when planning for long time periods, as in the case of climate change adaptation or the renewal of hydraulic infrastructures (van der Vlist et al. 2015). Planning and water management theorists have argued that uncertainty can be understood in multiple ways, with different impacts on the planning of water systems (Pahl-Wostl et al. 2007; Hillier 2013; van den Hoek et al. 2014a). If the consequences of uncertainties are not properly abated, planners can end up making unnecessary or inadequate interventions and decisions or interventions may turn out to be maladaptive (see Chapter 2).

Categorising uncertainty can help to identify the consequences of uncertainty for the planning of water systems. One way of categorising uncertainty is by its 'nature', 'level' and 'location' (Walker et al. 2003; Kwakkel et al. 2010b). Regarding its nature, scholars argue that uncertainty can be understood in three distinct ways (e.g., Walker et al. 2003; Brugnach et al. 2008; Kwakkel et al. 2010b). First, as a variability-induced concept (ontic uncertainty), which arises out of the nonlinear behaviour of a system and is irreducible. Second, as a knowledge-related concept (epistemic uncertainty), which is reducible by gaining more knowledge or conducting experiments. Third, it arises out of different frames of understanding the world (frame uncertainty). The level of uncertainty addresses the gravity and the possibility to quantitatively express uncertainty (Kwakkel et al. 2010b), while the location indicates what exactly is uncertain and refers to the water system, including its social and institutional components (van den Hoek et al. 2014a).

When deciding about interventions in water systems, planners need to deal with different uncertainties, but they also need to account for differences in the actors' interpretations of uncertainty. This is particularly difficult when planners need to incorporate long-term, irreducible (ontic) uncertainty into their decisions by means of adaptive planning tools and strategies. These different interpretations can

collide when collaborating in a planning process (Healey 2007). While several scholars point to the relationship between collaboration and adaptiveness (e.g., Connick & Innes 2003; Pahl-Wostl et al. 2007; Islam & Susskind 2012), little attention has been paid to the influence of collaboration on the ability to handle a variety of different uncertainties, and whether this leads to adequate interventions in water systems. Collaboration might influence if, when and how adaptiveness is used to handle uncertainty, or might challenge the presence of uncertainty. Therefore, we intend to contribute to the scientific literature by studying how the dynamics in collaborative planning enable or challenge the handling of uncertainty through adaptive planning.

Our research question is: 'What is the influence of collaborative planning for water systems on dealing with long-term ontic uncertainty through adaptive planning?' We studied a four-year planning programme to develop water resource management and flood safety strategies for the IJsselmeer. The main concern regarding the IJsselmeer was to provide a strategy to manage flood risk and water resources in the medium (2050) to long term (2100), primarily through interventions to control the water level. Climate change projections indicate sea-level rise, putting the water discharge ability of the sluices in the Afsluitdijk (built in the 1930s to close a former river estuary) under stress. Climate change may also reduce the influx from the IJssel River in times of drought and increase the inflow during winter (Deltacommissie 2008). Each of these issues is surrounded by considerable uncertainty as to the exact impact and viability of alternative management strategies. In the ensuing sections, we outline our research approach, describe the findings from the IJsselmeer case and, lastly, discuss our findings.

6.2 Research approach

To structure our research, we concentrated on three key elements of collaborative planning, which we hypothesised to particularly influence dealing with uncertainty with regard to interventions for the long term (e.g., Emerson et al. 2011; Hillier 2013). We were particularly interested in the uptake of adaptive planning when collaborating, and in elements already hypothesised in the literature to explain the handling of uncertainty. We first describe these elements and their expected relation to handling uncertainty through adaptive planning in our conceptual framework, before describing our approach and research methods.

6.2.1 Conceptual framework

We distinguished three elements which seemed to have a particular effect on the adequate handling of uncertainty (in addition to other elements of collaboration such as those outlined by Healey 2007; Ansell & Gash 2008; Innes & Booher 2010; Emerson et al. 2011). The first is a strong fixation on certainty, which results from actors not being open to uncertainty or being convinced of their own truth. These actors are subject to an illusion of certainty, or to a certainty paradigm (Hillier 2013). Fingland (2011: 2) states in this regard that: '[C]ertainty has "become central to the operation of the process and its justification"'. If different values and actor knowledges are incorporated into a planning process (Susskind & Field 1996; Innes & Booher 2010), perceptions of certainty can collide, and this can lead to a neglect of uncertainty. In addition, a fixation on certainty can be embedded in the local planning culture, which challenges the use of adaptiveness. Since adaptiveness starts from the premise of uncertainty, its acknowledgement is needed to make actors receptive to it. A fixation on certainty might hamper such acknowledgement.

Secondly, actors differ regarding their world views, goals, stakes or resources (Ansell & Gash 2008; Innes & Booher 2010; Islam & Susskind 2012). To make sense of decisions, actors frame facts towards their perspective. In such situations, uncertainty is seen as subject-dependent and a clash between different perceptions can lead to indecisiveness, doing nothing or overinvestment. Actors may overcome these differences in collaborative processes, although this can be problematic due to involved costs or the need to alter frames (Innes & Booher 2010). Under the influence of different actor perspectives, uncertainty can become subject to debate, which may hinder the adequate uptake of solutions when the result of negotiations is a wrong uncertainty definition.

A third element of collaborative processes is the occurrence of an unclear division in responsibility regarding the problem and solutions. This arises, for example, from a transition from top-down to bottom-up structured governance processes, resulting in fuzzy boundaries between institutional arenas in which collaboration takes place (Healey 2007; Newig & Fritsch 2009; Innes & Booher 2010). It is argued that collaborative projects are causing the traditionally clear sectorial and hierarchical organisation of water management to become less

structured, with no clear boundaries as to who is responsible for what (van Wezemael 2008; Albrechts & Balducci 2013). Through collaborative projects, new institutional arenas evolve. In these – sometimes temporary – projects, instead of the clear hierarchical organisation of water management, actors often have different foci on problems and solutions, act at different geographical scales and have diverging time horizons (Newig & Fritsch 2009). Moreover, these arenas are in constant change, leading to an institutional context in which representation and responsibility may become subject to debate (Allmendinger & Haughton 2009). The foci, problem perceptions and institutional boundaries can be so volatile that adequate use of adaptiveness is hindered. Therefore, planners should account for the inclusion of each arena and balance them interdependently.

We chose to focus on these three elements of collaborative planning because of the suggested influence on handling uncertainty when planning for long-term issues (Figure 6.1). This contrasts with an approach based on a full assessment of the different elements in a collaborative governance setting (e.g., Ansell & Gash 2008; Emerson et al. 2011) or collaborative planning (Healey 2007; Innes & Booher 2010). Instead of being comprehensive in terms of elements of collaboration, we intend to be comprehensive in terms of our dependent variables: uncertainty and adaptiveness, and show for the three particular elements of collaborative planning what their role is in handling uncertainty through adaptiveness. Since it is unclear how a fixation on certainty, different perspectives and the existence of different arenas interact with and affect how uncertainty is handled by adaptiveness, we use uncertainty as an entry point to analyse the collaborative planning process for long-term adaptive strategies for the IJsselmeer region.

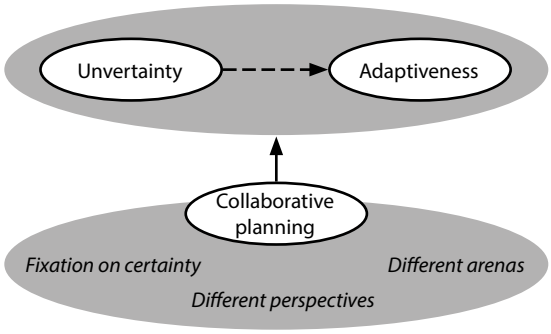

Figure 6.1. Conceptual relation between uncertainty, adaptiveness and collaborative planning.

6.2.2 Case study approach: the IJsselmeer

This study's research design is based on a single case study approach. The strength of case study methodology is that it enables research to develop emergent theory, in this case on the use of adaptiveness to handle uncertainty in collaborative planning processes. Case study research allows for high information richness and the exploration of sensitive issues such as contrasting perspectives and how these issues influence the handling of uncertainty (Farthing 2016). A single case study allows for in-depth study of a process and the mechanisms that influence the dependent variables (uncertainty and adaptiveness) (Beach & Pedersen 2013). This offers new insights for existing theories and cross-connections between themes, although it does not allow for generalisation (although neither does a multiple case study approach per se) (Thomas 2011; Yin 2014). Instead, it offers insight into a particular context for a particular problem, creating an understanding of what is wise in such situations (Thomas 2011; van den Brink et al. 2016). The role of the theory, described in the introduction and framework above, is to offer a heuristic to discover what drives the handling of uncertainty through adaptiveness in planning processes. It is used to find information and relations, in an exploration of the situation and findings from the collected material (Thomas 2011).

We investigated the planning process for long-term water management of the IJsselmeer and chose this case for several reasons. First, the national government, as initiator of the planning process, has explicitly addressed the need to deal with uncertainty. In this case, uncertainty existed in relation to climate change and the viability of the future management of the lake. Second, strategies were intended for a complex system including the lake, its surrounding water systems and dependent land uses. Strategies needed to be viable until 2100 because of the involved investments by actors in the area. Third, planners and water managers were stimulated to use an adaptive planning approach called adaptive delta management (ADM), which explicitly takes into account four scenarios to deal with uncertainty related to climate change and socio-economic development. All stakeholders (the major sectors being regional and local governments, nature protection, agriculture, recreation, transport and heritage preservation) were invited to the table as part of the planning process. This case can therefore be considered groundbreaking when it comes to the handling of long-term uncertainty in a large, multi-actor and multi-level

collaborative process for which adaptiveness was sought. It can offer an in-depth understanding of the relation between the variables described and act as an exemplar for comparable cases, in which the development of adequate long-term adaptive strategies involves uncertainty.

The IJsselmeer is situated in the Netherlands and has a water surface of 1,100 km^2 (Figure 6.2). Management of the lake is influenced by a centuries-long history of water management in the Netherlands. Over time, water management has become increasingly efficient because of the demand of high-revenue land uses and the technical feasibility of precise management. The idea of technocratic 'makeability' has reigned, both in the day-to-day operation and management as well as in long-term planning. Over the past decades, this has been perfected with the increasing precision of hydraulic models, the real-time steering of pumps, locks and weirs, and the management of water levels in all water bodies, including the IJsselmeer, to an exactness of one centimetre (van der Ham 2007). This strongly institutionalised technical precision has resulted in the diminished dynamical nature of both the lake and the river systems. Over time, most actors have adjusted their activities along the lake to the stable water level, increasing the need to limit alterations and demanding the sustenance of the set margins. The current margins for changes in water level are, therefore, small.

Figure 6.2. The location of the IJsselmeer, Afsluitdijk and IJssel River in the Netherlands.

Due to the increasing recognition of possible climate change impacts and the resulting need to adapt the water system, the government established the Delta Committee to investigate and recommend viable ways to manage the delta in the years up to 2100. The committee

presented its report 'Working Together With Water' (Deltacommissie 2008) in 2008 and advised investment in a multi-year programme to further investigate the effects of climate change and to create necessary water management strategies up to 2100. Their advice led to an intergovernmental programme, the Delta Programme, which was headed by a commissioner and encompassed six regional and three national sub-programmes. The Delta Committee proposed a phased approach. This approach should transparently deal with uncertainty and allow for adaptive implementation of the water management strategy to adjust to uncertain future climate and socio-economic developments (Deltacommissie 2008). In the Delta Programme, the ADM approach was therefore developed to support the strategy-formulation process (van Rhee 2012; van der Brugge et al. 2012; Vlieg & Zandvoort 2013). For ADM, the developers used insights from Dutch water management and planning practices, such as the Room for the River Programme (Klijn et al. 2012b; Zevenbergen et al. 2015), and scientific insights into adaptiveness (Haasnoot et al. 2013; Gersonius et al. 2015) and flexibility (Scholtes & de Neufville 2011).

6.2.3 Data collection, analysis and interpretation

We collected documents relating to the strategy-making process from 2008 (policies, intermediary plans, status reports, minutes of meetings, Appendix D), which was the year of publication of the 'Working Together With Water' report (Deltacommissie 2008), to 2014 when the Delta Programme delivered its main strategies. The documents were categorised according to the three main aspects of each phase of the process: knowledge production, formal policy formulation and documentation of collaborative activities (e.g. minutes of meetings and meeting reports), 36 documents were included in the final analysis. These three aspects and the included documents (Appendix D) were studied because of the assumed prevalence of descriptions of activities related to uncertainty, adaptiveness and collaboration.

In addition to these documents, data were collected via a focus group (Farthing 2016) during the strategy formation process, in which the process was discussed with actors involved in developing the water management strategy. Also, 11 interviews (Appendix E) were conducted to collect additional data about the process, future implementation, uncertainties involved and the role of ADM. We asked stakeholders

involved in the process about these topics in a semi-structured way (van den Brink et al. 2016). Interviewees were selected to provide information relevant to the IJsselmeer process using purposeful sampling (Seidman 2013). Relevance was determined based on involvement in the process as an expert or stakeholder and institutional background, to account for different perspectives.

The data were analysed to construct a case study narrative, addressing uncertainty, adaptiveness and collaboration in the evolving water management context. We interpreted the data in a bottom-up coding procedure. We first traced how uncertainty was dealt with. If we encountered references to uncertainty we explored whether these were related to the three elements identified for collaborative settings. We did this by coding for instances in which ontic, epistemic or frame uncertainty or connected responses were described. We also coded for the three elements of collaboration we were interested in. By categorising the insights into uncertainty and the elements of collaboration according to the four different phases in the process, we determined which uncertainty received the main emphasis in each phase and traced the connection with a fixation on certainty, different perspectives and different arenas (Beach and Pedersen 2013). We hypothesised that collaboration has a decisive role in the connection between uncertainty and adaptiveness, which might turn out to be either positive or negative as far as dealing with uncertainty through adaptiveness is concerned.

Following this analysis, we discussed our preliminary findings with three key informants involved in the planning process to verify our preliminary results and to query for additional insight into the relation between uncertainty and the collaborative setting in the IJsselmeer process. This enabled us to further fine-tune our findings and corroborate them through a critical evaluation of the practitioners themselves, allowing for mutual reflection (Schwartz-Shea & Yanow 2012).

6.3 Results

In this section we present the findings of the study in four steps. First, we address how the strategy-making process in the IJsselmeer programme started and how agenda-setting activities turned out to play a decisive role in the perception of uncertainty about future

climate change. Subsequently, we study the scoping phase, in which different studies were carried out and multiple strategies were reduced to a few preferable ones. The third section analyses the finalisation of the strategy, while the fourth section addresses the ongoing implementation phase of the strategies. For each of the four phases in the strategy-making process, we discuss the role of uncertainty and the three elements: a fixation on certainty, different perspectives and different arenas.

6.3.1 Agenda-setting in the Delta Programme IJsselmeer

The Delta Programme IJsselmeer (DPIJ) bureau was established in 2010. It was legally bound, and funded, by the Delta Act to carry out its commission for the next four years (Vink et al. 2013); an assignment that was partly formed by government preferences. As a government policy advisor stated: 'The time was right for a far-reaching programme that included both research and planning.' The broad assignment was to also prepare for a National Water Plan in 2015, an obligation under the European Water Framework Directive, which would be more coherent if informed by a long-term strategy. The DPIJ staff consisted of policymakers from all layers of government (ministries, provinces, municipalities and water boards).

The Delta Committee played a crucial role in the agenda-setting phase by proposing to raise the water level at the same pace as the predicted sea-level rise (Deltacommissie 2008). As a result, the committee's proposal was to prepare for an increase in the water level in the lake of up to 1.5 metres by 2100. This proposal was highly controversial (Zegwaard et al. 2014) and fiercely opposed by regional and local partners, who stated that raising the lake's water level was not necessary at all. Weakening the advice of the Delta Committee, the assignment for the DPIJ was subsequently formulated as (1) to achieve an outcome that would satisfy the different regional and national partners, and (2) to develop a strategy sufficient to deal with the projected climate change effects up to 2100, while also taking into account socio-economic trends and local desires. In the first phase, the bureau developed four possible strategies regarding the water level in the lake which were connected to safety, water provision and spatial quality issues.

Regarding the first element (fixation on certainty), we found that some of the actors neglected uncertainties regarding regional socio-economic change. As one interviewee stated: 'They [the actors in the area] perceived [socio-economic change] as something that was not uncertain because it is steerable and manageable in the region itself. It is perceived as being not exogenous to the area.' This hints at a culturally-embedded sense of certainty among the stakeholders based on the idea that socio-economic change can be steered and properly managed for their desires, thus offering certainty regarding their investments. In this phase, the choice was therefore made to exclude socio-economic variables.

In this first phase, we found that the different perspectives strongly corresponded to the different arenas, and that the actors in the different arenas highly opposed the committee's advice. According to several interviewees, however, the failure of the 2008 advice due to the fierce opposition in the whole IJsselmeer region did at least have the benefit of creating a strong coalition of regional partners across different arenas who, as one of the interviewees put it, 'for the first time really sat together around the table' (see also Zegwaard et al. 2014). This regional coalition consisted of different representatives from multiple institutional arenas and initially enabled the acceptance and use of adaptive planning, as well as agreeing on at least one issue, which was to discard the advice to increase the lake's water level by 1.5 metres.

6.3.2 A collaborative fact-finding process

The aim of the second phase of the Delta Programme was to focus the strategies to create a viable set of alternatives. This initially started with efforts by the DPIJ bureau to organise fact-finding. At the DPIJ bureau, strategists argued for shared responsibility for the problem definition and analysis. The different actors explored the local problems that would arise if a change in the IJsselmeer's water level were to take place. These explorative studies all pointed in one direction, as described in the minutes of the second large stakeholder meeting: 'The system boundaries are largely reached' and 'The system is indeed inflexible. This inflexibility applies to the design, management and use of the system.' Over the course of decades, the water system had become rigid. Both the larger water bodies (lakes and rivers) and the smaller canals and ponds had been given fixed water levels to sustain different

functions. Any attempt to make the water system more flexible was constrained by these different functions, which over time had adapted to the rigid water management system. A general conclusion of the fact-finding process was that there was not much room to manoeuvre to alter the management of the system without changing this status quo of functions. The solution was sought in gradually increasing flexibility in the system. To do so, no-regret measures under all climate change scenarios were a change towards a more flexible water-level regime and the installation of pumps to increase capacity for water-level management in the IJsselmeer and the surrounding water bodies (lakes, ponds, canals and rivers).

In the fact-finding phase, we observed a shift from debating ontic uncertainty about the impact of climate change on the water system towards debating epistemic uncertainty concerning the amount of flexibility allowed within the boundaries set by current functions. This shift was especially visible in a refined problem statement for the IJsselmeer in the national Delta Programme 2012. Here, climate change is only mentioned in relation to its influence on the regional water system and the proposed solution of the Delta Committee, which was discarded based on new scenario studies for sea-level rise. While climate change scenarios were used to create different strategies, we found that actors demanded less extreme climate change scenarios that would 'limit the uncertainty to manageable proportions.' A central theme in the documents in this phase is the amount of possible flexibility, and stakeholders' concerns with increasing flexibility. This can be illustrated by formal questions from a consulting round among all involved governmental organisations, in which climate is mentioned just twice: once related to a possible lock-in of the current choices and once related to water sport facilities. Sea-level rise scenarios are mentioned regarding a possible lower level than currently planned for (15 cm instead of 85 cm in 2100). The answer given to this question from a stakeholder is telling. Instead of debating sea-level rise predictions, this governmental official pointed to the adaptive properties to avoid overinvestments, framing the discussion about sea-level rise as redundant for the strategy. In this phase, the bandwidth of possible water-level fluctuations increased, but the limited flexibility of the water level in the lake is not questioned in our data in terms of its effectiveness in dealing with climate change. This indicates a shift in attention from ontic to epistemic uncertainty in the collaborative process.

In the fact-finding phase, a fixation on certainty was only found to be connected to different arenas. While at this stage there was not a full demand for certainty, the involved actors clearly could not accept too much uncertainty in the fact-finding process. The reason for this lack of acceptance of uncertainty by actors is the threat of a strong increase or decrease in the water level for the various functions that depend on the water level. An increase or decrease in the water level would cause large problems, for example for agriculture, nature, flood risk management, recreation and infrastructure. Despite these problems, the actors came to a partly shared problem perception regarding the future management of the water level, which translated in 2011 into a shared vision of climate change impacts. However, this did not result in a shared perspective on a water management strategy, because further research was necessary. Unclear issues included the effects of future management choices on local water use and water system functions, and the division of costs for possible solutions.

Regarding the second element (different perspectives), the start of the process led to emphasis from the DPIJ bureau on building mutual trust among the stakeholders. To do so: 'The participants in this [joint fact-finding] phase [we]re asked to rise above their own stakes, to look at the full picture of the IJsselmeer and to perceive the information objectively.' This should allow for the continued existence of conflicting values and ideas about what is factually right which, according to the DPIJ bureau, should enable 'taking good decisions, which do justice to what's going on in the area.' We observed a contrast with the worries of policymakers, residents and politicians regarding the applied upper range of the climate change scenarios, which was perceived as being not very likely (i.e. unrealistic). Despite the emphasis on building mutual trust and the shift towards epistemic uncertainty, the DPIJ bureau still regarded ontic uncertainty concerning long-term climate change as something that should be addressed, at least to introduce some flexibility in the water level in response to sea-level rise.

6.3.3 Strategy finalisation

During the strategy finalisation phase, two debates took place in which uncertainty had a key role. In the first debate, uncertainty had a role in two different arenas of concern for the IJsselmeer. In the second debate, there was uncertainty concerning the water level and the final decision

to install pumps in the Afsluitdijk (see also Janssen et al. 2014). In both debates, epistemic uncertainty was important and major efforts were undertaken to decrease uncertainty through additional research. The IJsselmeer process was influenced by uncertainty both about upstream river discharges and the strictness of the new national safety standards. The resulting uncertainty can be characterised as both epistemic and frame uncertainty because, in these decisions, different perspectives both conflicted and were unresolved (frame uncertainty) and it was not yet known what the exact change would be in both river discharge and safety standards, due to pending research. In the process regarding the Afsluitdijk this is coupled to uncertainty about which course to take (epistemic uncertainty). We first discuss the debate on the two external decisions and then link them to collaboration in the DPIJ strategy-making process.

The IJsselmeer strategy partly depends on the future discharge distribution for the IJssel River. This distributary of the Rhine determines the amount of water that needs to be discharged via the sluices in the Afsluitdijk. Moreover, in times of drought the IJssel River is the main supplier of fresh water into the system. Where the IJssel meets the river Rhine, water managers can to some extent determine the percentage of discharge via the IJssel and the other two distributaries at times of low discharge. This discharge regime was discussed and studied in another arena. The other decision on which the IJsselmeer process depended was about the flood safety standards, which were to be updated based on national studies, but which would necessitate additional investments along the IJsselmeer shore. The old standards were based on probabilistic calculations of water levels. Changes to the safety standards and the underlying method of calculation would lead to different requirements for flood defences along the IJsselmeer. In the end, the decision made regarding the discharge distribution was to leave it unchanged, because the epistemic uncertainty remained too large, while time and money did not allow further research at that moment. The safety discussion was resolved with the conclusion that any possible alteration of the safety standards would have a negligible effect on the water level. This is because the freshwater system is much more sensitive to alterations in the water level than the flood protection system. The water level discussion therefore only proceeded regarding flexibility for freshwater availability and the discharge capacity of the sluices in the Afsluitdijk, while the safety discussion was temporarily abandoned.

In the second debate, concerning freshwater storage and supply and related to the discharge capacity of the Afsluitdijk, the final decision was to install pumps to better manage the discharge to the Wadden Sea. The instalment of pumps is described as a no-regret solution for all scenarios and related strategies because the pumps enable water managers to create a water level closer to the current level than to rising sea levels at the receiving end of the pumps. We found that the created flexibility could well turn out to be a strategic inflexibility regarding future water management, as the more the sea level rises, the more pumping capacity will need to be installed to keep pace with this rise. Future adjustments of the functions that depend on the water level along the shores of the lake were deemed too costly, unacceptable and far-reaching compared to this ongoing instalment of pumps.

Regarding fixation on certainty, the instalment of pumps sustains, and possibly even creates, a new fixation on certainty that is related to the responsibility of managing the lake and the use of pumps. The availability of pumps to manage the lake's water level makes Rijkswaterstaat better able to manage and guarantee a specific water level in the perception of actors. The water level can consequently be perceived, even more than is currently the case, as fully manageable, which provides full certainty about the availability of water. As a strategist at the DPIJ said: 'It's very funny. If you say the water level should be more flexible, everybody applauds: "yes it should!" But if you look at all the reactions to the concrete proposals, then flexibility suddenly means: "we should more strictly regulate the intended water levels to reduce variability"'. This perspective on flexibility could result in a more rigid interpretation of the responsibility of Rijkswaterstaat to manage the water level. If, for some reason, high water levels cause damage along the shore of the IJsselmeer, Rijkswaterstaat can no longer blame this on the dynamics of nature. Rather, any damage will be the result of the improper operation of the pumps in managing the water level. The discussed fixation on certainty regarding management practices and the responsibilities of water managers and actors may, thus, hamper adaptive planning due to a lock-in of actors' fixation.

Regarding different perspectives, a cultural lock-in on a vision of the water system as being closed was visible in the DPIJ strategy formulation. The system, which once was highly dynamic, became fixed when the Afsluitdijk was closed in 1932. The spatial developments along the IJsselmeer's shore were adjusted to this seemingly stable

and closed situation, leading to an increasing lock-in regarding the specific water level. This water level is based on consensus between different perspectives about what has been the best water level for sustaining all functions between the 1940s and 1950s up to the present. Overcoming the current static situation, which was perceived as being a main goal in light of future developments, demands breaking open the consensus and allowing different perspectives to challenge the status quo. However, the unsettling effect of different perspectives has made it difficult to establish a new status quo in which flexibility in the water system becomes accepted. Perhaps the largest struggle for the DPIJ bureau was to change the perception of the IJsselmeer as a static and closed system to an open and dynamic system, albeit still within boundaries. However, building pumps on the Afsluitdijk is contradictory to this perception of a dynamic and open system behaviour. Pumps create a dependency on a paradigm of precisely determining the lake's water level. Although the system is in any case technically managed, cultural sensitivity to this dependency might be necessary to open the solution space in the long term, for example if flexibility in the water level needs to be increased in the future. We found that this lock-in on a specific water level hampers adaptive planning in response to uncertain climate change.

The different arenas relate to the debate about safety standards and river discharge outside the DPIJ arena, which added additional uncertainty to the IJsselmeer process. This debate can be coupled to uncertainty about which course to take (epistemic uncertainty) in other arenas, while the altered responsibility meant that the debate became external to the DPIJ's strategy-making process. The possible decisions were subject to debates in other arenas and thus bound to other interests and frames of reference, which increased frame uncertainty for the DPIJ process. This unclear institutional situation led to frustrated comments from actors regarding cooperation within the national, intergovernmental programme. For example, a representative of the Zuiderzeeland water board made the following comment on the progress report: 'Keep local democracy [municipalities and provinces] sufficiently involved in the process. I see a lack of information', and a representative of the province of Friesland said: 'Decisions are not only taken in The Hague! [the seat of national government].' This unclear institutional situation and different views on collaboration also hampered adaptive planning, because the uncertainty arising from the large number of institutional variables and debates became too large

to envision alternative trajectories for the lake that could count on sufficient support at this stage of the process.

6.3.4 Ongoing implementation

Following the presentation of the final strategies in Parliament in 2014 and a change to the National Water Plan, the implementation phase started in 2014. However, the strategies only accepted minor flexibility in the IJsselmeer's water level. A programme of future actions for the years after 2014 was proposed to improve flood safety and to implement a monitoring system for future choices related to drought. The proposed strategy ensured that the discussion regarding options for steered adaptation, such as pumps in the Afsluitdijk, was placed on the long-term agenda, with just limited water-level adjustments in the short term. This was coupled to a lock-in on the pump-based solution, limiting system openness now and in the future. The DPIJ debate was dominated by a constant trade-off between the regional water system supporting the hinterland and the functions of the total lake system. The result was an emphasis on the constant ambiguity between the frames of the various actors. This concerns both ambiguity between the frames of stakeholders in the IJsselmeer and between stakeholders in upstream arenas, thus inducing both internal and external frame uncertainty to the IJsselmeer process. The trade-off, both in an economic and a cultural-historic perspective, means that no actions were taken that might affect the system at large. The constant message seemed to be: limit any increase or decrease in the water level. The conservative view, which was to maintain the current situation, displays a constant emphasis on the short-term perspective, based on the current configuration of the system, and certainty for the functional demands in the area. This was clearly visible in the summary of the final strategy: 'in the short term, the remaining space in the water system is used. A small alteration in the water level is sufficient. (...) In the long term, it will be researched how the water demand can be handled best', showing that the long term is still not included and requires further research. This was also linked to an awareness of what is called the *bestuurlijke werkelijkheid* which translates as *administrative reality*. This administrative reality seems to be one of the hardest things to overcome for future-oriented water management in a democratic society, which can be illustrated by statements such as: 'We search for continuity, but have to deal with the administrative reality' and 'Because

the most extreme alternatives [for water management solutions in the IJsselmeer] were deliberately included, they are far removed from administrative reality.'

In the implementation phase, we observed a close relationship between a fixation on certainty with the current situation, creating a high likelihood of what politicians and inhabitants can expect in the years to come. This contrasts, however, with adaptive planning, in which change and uncertainty are decisive in formulating strategies. While being an obstacle to adaptive planning for the whole system, the chosen strategy itself might enable a desired trajectory for climate change adaptation due to the provision of legal certainty for stakeholders who are sure of their revenue from climate-positive investments. This, however, does not enable flexibility on the scale of the whole water system.

Different perspectives were found to relate to the responsibility of local and national water management authorities. Ambiguity arose in relation to water managers' responsibilities to provide a certain water level. There is a difference between water use in an area and sustaining societal functions of the water system. In the debate about the water level and instalment of the pumps, the main argument put forward was to lower the upper limit of the water level in the lake to protect existing societal functions. This changed, however, into a vision of actors seeing the pumps as tools to enable specific water usage. In contrast to water system functions, water use is local and subject to debate among actors with diverging preferences for a specific water level. Moreover, the water level is bounded by physical system characteristics which limit alterations for such preferences, while put under stress by climate change. Problems arise due to different perspectives on the uncertainty related to these boundaries, but also due to different perceptions on the role pumps should have in managing the water level for different interests. The hurdle imposed by different perspectives was tied to an unclear demarcation between the water system, its societal functions, water usage, and the relation with system rigidity and flexibility. These differences are ultimately expressed as a reliance on technical measures or not.

Multiple arenas were involved in adaptive planning regarding the ongoing implementation phase. In the IJsselmeer collaboration, an essential feature of the strategy according to different actors was a continuation of existing policy in each arena, rather than a large

deviation from current practices. Only gradual change, as was ultimately proposed for the management of the IJsselmeer, was deemed fitting in the specific institutional context. This was shown to be a hurdle regarding dealing with uncertainty, as it can lead to a false sense of being on the right path, due to the established consensus among the multiple arenas concerning the way forward. It is not yet possible to say how the strategy for the IJsselmeer will turn out in terms of effecting a lock-in or setting course on a different trajectory, but by choosing to use pumps it remains firmly fixed in the existing technological practice that has dominated water management for the past decades.

6.4 Discussion

In this section, we first discuss how the focus on uncertainty changed during the process. We then discuss the three elements of fixation on certainty, different perspectives and existence of different arenas, and how they influence the handling of uncertainty.

One of the main observations in this study is that ontic uncertainty was treated as epistemic uncertainty and became subject to different perspectives during the collaborative process. This was particularly visible in the use of extreme scenarios and the discussion about the necessity of alternative strategies, which was influenced by colliding perspectives and a fixation on the status quo of functions. It appeared difficult to deal with ontic uncertainty in the IJsselmeer case, despite the use of adaptive planning. We observed that dealing with the inherently irreducible, ontic uncertainty was quickly pushed to the background. Under the influence of a strong fixation on certainty, the emphasis changed to attention to values and visions of actors regarding issues that were manageable, such as the water level in the lake. This shift took place through a focus on epistemic uncertainty about the possible decisions and interventions in the second phase.

A second insight is that the collaborative setting influenced how uncertainty was treated in each phase of the planning process, but with different causal relations in each phase (Table 6.1). Handling uncertainty was problematic due to holding onto an existing fixation on certainty, different perspectives on the long-term feasibility of technical measures among participants, and fuzzy boundaries and unclear responsibilities between arenas. These issues determined which uncertainty was

dominant and which role was sought for adaptive planning throughout the process. A reason for their influence is that, while being vital for choosing adequate measures, what uncertainty entails and what its consequences are for a long-term water management strategy have not yet been fundamentally discussed (Pahl-Wostl et al. 2007). The main hurdle seems to be an existing fixation on certainty, embedded in reliance on technical measures, which has led to an inflexible manner of managing the water system. Also, responsibility turned out to have a major role in each of the challenges posed by collaboration, since the public water authority was confronted with different perspectives and different stakes arising in multiple involved arenas. Collaboration pushed the focus on ontic uncertainty and the responsibility for its impact to the background. Only the DPIJ bureau, bearing responsibility for the total system, continued to highlight that it is this ontic uncertainty about the changing climate that, despite the consensus reached, will have major effects on the area. This is also connected to the perspectives of different actors, who only have short-term interests and responsibilities.

The IJsselmeer case supports the idea that categorising uncertainty based on its characteristics (Walker et al. 2003; Kwakkel et al. 2010b) can enable analysis of how different types of uncertainty are treated in collaborative planning processes. The findings contribute to the further exploration of how collaboration affects the handling of uncertainty and identifies causal relationships between elements of collaborative processes and uncertainty or adaptiveness. The results, however, should be applied with some caution when generalising, because the IJsselmeer water system is a specific case, in particular regarding the highly artificial and technical management of the system. This also applies to the collection of data. Studying how uncertainty is dealt with and what hurdles collaboration creates for the adequate use of adaptive planning could be strengthened by an ex-ante research design. An ex-ante design would allow for the better detection of uncertainty by collecting different types of data, in addition to interviews and artefacts of the strategy formulation process, such as data from participatory meetings and observations from action research. Another consideration in interpreting the results concerns the adaptive planning principles and tools applied in the Delta Programme. ADM was not yet fully crystallised at the start of the Delta Programme, and scientific reflection on, for example, the underlying adaptation pathways approach (Haasnoot et al. 2013; van der Brugge & Roosjens 2015) and ADM itself

Table 6.1. The differences between the type of uncertainty and adaptiveness and the pointers for the causal relationship between the three elements in each of the phases.

	Phase 1	Phase 2	Phase 3	Phase 4
Uncertainty	Ontic uncertainty about sea-level rise (SLR) and socio-economic trends	Epistemic uncertainty in the debate about flexibility in the current system organisation	Epistemic uncertainty partly reduced with research, lack of resources hindered additional study Frame uncertainty remained about river discharge measures	Frame uncertainty about the use of pumps within the system organisation and frame uncertainty about the responsibility for solutions
Adaptive planning	Flexible water level with a tiered approach was accepted to discard a 1.5m water level rise	Adaptiveness challenges the current functions, leading to a plea for low flexibility and gradual adaptiveness over time	Flexibility and water-level change was only pertinent for freshwater supply Sluices and optimisation of regional water management were the main solutions found to enhance adaptiveness Alternative trajectories could no longer be envisaged	Low level of variation in the water level is allowed; other adaptive options were suggested for the mid to long term
Fixation on certainty	Fierce opposition to suggested water-level rise – strong sense of status quo Certainty about control over socio-economic change	Climate change scenarios perceived as certain, extremes as not very likely Considered uncertainty within manageable limits	Pumps offer additional certainty and guarantee management of the water level to some degree. This affects adaptiveness by creating new fixation and cultural inability to handle uncertainty	Status quo maintained, system remains closed and manageable using pumps. Suppresses lower or higher water levels. The current situation and expectations for users and politicians overrule change and ontic uncertainty about climate change
Different perspectives	Included after fierce opposition Brought together due to advice of the Delta Commission (national level)	Fear among users of changing functionality conflicted with necessity to handle SLR and climate change	Flexibility can be seen as creating more headroom to manage the water level (national level) versus better (strict) control of the water level (regional partners) This is in line with an open, dynamic system perspective versus a manageable, closed system	Functions provided by the lake (long-term perspective) conflicted with the sustenance of current usage (short-term perspective). These two perspectives originate from ambiguity about climate change impacts and responsibility between local and national authorities and the demarcation of the water system
Different arenas	Strong conflict between national arena (Delta Commissioner advice) and regional + local arenas Acted as a lever to bring different perspectives together	Tension arose concerning responsibility for solutions to the SLR problem Arenas shown to be dominated by different uncertainties: national level / DPIJ bureau – ontic; regional partners – epistemic	Multiple other arenas influenced the process. This led to discarding of the safety discussion altogether and left additional epistemic uncertainty about river discharges	Administrative reality is decisive for the perception of scenarios and climate adaptation. Scientific 'facts' are mitigated to the institutional arena in which decisions about what is incorporated or not are made An intricate relation between arenas, responsibility and perspectives on the use of pumps was shown to be decisive for handling uncertainty

(Gersonius et al. 2015; Zevenbergen et al. 2015) had only just started. This meant that adaptive planning itself was subject to debate during the process. Future research into adaptive planning should enable trials and tests to refine and improve implementation.

6.5 Conclusions

We investigated how collaboration influenced the handling of uncertainty through adaptive planning. We took a case study approach to explore this and identified three elements of collaborative planning processes that might complicate the handling of uncertainty. These were explored in terms of their explanatory force for handling uncertainty in the IJsselmeer planning process. This study has shown that collaboration can cause uncertainty to sometimes be treated as a different kind of uncertainty than it actually is. Shifting the emphasis from ontic to epistemic or frame uncertainties leads to the danger of not taking appropriate interventions in time to be prepared for the risks of climate change. While adaptive planning is developed for taking appropriate interventions amid ontic uncertainty, not assuming or reasoning away ontic uncertainty is at least problematic for its adequate use.

The results of this study also indicate that the studied elements of collaboration indeed trigger such shifts. It is possible that actors will tend to have a fixation on certainty rather than on uncertainty in many more collaboratively managed water systems. The inclusion of different perspectives can increase this fixation, even when mutual trust and clear responsibilities for solutions are established. Adaptive planning was shown to challenge the status quo and open up possible threats to existing functions, creating resistance from actors. The IJsselmeer process showed that different arenas can shift the attention to particular details of a solution not congruent with the particular uncertainties affecting a problem. While the confrontation of perspectives from the different arenas can break the fixation on uncertainty open, in the IJsselmeer case it triggered a shift from ontic uncertainty to epistemic and later frame uncertainty (Table 6.1).

In addition, responsibilities and system perspectives play an important role in dealing with ontic uncertainty about long-term changes affecting the water system. The actors involved in the management of water systems often have different perspectives on the water system.

Although our study had a specific context due to the highly technical management of the IJsselmeer, it can be concluded that, at a minimum, a clear demarcation between the system properties, the societal functions of water systems and water use are necessary to make adaptive planning successful. Responsibility is not equally distributed among public and private actors, creating an additional hurdle when dealing with uncertainty, which corroborates findings from other studies (e.g., Mees et al. 2015). Shifting decision-making authority back to those who bear responsibility could be necessary to prepare for uncertain climate change.

Possible directions for future research lie in the domains of uncertainty studies and adequate adaptive planning. A systematic tracing of uncertainty in policy development could enable the further testing of adequate ways of handling uncertainty. After our and other attempts to trace uncertainty from different perspectives (e.g., van den Hoek et al. 2014a; Lorenz et al. 2015), a future research direction could be to develop a more formalised process tracing tool to assess qualitative data on uncertainty descriptions in relation to the full range of elements in a collaborative process, particularly for large-N comparative case studies (Ansell & Gash 2008; Farting 2016). Another direction for future research could be to test adaptive planning in different institutional and cultural contexts (van der Brugge & Roosjens 2015). We have shown that institutional aspects can influence the use of adaptive planning, depending on the cultural context. Further advancement in the coupling of adaptive planning and collaborative processes is necessary to adequately deal with uncertainty in water management situations.

7

Discussion and conclusions

Discussion and conclusions

This thesis set out to investigate how adaptiveness is understood in spatial planning and used in planning practices to handle uncertainty. The study was prompted by the attention given to adaptive planning in the Dutch Delta Programme, a programme that aims to deliver long-term strategies for water management, and was undertaken after signalling contradicting understandings of uncertainty in planning theory. These contradicting understandings call for clarification. Also, since uncertainty is an important reason for using adaptiveness in planning, studying uncertainty is relevant to both theory and practice. It is particularly important to consider uncertainty and adaptiveness when planning for interventions in deltas. Deltas, which are made up of closely interlinked socio-physical systems that face pressing challenges caused by climate change and urbanisation, require long-term infrastructure investments. These are investments in interventions that will set the boundaries for how deltas can transform in the near and far future, but that are also necessary to sustain existing land uses and water-related functions. Uncertainty affects the taking of adequate interventions, which are understood as interventions that are appropriate to account for the uncertainty at hand. For planners, adaptiveness holds the promise that uncertainty is accounted for in their interventions.

Against this background, the purpose of this study was threefold. First, to investigate what uncertainty is exactly in the context of planning for interventions and long-term spatial transformations. Second, to obtain insight into what adaptiveness is and to explore how it can help planners decide about interventions amid uncertainty. Third, to

elaborate on the applicability of adaptiveness in planning practice. These objectives were addressed by the following research question:

What differentiation of uncertainty helps planners to decide about interventions in delta areas and to what extent does adaptiveness contribute to handle this uncertainty?

Two theoretical explorations led to a conceptual understanding of *uncertainty* and *adaptiveness*. Uncertainty is a concept which contains different types, of which an understanding offers insight into adequate and warranted planning interventions. Adaptiveness refers to a type of planning which is stepwise and intentionally focussed on ongoing adaptations based on uncertain future change. Interpretative analysis of several cases provided insight into what is meant by uncertainty and adaptiveness and what these concepts entail for spatial planning. In these cases, the expression and empirical manifestation of uncertainty and adaptiveness were studied for three elements of spatial planning, namely planning approaches, planning tools and planning processes. Approaches and tools are of particular importance when planners take uncertainty into account, because they aid the preparation for interventions. In planning processes, the use of approaches and tools is altered by actors operating at different institutional levels and with conflicting stakes. A premise in this thesis was that the way in which planners use adaptiveness in planning practices in which they are confronted with uncertainty might determine the adequacy of interventions (and related approaches and tools).

In the subsequent section, I offer my conclusions based on the findings of this study. I then discuss what my conclusions may mean for handling uncertainty through adaptiveness in the context of the logic underlying adaptiveness, the operationalisation of adaptiveness and the normative issues when using adaptiveness in planning practices. In the next section, I reflect on the research design. The chapter ends with an indication of the societal relevance of this study and suggestions for future research.

7.1 Answering the research question

To answer my research question, I first unravelled what uncertainty in planning is. I found that the recognition of different types of uncertainty and their understanding offers insight into adequate and warranted planning interventions (Chapter 2). Second, I proposed a typology of adaptiveness in planning, based on a qualitative systematic review of the scientific literature (Chapter 3). Because these two theoretical explorations would give an incomplete answer to my research question, I studied three elements of spatial planning in order to understand and evaluate how adaptiveness is used to handle uncertainty in planning practices. First, I studied two planning approaches originating from the audacious attempt of practitioners to get a grip on situations fraught with uncertainty (Chapter 4). Although the studied approaches (the water diplomacy framework and adaptive delta management) both claim to offer a coherent planning approach to handle uncertainty, they were found to relate to different orientations in planning. Water diplomacy to a collaborative, consensus-based planning orientation and adaptive delta management to a rational, instrumental planning orientation. Second, I studied the application of a tool that aims to support planning: adaptation pathways (Chapter 5). This tool was developed to help planners develop policy strategies for the long term, which is deeply uncertain. The tool's use was studied in different climate adaptation planning practices. Third, I followed how planners effectuated adaptiveness in their collaborative planning process in one case, which was strategy-making for the IJsselmeer area (Chapter 6). I elaborate on these studies below and on my theoretical explorations to synthesise the findings and answer my research question.

7.1.1 Uncertainty in planning for spatial interventions

An understanding of the consequences of uncertainty for planning is needed to enable planners to adequately handle amid uncertainty. I started studying uncertainty based on the premise that, without a proper understanding of uncertainty, planners will find it difficult to choose the right intervention. A 'right' intervention is adequate to the uncertainty at hand and warranted as to its outcomes. Adequacy is of prime concern, since it relates to tailoring an intervention to the specific uncertainties with which planners are confronted. The second concern is taking a warranted course of action, which is a course of action that

is valid in terms of its goal-orientation, legally correct and does justice to the affected parties. An intervention could be the implementation of physical infrastructure, but also drafting plans, defining design standards, developing strategies, and so on.

Spatial planning theory does not yet offer an understanding of uncertainty that can coherently inform spatial planning interventions. Coherent information about different uncertainties and their implications for planning is only possible if there is a framework that builds on a plural understanding of uncertainty. Such plurality can be found in the different characteristics of uncertainty that planners can use to determine which sort of intervention is adequate. At the most abstract level, this is a question of how to cope with uncertainty or, if possible, how to reduce uncertainty. The main characteristics by which uncertainties should be distinguished to offer a congruent set of implications are uncertainty's nature, level and location.

Planners who intend to intervene in deltas are confronted with different uncertainties simultaneously, which can be distinguished by their nature, level and location. The nature of uncertainty refers to the origin of an uncertain phenomenon and informs about the possibility to reduce an uncertainty. Uncertainty may have an ontic, epistemic or ambiguous nature, and the planner can determine distinct interventions that are most adequate to deal with the prevalent uncertainty. Ontic uncertainty implies that an uncertainty is irreducible and can most adequately be handled by adjusting the object of planning to the specifics of the uncertain variable. Epistemic uncertainty implies reducibility and can most adequately be handled by gaining more knowledge. Ambiguity implies conflicting frames, which can be partly incorporated into the planning process to build on a common knowledge base and to align frames.

The level of uncertainty offers pointers about the type of knowledge that can be derived about an uncertain variable, which constrains the choice of planners for specific interventions. In this thesis I used the four levels of uncertainty distinguished by Kwakkel et al. (2010b). Level one, shallow uncertainty, refers to variables for which multiple alternatives can be enumerated including a probability of occurrence. With level two uncertainties, medium uncertainty, planners are unable to distinguish probabilities, but can still rank order alternatives based on likelihood. Level three, deep uncertainty, refers to a situation where neither the

plausibility nor likelihood of different alternatives can be distinguished. Level four uncertainty, recognised ignorance, is a situation where planners are not able to enumerate different alternative events and can only admit they might be surprised. This informs planners, in that they know that handling level two uncertainties can be informed with probabilistic information, while probable scenarios can be enumerated for a level three uncertainty, but without a probability distribution to determine the chance a particular scenario will occur.

The location of uncertainty points to the place where an uncertainty manifests itself and is important when determining where to intervene. For example, this can be a choice about interventions in either the institutional setting (is co-construction a feasible solution?) or the physical environment (is a different dyke alignment adequate?) of a planning practice, and the scale of an intervention (a dyke reinforcement or a change in a river's discharge distribution). Each of the characteristics of uncertainty implies something about the adequacy or inadequacy of specific interventions and indicates whether an intervention is warranted with regard to its outcomes. This is unequivocal for each characteristic: an intervention is adequate for abating an uncertainty with specific characteristics, and can be inadequate if these characteristics are not incorporated. An example is that an intervention in the institutional setting (for example co-constructing knowledge with multiple actors) is not adequate to reduce epistemic uncertainty about dyke strength, while measuring the strength of a dyke (adequate to reduce epistemic uncertainty) is inadequate for coping with ontic uncertainty about the future river discharge (for which strengthening or heightening the dyke might be an adequate solution). Uncertainty is, thus, a plural-unequivocal concept.

A plural-unequivocal conceptualisation of uncertainty distinguishes uncertainty from risk and offers a broad understanding of uncertainty, crossing different orientations in planning. Uncertainty understood as plural-unequivocal differs from risk (Knight 1921; Gardiner 2010) and is not a strictly relation-dependent, subjective concept (Gunder 2008; Hillier 2013). It contrasts to the handling of uncertainty as singular, that is without distinguishing possible differences between uncertainties (Islam & Susskind 2012; Gunn & Hillier 2014), or subjective to a specific type of planning (Alexander 2015). Uncertainty differs from risk because the latter is by definition focused on the adverse consequences of an activity, or the possibility of these. Uncertainty

can result in risky activities, but not necessarily. In a plural-unequivocal conceptualisation, uncertainty in planning is never strictly subjective, since the uncertain future behaviour of variables will affect planning nonetheless. In particular planning situations, this can result in a paradoxical tension, because planners need to deal with uncertainty as both a subjective aspect of actor perceptions and a real, objective aspect of phenomena. An example of this tension is that increasing the height of a dyke does not offer a solution for ambiguity due to actors having a different perception of a dyke (e.g. the dyke should be higher to offer sufficient protection versus the dyke is already too high to enjoy the view over the floodplains). Neither will seeking consensus help avoid adverse impacts if a dyke is too weak for river discharges of which the probability of occurrence is uncertain. Uncertainty itself can also be a subject of disagreement. The resulting discursive uncertainty can arise in situations where perceptions of the existence, type or severity of uncertainty differ. Discursive uncertainty further problematises the handling of uncertainty for planners.

Unequivocal implications necessitate distinct ways of handling uncertainty. Not clearly distinguishing between the natures of uncertainty, for example, can spur debate about the adequacy of interventions, even to the extent that ontic uncertainty can become subject to controversy. Such controversy can hamper the activities of planners to ameliorate the adverse impacts of uncertain change. With the pressing need to handle ontic uncertainty about, for example, climate change impacts, planners need to take adequate interventions or will be confronted with unpredictable but adverse effects of floods or droughts. The implication of irreducible, ontic uncertainty is that some control over the physical environment is necessary to prepare for as yet unknown change. Planners need to be specifically cognisant of the characteristics of uncertainty when they aim to ameliorate the effects of uncertainty by using adaptiveness in preparing their spatial planning interventions.

7.1.2 Adaptiveness in planning to account for uncertainty

Adaptiveness refers to a way of handling uncertainty and change. There are multiple forms of adaptiveness, each with a distinct underlying rationale, and three main archetypal forms that are relevant in spatial planning. The first of these is adaptive management, which is based on

trial and error in deliberately designed experiments and on constant interventions in accordance with the latest insights derived from these experiments. This is adaptiveness through constant readjustment and learning how a system responds to interventions. The second archetypal form involves increasing a system's adaptive capacity, which is the inherent capacity of a system such as an ecosystem or city to adapt to changing circumstances. A system's adaptive capacity can be enhanced by focusing planning on establishing and enforcing internal learning mechanisms, on institutional structures that respond to stakeholder needs and on increasing system resilience through creative, possibly ad hoc, flexibility. The third is adaptive planning, through which planners create headroom for anticipating as yet unknown events and map possibilities for future interventions. Adaptive planning is deliberately anticipatory and helps planners implement interventions responsive to possible future situations, intermediate change or sudden events.

Adaptive planning originates from theories about adaptive management and adaptive capacity, but significantly diverges from these forms of adaptiveness by emphasising deliberate anticipation of the future. Adaptive planning claims to be better equipped to deal with ontic uncertainty about the long-term consequences of spatial interventions than the other forms of adaptiveness. Adaptive management and adaptive capacity assume adaptation to current situations and events, rather than anticipation of future developments, which is fundamental to adaptive planning. Adaptive management and adaptive capacity therefore seek the optimisation of interventions, of the capacity to learn, the capacity to keep functioning during adverse situations or trust in other actors.

Adaptive planning raises awareness of the long-term spatial consequences of interventions and emphasises the need for planners to decide and act. This decision- and action-oriented focus makes forward-looking necessary to create headroom and to map possibilities for future interventions. Identifying such possibilities includes making clear what sort of lock-ins or lock-outs exist and how these may be avoided. Adaptive planning can be seen as being tailored to handling some degree of ontic uncertainty in planning and decision-making. Adaptive management, in contrast, offers a conceptualisation better aligned to the resolution of epistemic uncertainty, or to aid short-term planning goals. Adaptiveness in light of ambiguity helps planners start

implementing initial interventions before contentious issues about longer-term issues are resolved.

Adaptive planning depends on the flexibility that planners can enhance and use to adapt to opportunities at a later time. Flexibility is a way to operationalise headroom for adaptations. Planners can seek flexibility with respect to the timing of interventions; they may postpone interventions or advance them when the situation makes this necessary. Moreover, planners may seek flexibility to enable the later adjustment of interventions to better fit them to altered circumstances. Lastly, flexibility can be enhanced by diversifying the set of options to which planners can adapt over time. In seeking such flexibility, some insight into future change may help. The acknowledgement and identification of tipping points offer specific insight into when decisive change might happen and which possible future trajectories might be open to future adaptations.

7.1.3 Adaptiveness in approaches and tools for handling uncert[a]inty

Planning approaches and tools that claim to equip planners to handle uncertainty need to acknowledge the implications of different uncertainties. When using approaches and tools such as adaptive delta management, water diplomacy or adaptation pathways, planners first need to identify which type of uncertainty they are dealing with, in order to be able to select the most appropriate approach or tool. They thus need to give proper attention to ontic, irreducible uncertainty due to future change, to epistemic, reducible uncertainty due to a lack of knowledge, and to ambiguity due to different frames. The balance in attention depends on the uncertainties with which a planner is confronted in his or her particular context. In addition to giving proper attention to the different uncertainties, planners who want to use adaptiveness need to do so in an adequate way since adaptiveness also comes in various forms. Planners can construct more reactive styles of adaptiveness by enhancing adaptive capacity or by developing adaptive management schemes. They may also use adaptiveness as deliberate, planned anticipation. These three sorts of adaptiveness equip planners to handle uncertainty in different ways.

When using adaptiveness in planning, it is necessary to strike a balance between reactive, experiment-based adaptive management and

adaptive planning through deliberate anticipation, to handle both epistemic and ontic uncertainties. To handle ambiguity, tools to include the short-term stakes of actors need to be adopted without losing sight of the long-term planning objectives. Possible tools to include in planning practices are joint fact-finding and scenario workshops to address ambiguity and discursive uncertainty, and agenda-setting for reducing epistemic uncertainty. Connecting different tools in planning approaches helps planners account for ambiguity and the short-term stakes of actors, as well as for short-term reducible epistemic uncertainty and long-term uncertain changes.

To handle all uncertainties, planning approaches should offer a coherent package that addresses the nature of the uncertainty, identifies the implications of these uncertainties for the problem at hand and provides the necessary tools to handle each of the uncertainties. Two approaches that claim to handle uncertainty (understood as a singular concept) through adaptiveness are water diplomacy (WD) and adaptive delta management (ADM). This thesis shows that these approaches, however, do not adequately handle all types of uncertainty at the same time. WD focuses on ambiguity and epistemic uncertainty, while it neglects ontic uncertainty about long-term change. ADM focuses on ontic uncertainty, but does not pay attention to epistemic uncertainty or ambiguity. The adaptation pathways tool, part of ADM and also studied in this thesis, is used to deal with deep uncertainty, level three uncertainty of an ontic nature. However, adaptation pathways are also not suited to dealing with ambiguity. Attempts to integrate adaptation pathways into more encompassing planning approaches to strike a balance between the implications of different uncertainties are progressing. For example, integrating adaptation pathways with scenario workshop methodology in a single approach is suitable for handling both ontic and ambiguous uncertainties. As a tool, adaptation pathways is flexible enough for planners to adjust it to their specific planning practices and to couple it to other tools to abate different uncertainties simultaneously in a planning process. In WD, joint fact-finding is used, which is perfectly suited for dealing with ambiguity, less suited for accounting for epistemic uncertainty and not at all suited for dealing with ontic uncertainty. While ADM seems to be a management approach, ADM can better be characterised as an adaptive planning approach based on its characteristics. Since neither of the approaches is fully equipped to handle all three natures of uncertainty, cross-pollination and integration of the different tools and principles in a

revised approach would be a viable option to account for all three natures of uncertainty. However, even if such integration is established, the simultaneous handling of ambiguity and long-term uncertain change can remain troublesome in collaborative planning practices, as this thesis shows for the IJsselmeer case study.

7.1.4 Handling uncertainty through adaptiveness in collaborative planning

The IJsselmeer and adaptation pathways case studies show that uncertainty cannot be handled through adaptiveness without proper attention for the struggle policymakers and planners face in articulating and operationalising both concepts in collaborative planning practices. The most striking misunderstandings arise when planning is practiced in situations with both ontic and ambiguous uncertainty, as was the case in the IJsselmeer strategy-making process. These two types of uncertainty contrast most strongly in the approaches used by planners. In the case studies in this thesis, their simultaneous occurrence was found to cause the most trouble. While ontic uncertainty demands interventions aimed at ensuring the effectiveness of planning while anticipating future change, ambiguity requires a focus on the planning process and the co-construction of knowledge, deliberating about values and increasing the adaptive capacity of actors and institutions (i.e. responsiveness to different stakeholder needs). If both require pressing attention, conflicts between knowledge frames can easily distract planners from paying attention to the handling of ontic uncertainties. In other words, if what can be known is debated, what can be done takes second place.

Making a distinction between uncertainties is important in collaborative practices, since the material world will not conform to a particular definition and vision on ontic uncertainty. However, adaptiveness is enabled by paying attention to uncertainty of any nature. Even with ambiguity, the necessity to balance different stakes and to align frames while handling uncertainty arising out of those diverging frames helps to emphasise the possibilities of adaptiveness. When actors are not certain together, due to different visions on the facts and indeterminacy about what is certain, they respond by waiting and maintaining the status quo. Actors who want to proceed, and need to convince others to do so, will benefit from mapping possible future trajectories (adaptive

planning) and experiments (adaptive management) to gain more insight into the current situation or the effectiveness of interventions. Ambiguity can, however, also obstruct adaptiveness in situations in which the handling of ontic uncertainty is required for the timely preparation for future adverse impacts. Moreover, experiments may set out a maladaptive track and not all situations allow for experimentation due to the potentially large off-site or delayed consequences of particular interventions.

Some intricate mechanisms are at play when seeking adaptiveness in collaborative planning processes. The efficient design of adaptation pathways in collaborative planning practices depends on when the pathways are proposed and with whom they are designed. The timing of stakeholder involvement and the question as to who should be involved are for example influenced by existing institutional dynamics, which also play a decisive role in operationalising adaptiveness to handle uncertainty. Participants in collaborative planning practices were found to be reluctant to embrace adaptiveness due to vested interests in the status quo. The dynamics in the IJsselmeer planning process were influenced by the institutional arena, in which responsibilities were unclear regarding the impact (financial or otherwise) of the sought interventions. Moreover, the highly expert-based water management situation in the Netherlands has led to a reluctance to accept adaptation pathways to explore alternative options, to avoid lock-ins and to overcome the structuring effects of past choices. The expert-based formulation of policy has led to a narrowing down of the considered options, affecting the advancement of adaptiveness. Thus, the institutional context, including vested interests of stakeholders and actors, unclear responsibilities and cultural values, can jeopardise the exploration of options that might enhance adaptiveness to handle uncertainty in spatial planning.

7.1.5 Planners can account for uncertainty through adaptiveness

As explained above, planners must distinguish between different sorts of uncertainty based on its characteristics. They therefore need to distinguish between an ontic, epistemic and ambiguous nature, as well as the level and location of uncertainty. This enables planners to account for the different implications of these types of uncertainty. Interventions can then be assessed as to their adequacy, which has

implications for the type of adaptiveness to be sought for in planning practices. Three archetypal forms of adaptiveness were distinguished: adaptive management, adaptive capacity and adaptive planning. These have close ties to the three natures of uncertainty. In a sense, each of the forms of adaptiveness is tailored to specifically abate one of the three natures of uncertainty, but with some additional effects for dealing with other types of uncertainties (Figure 7.1). Adaptive management enables planners to deal with epistemic uncertainty, but also helps planners handle ambiguity with its directed attention for increasing the knowledge base. Adaptive capacity enables planners to deal with ambiguity by co-constructing knowledge, learning and responsiveness to stakeholder needs, which affects the handling of ontic uncertainty by increasing the responsiveness to uncertain future change. Adaptive planning enables planners to deal with ontic uncertainty by anticipating future conditions through defining windows of opportunity and three forms of flexibility (the flexibility to time, to adjust or to shift between interventions) and contributes to the handling of epistemic uncertainty through the need to determine conditions for future interventions and directions of change. This thesis shows that it is possible to tailor forms of adaptiveness to particular uncertainties, as long as planners are aware of the premises underlying their approaches and tools and the functioning of both in collaborative planning processes.

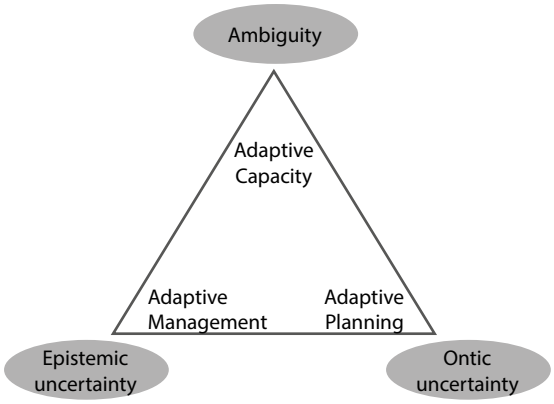

Figure 7.1. The relationship between the natures of uncertainty and the three domains of adaptiveness.

Adaptiveness based on adaptive management, adaptive capacity and adaptive planning principles is a vehicle to rationalise planning, while acknowledging that conditions change due to natural developments and changing interests at play, now and in the future. As such, the use of adaptiveness is aimed at situations that will never be fully controlled,

nor be totally out of control. The first premise for adopting all three types of adaptiveness is that planners and water managers need to acknowledge that their predictive capacity is limited, but that adaptive planning can be enabled if there is a clear portfolio of options and the spectrum of possible outcomes is at least conceivable in light of future conditions. The second premise is that adaptive planning only thrives in conditions of variety and multiplicity, since the solution space must be explored and coupled to transparent steps in policymaking processes. Adaptive capacity offers specific directions to enlarge this solution space, based on the current situation and with attention for learning, reducing ambiguity through the co-construction of knowledge, and increasing responsiveness to and consideration of stakeholder needs. Third, conditions that are within the control of planners can be managed by conducting directed experiments to optimise the current situation in which planning takes place. With adaptive management, which leads to ongoing readjustments, planners can reduce epistemic uncertainty, hold the system inside the current desired functionality and optimise system performance. The rationalisation thus offered by adaptiveness should be understood as a balancing act between flexibility and control. When planners want to strike a context-dependent balance between flexibility and control through adaptiveness, a plural-unequivocal understanding of uncertainty and the offered benefits of each of the three archetypal forms of adaptiveness are pivotal.

7.2 Discussion

In this section, I elaborate on the conclusions drawn above in the context of planning debates pertaining to handling uncertainty through adaptiveness. First, I discuss the logic underlying adaptiveness, since this strongly relates to the premises guiding planners in their day-to-day actions. Second, I discuss the operationalisation of adaptiveness to handle uncertainty, because this appears to be a quintessential task throughout the literature and in the practices I studied. Third, I discuss the normative issues incorporated in many of the studies on adaptiveness and highlight some of the dangers when incorporating adaptiveness into existing planning schemes without due attention for uncertainty. These three topics are discussed because of their explanatory power for the findings in this thesis and because they help to cautiously interpret the arguments and conclusions of this thesis.

7.2.1 The logic underlying adaptiveness

I balanced two domains of logic in this study of uncertainty and adaptiveness. Adaptive planning, adaptive management and adaptive capacity are significantly influenced by positivist ideas and language. Holling et al. (1978), Walters (1986), and many others (e.g., Lessard 1998; Kato & Ahern 2008; Chaffin et al. 2014) embed adaptiveness in what is considered in planning literature as rational, essentialist, Euclidian or modernist planning theory, with an underlying instrumentalist and positivist logic (Friedmann 1993; Innes 1995; Allmendinger 2002). Adaptive delta management, collaborative adaptive management in the water diplomacy framework and adaptation pathways are no exception. Adaptive planning and management in this view centre around deliberate interventions that are monitored and adjusted if some threshold or boundary of change is approached or crossed. The related terminology bears resemblance to a laboratory environment in which experiments, observation and monitoring in a controlled environment are combined to the collection of 'objective' facts to constitute evidence. The knowledge resulting from the collected evidence is then used in an instrumental fashion to steer clear of the threshold by altering the intervention or plan. A main difficulty is the uncontrollability of the environment in which planners experiment (Lessard 1998), in other words uncertainty.

Adaptive management (as well as adaptive capacity) has been embraced by the interpretative and communicative planning domains in recent years (Healey 2007; Innes & Booher 2010). The theoretical shift from a positivist and instrumental logic towards embedding adaptiveness in an interpretative and communicative logic grew organically from insights into planning confronted with complexity (Innes & Booher 1999; Rauws 2015) and related to governance issues in applying adaptive management (Kato & Ahern 2008; Chaffin et al. 2014). Consensus-based and communicative planning are claimed to 'ultimately (...) build the capacity of key players to help the system to adapt creatively to change' (Innes & Booher 1999: 420). When embracing adaptiveness in a communicative logic, the theory underlying adaptiveness is challenged. The result is a fuzzy theoretical position or theoretical multiplicity (Karpouzoglou et al. 2016) regarding what is adaptive. The logics of positivist and interpretative planning respectively need to be reconciled to overcome this challenge and to coherently address the multiple expressions of uncertainty.

This is needed because the rationale for handling different types of uncertainty can be found in either the positivist logic (ontic and epistemic uncertainty) or in the interpretative logic (ambiguity).

When uncertainty is understood as having three characteristics with consequences for their handling in planning, reconciliation may be found in a third logic. This third logic has been explored and further developed in recent years. It starts from the premise that planning and planners act in complex situations, in which adaptive behaviour, emerging self-organisation and non-linear change are the main characteristics of the socio-physical system at which spatial interventions are aimed (Folke et al. 2005; de Roo & Silva 2010). This recognition of complexity has led to a shift towards communicative and consensus-building theories, but there is more to complexity than only allowing the planner to perform his or her duties in a social, communicative sense (cf. Healey 2007; Susskind & Islam 2012). Where positivists start from a material disposition, and interpretivists from heterogeneity, poly-rationality, and a communicative disposition (Sandercock 1998; Davy 2008), an epistemology based on complexity necessarily requires the establishment of a connection between both (Folke et al. 2005; DeLanda 2006). Indeed, presupposing, acknowledging or making claims about the complexity of socio-physical systems are in themselves realist claims. To come to a synthesis between both, in this thesis I assumed that planners and scientists need to make realist claims about the functioning of socio-physical systems. Specifically, variables in the physical environment with ontic uncertainty influence the performance of planners and the functionality of systems, regardless of how such variables or their uncertainties are perceived. Ontic uncertainty arises out of the aleatory behaviour of systems, such as the shifting baseline underlying climate trends. It is ontic uncertainty, and the related unpredictable behaviour of systems, which contrasts with both a positivist planning logic, where planners can know and control the environment, and an interpretative logic, where reality can only be known through social construction.

Ontic uncertainty means that planners cannot control a complex physical environment. Meanwhile, there is a need to sustain and control the environment, with its ontic uncertainty, instead of leaving it open to full self-organisation. This need is seen in the sustainment of societies through planning by ensuring (possibly legal) certainty, security, avoidance of conflict and control of positive and negative externalities

(Yiftachel 1995; Rauws et al. 2014; Savini et al. 2015). An example is the rules that guide urbanisation in a delta, which can be strict (enforcing type, colour, height, etc. for houses in particular zones) or open to a high degree of self-organisation (enforcing as little as possible, but with boundaries to sustain a proper functioning neighbourhood and city). The full self-organisation of urban development, as seen in the poor suburbs of developing countries, can for example lead to building in floodplains (lack of control of negative externalities such as floods and water pollution) or conflicts regarding property rights. I therefore argue that the claim underlying adaptiveness is that planners need to let go of a logic of control, while simultaneously trying to offer certainty and direction to control specific situations. Planners will have an increasingly important role to play when knowledge, uncertainty and interventions are debated, while the demand for safety in deltas is increasing, for example due to climate change and economic growth.

7.2.2 The operationalisation of adaptive planning

Accounts of adaptive planning claim that it is possible to design adaptive planning schemes (e.g., Lempert et al. 2006; Haasnoot et al. 2013; Walker et al. 2013), despite studies that have identified unruly planning processes (Allan & Curtis 2005; Rauws 2015). Adaptive planning allows planners to retain control under conditions in which ontic uncertainty is present. At an abstract level, adaptive planning can offer a realism-based paradigm for thinking about the structure and structuring forces of time and space (cf. Graham & Healey 1999; Innes & Booher 2010).

Supporting my conclusions, the 'adaptive planner' must have a clear understanding of how time and space are perceived in his or her particular planning context. These two concepts constrain the perception of uncertainty and are brought into the planners' focus by an emphasis on thresholds or tipping points (Werners et al. 2013) and by monitoring change to adjust planning at the right moment and making use of the right spatial interventions (Hermans et al. 2014). Here, adaptive planning has an obvious advantage over adaptive management. Thresholds, tipping points, turning points or triggers for adaptation establish some control over time-space constellations by indicating when and where to intervene. However, underlying such thresholds, more critical issues arise. How may indicators or parameters

be determined for monitoring, in order to act in a timely and adequate manner if a change approaches a threshold, while poly-rationality diminishes the possibility to establish clear thresholds in the planning process? It is important but quite difficult to define what should be monitored if it is uncertain which variables might become decisive in terms of future adaptation (Rae & Wong 2012), in which case long-term adaptive planning can become obsolete (Islam & Susskind 2012). Because the duration of interventions and decisions in the context of spatial planning is often long and full of dynamic and non-linear developments, this question of what and how to monitor becomes even more challenging. This is primarily the case for level four ontic uncertainty, described above as a state of recognised ignorance where planners are unable to enumerate multiple alternatives while admitting the possibility of being surprised. When confronted with level three or lower level ontic uncertainties, future change might be more or less anticipated through planning interventions. It is in this realm that adaptive planning has its greatest added value.

It is because of ontic uncertainty that we strive for adaptiveness in planning. However, ontic uncertainty is also a reason for rejecting the monothetic use of indicators, such as those proposed by adaptive management. This rejection complicates the monitoring and continuous evaluation of spatial plans (Wong 2003; Alexander 2011; Rae & Wong 2012). The monothetic use of indicators and singular definitions of tipping points might not pose problems in a Euclidean, deductive logic. When accepting poly-rationality in planning, the operationalisation of adaptiveness through a strict interpretation of its mechanisms is, however, difficult (cf. van der Vlist et al. 2015). To overcome such difficulties, Rae and Wong (2012) use an indicator-bundling method to evaluate spatial planning policies. This method is 'based on consulting practitioners and key stakeholders [about] what they think are the critical issues, providing flexibility to choose and bundle indicators to address the framing of spatial planning issues and the spatial and sectoral integration issues related to complex policy making' (Rae & Wong 2012: 885). An example is a decision that needs to be made about the replacement of a weir: this can be solely based on its technical design lifetime (a fixed point in time), but could also include indicators based on the functional performance of the structure (for multiple functions), its location and role in the water system and options for lifetime extension (Smet 2017; van der Vlist et al. 2015). A danger of using bundles of indicators is that it may expose

adaptiveness to continuous reinterpretation and flexible adjustments of thresholds for corrective actions and monitoring efforts. In addition, the weight different actors assign to each threshold will differ and shift over time. This thesis shows that adaptation pathways can also be subject to such continuous reinterpretation. This makes adaptiveness vulnerable to malfunction and can lead to difficulties in determining or judging corrective actions due to unclear indicators, undefined performance criteria or ambiguous mandates (Reed 1999; Green Nylen 2011). The mechanisms offered by adaptive planning can help planners identify and explore a plurality of possible futures and anticipate change, both with regards to drivers of change and across different geographical scales and timeframes. Adaptiveness can therefore sufficiently equip planners to handle ontic uncertainty by balancing flexibility and control in their spatial interventions with long-term consequences (Savini et al. 2015).

Making decisions on parameters and indicators for monitoring leads to a process of defining, selecting, structuring and rigidifying (e.g. creating lock-ins in) time and space themselves (van Assche et al. 2011; Zegwaard 2016). Selection, and the resulting fixation by defining a monitoring scheme, posits dangers for effective adaptations if unpredictable change happens or if set boundaries conflict with adequate interventions. This can be ameliorated by shifting to adaptive planning, but only when adaptive planning is applied flexibly enough to de-rigidify and break lock-ins due to such structuring effects over time and space. In other words, if planners fail to distinguish differences between the nature, level and location of uncertainties, well-considered adaptiveness to provide sufficient flexibility while maintaining the desired control may be hampered. For example, failure to account for uncertainty in changes in river discharge can result in a lock-in on urban development in a future floodplain. Considering ontic uncertainty makes it possible to maintain flexibility to prevent future floods, while allowing for land uses (e.g. control development to avoid a negative externality). Acknowledging and openly debating the unequivocal implications of different uncertainties over multiple geographical scales and timeframes might soften strong structuring effects.

The structuring role of uncertainty directs the attention of planners to where the effects of possible interventions are not certain, and to which uncertainty needs to be handled. Planners seek assurance that the plans and interventions they advance have the desired and

intended effects (Hillier 2013). When distinguishing different natures of uncertainty, such mechanisms of establishing control can be diversified in specific ways. This offers guidance for adaptive planning and the use of tipping points to create insight into lock-ins and lock-outs of current and alternative development trajectories. An important criticism in this respect is that uncertainty can become a political force through its discursive construction (Taddei 2012; Gunn & Hillier 2014; Zegwaard 2016). Uncertainty not only structures which interventions are sought, it is also used to question the validity and legitimacy of suggested interventions. This is what I have described in this thesis as discursive uncertainty, which is clearly visible in the climate change debate (Morton et al. 2011; Patt & Webber 2014). Planners should take such discursive uncertainty into account in the design of adaptive planning schemes, although uncertainty is not the only concept at play when considering the validity of interventions. Thus, while uncertainty can become a contentious issue, it may offer a structuring principle for the search for and advancement of adaptiveness in planning processes.

7.2.3 The normativity of adaptiveness to handle uncertainty

The proposed plural-unequivocal conceptualisation of uncertainty starts from the assumption that a course of action can be more or less adequate to handle a specific uncertainty. A course of action based on adaptive planning is forward-looking. Resulting future-oriented decisions are often decisions to not intervene yet, but to create the headroom (flexibility) to do so either at a later moment or by shifting between options. This is influenced by an underlying idea of learning by trial and error and experimentation. As discussed above, the notion of ontic uncertainty contrasts with a course of action based on continuous adjustment to change. Experiment-based learning and additional research emphasises the reduction of uncertainty, which directs the planner to a specific course of action that might not be adequate if the specific uncertainty turns out to be irreducible, or if it can only be handled through other interventions. My conclusions, therefore, differ from the viewpoint of Tannert et al. (2007), for example, which is that uncertainty makes research a moral duty. The underlying perception of uncertainty as a singular concept problematises the adequate handling of uncertainty. The viewpoint that doing more research is necessary, that it is a moral duty when confronted with uncertainty, is not strictly necessary. Doing more research in advance can even be an inadequate

and morally wrong approach when ontic or ambiguous uncertainty need to be handled.

Advancing adaptiveness based on a singular perspective of uncertainty can be inadequate or maladaptive for another reason. This is because it justifies trials and pilots for research and experience-based learning. For example, the authorisation of trials may encourage potentially destructive and irreversible effects on systems (Green Nylen 2011). Adaptive management might be inadequate with respect to the specific uncertainty at hand, and resulting inadequate interventions can have destructive effects. This argument translates into an important reason for considering the normative implications of handling uncertainty and applying adaptiveness adequately, precisely because it provides headroom for an experimental approach. Moreover, criticism of the singular handling of uncertainty sometimes also goes hand in hand with a plea for more experimentation and lower governmental interference altogether (Scruton 2010). However, this plea should depend on the encountered uncertainty, as governments may very well be the most suitable candidates to carry out an intervention (even unilaterally) if the geographical scale of the impacts of the intervention warrants this. This is specifically the case when long-term interventions are required in the face of ontic uncertainty. Climate change is an example for which long-term interventions legitimate a strong state, because only the state is able to sustain long investment periods with such uncertainties. National governments can also sustain a broader system perspective compared with private actors or local governments. The same can be argued for experiments that might be perfectly suitable for epistemic uncertainty on a small geographical scale, but potentially destructive on regional scales. This is for example an argument for being extremely cautious with climate geo-engineering experiments (Shepherd et al. 2007; Thompson & Bendik-Keymer 2012).

There is another issue at stake regarding the normativity of adaptive planning and its forward-looking emphasis. Warranted courses of action are partly determined by the structuring force of adaptiveness and its constituent parts, such as monitoring to prevent thresholds at which a course of action becomes obsolete. As soon as planners start to think about adaptiveness, their perception of the environment and their proposals for interventions in the physical environment can start to change. Adaptive planners, by acknowledging the need to be adaptive at all, have to account for the long-term impacts of plans. The case with

which this thesis started can illustrate this point. The Afsluitdijk, built in the 1930s, heavily altered the Dutch delta in directions that were not foreseen during the planning and construction of the dyke. This thesis shows that planning for such long time spans is extremely difficult if not impossible. This difficulty arises from the long lifetime of spatial interventions and the inherent normative role of planning in structuring the future possibilities, or impossibilities, for development in deltas.

In the planning of deltas, planners rely on infrastructure to control physical circumstances and to adjust the landscape to humans' advantage (Selman 2012). When advancing adaptiveness, existing infrastructures might prove to be resistant when it comes to adjusting deltas to the redistributive consequences of, for example, climate change (Wilson 2014). This resistance includes the institutional system and past choices, as there is a tendency to retain the current situation, which is partly fixed by earlier interventions. Although tools such as the adaptation pathways intend to overcome this fixation, the current situation and how it came about is the point of departure for future interventions. Past choices and underlying values are embedded in the current physical organisation. Adaptiveness challenges such embedded values. The legitimacy with which adaptiveness is advanced is constantly challenged by, and in conflict with, the current organisation of society's physical environment.

Adaptive planning, by definition, challenges a status quo by addressing (and intending to offer methods to overcome) existing lock-ins of planning policies (Walker et al. 2001). Halleux et al. (2012: 887), for example, argue that: '(...) despite recent attention of planning theory for institutional change, the way planning policies evolve – or cannot evolve! – in the context of innovations in technology, organization and structures, remains poorly theorized.' This extends the idea of a cultural or physical lock-in to the political manifestation of the organised environment. Still, 'much remains to be done in understanding how planning can avoid lock-in effects and develop or simply imitate innovative practices' (Halleux et al. 2012: 887). While this thesis contributes to this debate, many issues remain untouched. For example, adaptive planning approaches can justify probing new measures to overcome such lock-ins, but these may result in maladaptation or lock-in effects due to the effect of past choices on adaptiveness (e.g. the solution space, definitions of tipping points) itself. In this thesis, I

therefore argue for more deliberate planning and design choices when using adaptiveness.

Normative implications connected to uncertainty also underlie the advancement of adaptiveness. The location of uncertainty is the prime characteristic when it comes to questions of distributive justice of interventions or non-interventions. The difficulty with adaptiveness is that the underlying premises are change and uncertainty in general, rather than the particular location of uncertainty. What in general is perceived as ethically good conduct could mean that planners can be held responsible and accountable for interventions (Davy 1997; Watson 2003; Schultz & Nie 2012). However, if faced with uncertainty as the basic premise underlying adaptiveness, translating what is good conduct into a legal system is difficult, since the laws that structure responsibility to act and accountability for interventions in the physical system are retrospective. For example, for a long period of time, safety standards in the Netherlands were based on past variability in water levels and only included some leeway based on a rule of thumb to be on the safe side. Only recently have these safety standards included leeway that is forward-looking by making use of more sensible predictions based on modelling possible future situations, as well as a more specific understanding of where uncertainty might be located.

In addition, a warranted course of action is challenged by specific choices derived from thinking in terms of adaptive planning. This concerns both interventions, non-interventions, and delayed interventions, including the possible transposition of the location of uncertainty. Non-interventions and delayed interventions in particular cannot be easily included in policy due to difficulties with determining responsibility and accountability. For example, the choice of the Dutch government to appoint areas for possible bypasses or widening of floodplains transposes the uncertainty about future river discharges to local citizens, who get to bear the uncertainty instead of the government (which translates into uncertainty about their living and investment conditions and decreasing real estate values). Decisions about adaptive planning schemes should be made carefully to avoid new lock-ins. However, mechanisms also need to be explored to structure responsibility and accountability for long-term planning fraught with uncertainty (Mees et al. 2012; Thompson & Bendik-Keymer 2012; Nalau et al. 2015; Mees et al. 2016). One direction could be to base these mechanisms on what is termed forward-looking responsibility

(van de Poel et al. 2015), by defining responsibility as a virtue or seeking guidance in principles of moral justice (MacIntyre 1981; Davy 1997; Schultz & Nie 2012; Basta 2014).

7.3 Methodological reflection

The conclusions drawn and discussed above are based on a qualitative, interpretative research approach (Schwartz-Shea & Yanow 2012), inspired by insights from critical realism and material ontology (e.g., Bhaskar 1998; DeLanda 2006; Harman 2008) and recently explored and applied to planning theory and policy studies (e.g., Alfasi & Portugali 2008; Chia & Holt 2009; de Roo & Silva 2010; Gunn & Hillier 2014; Boelens & de Roo 2015; Rauws 2015). The second, empirical, orientation of this thesis builds on data derived from views and opinions expressed by stakeholders in semi-structured interviews and conversations, systematic interpretation of policy documents and reflections on the application of planning tools. Tracing patterns in this wealth of data led to thick descriptions of cases and particular planning practices (Marshall 1981; Beach & Pedersen 2013). By comparing these case descriptions and linking them to constructs theorised in planning and policy studies (including climate adaptation policy studies) and by condensing the information to reflect on and study such constructs, meaningful findings were substantiated. Although this process of condensation led to a loss of detail, the enhanced focus was necessary to come to meaningful insights and to substantiate my findings.

A reflection on the three types of logic underlying adaptiveness shows that recognition of the complex interplay between environmental and social systems can easily lead to a rejection of universal claims (Allmendinger 2002; Allmendinger 2009). A plural-unequivocal conceptualisation of uncertainty, however, does offer valuable insights into what uncertainty is, what planners ought to do about uncertainty through adaptiveness, and how this can be assessed in the use of planning approaches and tools in collaborative planning processes. Methodologically, I tried to resolve this tension by fitting the causal explanation of what and how to specific institutional contexts and planning practices. Inquiry that is based on the establishment of universal truths is impossible, because every time researchers look closely, their understanding retracts in a void of unknowing (Bhaskar 1998; DeLanda 2006; Byrne 2013). Observations and theoretical

constructs can, however, be used to develop generalisable knowledge by recognising the setting in which the contingent actions of planners take place (Byrne 2005; Alexander 2015). Generalisability is limited, but the claims made can help navigate planning through multiple, connected ways of knowing (Davoudi 2015; Zegwaard 2016).

Reflecting on my interpretative research design based on multiple case studies, I conclude that this design fits the perspective described above adequately as it describes the setting of the case studies and accounts for the inherently subjective interpretation of the researcher (Schwartz-Shea & Yanow 2012). The material infrastructure is just one layer scientists can try to understand, while this physical manifestation just as much articulates historic-political choices and perspectives on deltas (Wilson 2014). Acknowledging the possibility of methodologically multifarious applications to the same object of study, I deliberately set out to study adaptive planning in different contexts (with two chapters designed according to a comparative case study methodology, cf. Engeli & Rothmayr Allison 2014), aimed at legitimate but context and methodically-bound insights for planning practices.

Choosing a qualitative, interpretative research design within a comparative case study methodology and building on constructs from planning theory and policy studies turned out to be useful to study diverging uses of adaptiveness and uncertainty in the context of spatial planning. There are, however, also some limitations to my research design. First, even using comparative case studies, there is an inherent bias towards the contextual factors exposed. This thesis only engaged with planning for water and climate adaptation issues in developed nations, drawing on cases in Europe and the US. Its blind spots are the rest of the world and other issues pertinent to planning. While the studied patterns and settings are discussed in relation to planning theory and policy studies, even these tend to have a bias towards European and North American nations and continental philosophical thought. To illustrate this point, in 2014, 7 out of 32 contributions to the journal *Planning Theory* came from outside these nations (South Africa 4 times, Chile, Hong Kong, Mexico) and in 2015 just 2 out of 21 contributions were from authors outside these nations (Chile and Hong Kong).

Second, data collection was limited on the water diplomacy framework, the application of the adaptation pathways and the IJsselmeer case, all

due to a partly or fully retrospective research design. Either the duration of data collection was shorter than the period the projects ran for (in the IJsselmeer case), or the projects had already been completed (the water diplomacy framework was already fully developed and the adaptation pathways projects already ran). This influenced the type of data and the findings and conclusions derived from these studies. For example, participatory or action research methods could not be applied in any of the cases, but might have strengthened some of the results by bringing to light other types of evidence for my findings (except for the Ílhavo and Vagos cases where the collaboration with others enabled insights gained from direct participation). Even though the interviewees and policy documents offered a wealth of insights into the mechanisms in each of the cases, additional data through other *ex-ante* developed methods would have strengthened and enriched the claims and outcomes of this study. Nonetheless, I believe that by taking into account these limitations, the findings of this research offer valuable and legitimate, although context- and methodically-bound, insights.

7.4 Societal relevance

The role of the planner, or other agents involved in planning, is challenged if planning is adaptive. With the multilevel and continuously changing context of planning problems in mind, uncertainty and adaptive planning necessitate planners to alter the way they work. Planning as conceptualised in this thesis as a practice of navigating amid uncertainty implies a planner who navigates. Without searching for a comprehensive answer here, pointers are found throughout this thesis of what this changing role might entail, based on a conceptualisation of planning as a practice of navigating (Savini et al. 2015; Davoudi 2015).

To elaborate on the changing role of the planner, I compare the planner to the captain of a ship. A passenger will only embark if he or she has complete faith in the captain's capacity to steer clear of cliffs and submerged sandbanks. A captain is trusted to navigate a proper course to bring his or her crew and passengers safely to their destination. He or she has to behave responsible by not constantly altering course, and normally bears some proof of authority (such as wearing a uniform). Crew and passengers endow the captain with their trust based on his capability to use the appropriate instruments to navigate the ship safely and soundly into the destined harbour (and will be held accountable

should he or she fail). The captain needs to know the legal rules and geographical characteristics to safely navigate the particular stretch of sea the ship travels over and to act with due diligence for the safe arrival of the ship. For planning to become a practice of navigating, the planner needs to become such a captain. The planner similarly requires trust (de Vries 2015) based on his or her equipment and the skills to use this equipment in a proper way, with sufficient knowledge of the context (e.g. knowledge of formal, informal and cultural rules; the physical environment) to use them properly to achieve the – collectively – desired goal.

Based on this perspective, three implications for planners can be derived from this thesis' findings. First, the expertise of planners should include knowledge about how to apply planning approaches and tools. Comparing the use of adaptation pathways in different contexts shows that, notwithstanding differences in planning cultures, planners need to understand how planning tools work and to what end the planner's 'toolbox' can be used (Howlett et al. 2015). Moreover, the effective use of planning approaches and tools demands that stakeholders accept the approaches and tools involved. The planner not only needs to understand their application, he or she also has to be able to argue the legitimacy of approaches and tools, their underlying rationale and their possible outcomes, within the existing organisational routines (Rayner et al. 2005). In water diplomacy, much emphasis is put on establishing such legitimacy, while one of the adaptation pathway cases – ameliorating urban heat in Prague – showed that the outcomes of the adaptation pathways were not seen as realistic by all, undermining such legitimacy.

A second implication for everyday planning is the high reliance on the strategic communication of planners on behalf of their organisation (Aarts et al. 2015). It became clear from the IJsselmeer case that a lack of awareness of the effects of communication in the short and medium term can be detrimental to the further planning process. To properly navigate the process towards its desired end, it should be clear what this end entails and how efforts in earlier stages of the planning process might steer the course towards it. It is important that the uncertainty about contextual variables is accounted for. To reason by analogy, preparing for bad weather or sudden changes in the mudflats' pattern in a delta is good conduct for a captain. This rejects the allowance of a continuous existence of multiple accounts (contra Vink 2015), because

there is just one unequivocal implication of uncertainty. If this is not determined adequately, the cliffs or submerged mudflats might be disastrously close. Planners should therefore first establish a mutual account of their current position and the desired end before casting off. When planning becomes adaptive, the certainty that actors have that it is vested in law or through property rights can be put under stress because, for adaptiveness, the planning process might demand the flexibility to alter course (Davy 1998; Tasan-Kok 2008). Adaptive planners should address lock-in and lock-out effects and integrate future policy possibilities or impossibilities to evolve (Walker et al. 2001; Kato & Ahern 2008; Howlett & Rayner 2013). As is shown in this thesis, this is very difficult and requires planners to have the skills and wisdom to take the appropriate actions and set the right boundaries.

A third implication for the role of the planner is the awareness of his or her judging role when it comes to soliciting knowledge. The planner is essentially a knowledge broker (Pielke 2007) between contending parties and between science, the planning process and the democratic and legal structures for decision-making. For the planner to broker between contending parties (horizontal brokerage) and between the planning process and democratic and legal structures (vertical brokerage), it is essential to adjudicate. Judging based on what is known also implies insight into how to handle uncertainty and take timely action to advance the right measures through the appropriate planning tools. In particular, the connection between existing structures with inherent time frames and procedures and the planning process can determine the success of adaptiveness. In the IJsselmeer case, for example, the strategy-making process was not embedded in the legal provisions. To legally enforce the strategies, a new phase in the process was initiated, with a change of organisation and the staff responsible for the strategies. This undermined the gained support and established agreement, and present a serious threat for enforcing the necessary adjustments in the water level. Moreover, the gained co-constructed knowledge was highly transitory. The knowledge collected about the system, the boundaries for the agreed strategy and their details were quickly forgotten (or, from a cynical stance, seen as uncomfortable knowledge which could better be ignored; Rayner 2012). Thus, to use adaptiveness to handle uncertainty, planners need to act carefully and strategically and firmly embed their activities in legal and democratic structures, while acting as trustworthy partners for various parties. Acting in a responsible and trustworthy manner can prevent blame and

malcontent among parties, especially when uncertainty and collective anxiety for change are in play (Taddei 2012). The legitimacy of adaptive planning seen as a practice of navigating amid uncertainty is, thus, tightly connected to the trustworthy behaviour of planners.

The renewed role of planners for handling uncertainty through adaptiveness can be of relevance in different practices. Here, I refer to three practices in which adaptive planning is currently advanced and in which planners might take advantage of their above-mentioned role. First, the Dutch government is advancing adaptive planning in relation to revised spatial planning and flood risk management policy. In the context of the policy integration of all environmentally-related laws in accordance with the Environment and Planning Act (*Omgevingswet* in Dutch), a new national spatial vision (*Nationale Omgevingsvisie*, NOVI) needs to be formulated. The process of formulating this vision is being influenced by adaptive thinking through workshops (NOVI ateliers), and it incorporates ideas developed in, among others, planning studies (e.g. Busscher 2014; Rauws 2015), the Dutch Delta Programme (van Rhee 2012) and pilot projects for urban planning in Almere Oosterwold (Anderson-Frank 2015; Rauws & de Roo 2016; van Straalen et al. 2017). Critical reflection on what uncertainty is and how adaptiveness may function under the Environment and Planning Act can be structured based on this study.

A second practice is about the renovation or replacement of infrastructure. The US is notorious for its poor state of infrastructure (Frischmann 2012; Qureshi & Shah 2014), but countries such as the UK, France and Spain also need to invest in deteriorating infrastructure (Marshall 2014; Marshall & Cowell 2016). The long-term planning of investments for the renovation or replacement of infrastructure should be adequate (taking into account uncertainty) to prevent overinvestments, while simultaneously coming to wiser decisions and new approaches for adaptive planning for the renovation and replacement of infrastructure (Marshall 2012; Marshall 2014; Hijdra et al. 2015; Willems et al. 2016; Smet 2017). In the Netherlands, the Ministry of Infrastructure and the Environment needs to effectively invest the allotted money in infrastructure projects, which could benefit from a critical perspective on tipping points and thresholds to decide when and how to invest and to design the appropriate functionality of infrastructures (Hijdra et al. 2014; van der Vlist et al. 2015).

A third practice is the handling of climate change uncertainty, which calls for adequate and sufficient adaptation actions of governments, but also of private companies and civic organisations. Choices should be based on what is adequate in light of uncertainty about climate impacts and warranted from an ethical adaptation point of view (Thompson & Bendik-Keymer 2012). An issue in this respect is the slow uptake of climate change effects in environmental assessment practices. These are strongly guided by legal prescriptions from, for example, the EU and US federal government, which still do not incorporate climate adaptation nor mitigation as a prerequisite for effectiveness studies of new developments. The uptake of clear insight in climate change uncertainty and possibilities to ameliorate its effects through guided developments (i.e. include at least a specific amount of adaptation actions) is a third direction this thesis offers insights for.

7.5 Recommendations for future research

Additional research is required to further develop adaptive planning. An important direction for further study is to understand the division of responsibilities in terms of handling uncertainty in the constantly changing planning arenas of contemporary societies. This understanding is pivotal to the taking of warranted interventions. An important question is how the division between different public institutions and between public and private bodies in managing deltas affects the development of congruent and adequate policies (Newell et al. 2015). How may this account for long-term, ontic uncertainty while simultaneously bridging different values and frames in the short-term scale of planning? This relates to the responsibility of governmental actors to adequately handle uncertainty; a responsibility that is vested in democratic legitimacy gained through elections to represent the public interest (Hoogers 1999). This, however, is heavily criticised, although no solution is provided to the balancing act for which governments are responsible (and in the Dutch context seem so far capable of). To what extent is and should the government remain responsible for taking actions, or not, to handle uncertainty? As far as using adaptive planning approaches to come to properly-warranted decisions for contemporary value systems is concerned, decisions might be tailored according to the prevalent culture to *do planning* (Sanyal 2005; Davoudi 2015) and *who does planning* (Healey 2007). These might be promising avenues

for further study and the conceptual development of adaptiveness to handle uncertainty.

Two methodological advancements should also be considered. First, instead of retrospective case studies, insights can be gained through action research, designed before adaptiveness is advanced in planning practices. Such forward-looking, deliberately designed research methods could be used to further substantiate the here offered conclusions and to develop novel insights into handling uncertainty through adaptiveness. A second advancement is the explicit tracing of uncertainty and related interventions in planning and policy. Is uncertainty connected to specific interventions? And to what extent are such connections adequate? The difficulty of tracing uncertainty and establishing insight into the causal linkage between uncertainty and interventions should be studied to increase understanding of where improvements in handling uncertainty through adaptiveness may be found, and whether policy and plans deliver adequate outcomes under uncertainty.

Considering characteristics of uncertainty and their relevance to planning can help policymakers and planners take cost-effective, adequate and just interventions. This is not a straightforward matter; on the contrary, it is a contentious issue. Planning efforts are often as much structured by issues of framing, perceptions of justice and lack of trust as they are by straightforwardly addressing the uncertainty pertaining to climate change. Planning can only be informed by adaptiveness if it simultaneously accounts for this multifarious and complex context. But what is the proper distribution of interventions to deal with uncertainty? And who bears the costs for flexible measures? Moreover, how is flexibility understood by planners and are concepts such as adaptiveness and flexibility useful in the day-to-day operations of planners and water managers? These questions are in need of further study, especially when reflecting on upcoming costly infrastructure decisions which may structure the organisation of deltas around the world for decades to come.

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A

Appendices

Appendix A. Reviewed articles and the main domain of adaptiveness in which they were categorized

Nr.	Reference	Domain
	Adaptive Management = AM, Adaptive capacity = AC, Adaptive Planning = AP	
1	Ahern, J., Cilliers, S., & Niemelä, J. (2014). The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation. *Landscape and Urban Planning*, 125, 254-259.	AP
2	Almstedt, Å., & Reed, M. G. (2013). Introducing a framework for good and adaptive governance: an application to fire management planning in Canada's boreal forest. *The Forestry Chronicle*, 89, 664-674.	AM
3	Alterman, R. (1988). Adaptive planning. *Cognitive science*, 12, 393-421.	AM
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Appendix B. Interviews Chapter 4.

1. Policy advisor and member ADM team staff delta commissioner
2. Author ADM
3. Strategist DPIJ (1)
4. Strategist DPIJ (2)
5. Policy advisors Rijkswaterstaat (2 persons)
6. Policy advisor Ministry of Infrastructure and the Environment
7. Manager and strategist Delta Programme Rivers (2 persons)
8. Senior policy advisors from DPIJ (2) and staff delta commissioner (1)
9. Author 1, WDF (formally spoken with on three separate occasions)
10. Author 2, WDF

Appendix C. Coding scheme Chapter 4.

Themes	Variables (codes)	Number of Occurrences	
		ADM	WDF
Uncertainty	Uncertainty	53	44
	Uncertainty characterization	18	3
	Predictability	3	12
	Complexity	6	19
Adaptiveness	Adaptiveness	36	31
	Adequate measures	26	12
	Flexibility	15	7
	Link with uncertainty	15	10
	Lock-in/out	10	2
Context	Institutional context	25	20
	Problem description	7	23
	Stakeholders	16	28
	Decision-making	29	8
	Framing	5	20
	Transparency	4	3
	Responsibility	2	10
	Normativity	3	9
	Planning context	14	9
	Role of the planner	11	40
	Building blocks	22	43
	Products	16	26
	Interdependencies	13	17
	Physical context	8	2
	Scales	2	5
	Time	28	7
Descriptors	Description of the approach	13	27
	Information	1	20

The coding scheme including themes, coded variables and number of occurrences in the formal descriptions of adaptive delta management and the water diplomacy framework.

Appendix D. Project documents Delta Programme IJsselmeer Chapter 6.

	Type	Title	Date	Organisation
1	Advice	Een ander IJsselmeergebied, een ander beleid	2007 Feb.	Project group
2	Research report	Analyse veiligheid en zoetwatervoorzieningen IJsselmeergebied	2008	Deltares (company)
3	Advice	Samen werken met water - een land dat leeft bouwt aan zijn toekomst	2008 Sept.	Delta Committee (national level)
4	Research report	Effecten van seizoensgebonden peilbeheer in het IJsselmeergebied	2009	Deltares
5	Policy document	Beleidsnota IJsselmeergebied - Bijlage c, Nationaal Waterplan	2009 Dec.	Ministries (national level)
6	Policy document	Nationaal Waterplan 2009-2015	2009 Dec.	Ministries (national level)
7	Research report	Deltares 2010 IJsselmeerpeil bij zeespiegelstijging - Waterveiligheid IJsselmeergebied	2010	Deltares
8	Research report	Quick Scan Peilbesluit IJsselmeergebied 2013	2010	Deltares
9	Research report	Voorverkenning korte termijn peilbesluit IJsselmeergebied	2010 Mar.	Rijkswaterstaat (national water authority)
10	Project document	Voorverkenning lange termijn Peilbeheer IJsselmeer	2010 Apr.	DPIJ bureau
11	Policy document	Deltaprogramma 2011 - Werk aan de delta - Investeren in een veilig en aantrekkelijk Nederland nu en morgen	2010 Sept.	Ministries (national level)
12	Minutes of meetings	De IJsselmeerweek: het werkt! - verslag IJsselmeerweek 6-10 dec 2010	2010 Dec.	DPIJ bureau
13	Research report	Ecologisch optimaal peil en beschikbaar instrumentarium Deel I - Ecologisch optimaal peilbeheer	2011	Deltares
14	Minutes of meetings	Op koers - verslag tweede IJsselMeerweek 7-13 april 2011	2011 Apr.	DPIJ bureau
15	Project document	De hoekpunten van het Speelveld - Eindrapport Strategieontwikkeling DP IJsselmeergebied fase 1	2011 May	DPIJ bureau and DHV (company)
16	Project document	Plan van Aanpak Fase 2 Deltaprogramma IJsselmeergebied	2011 Sept.	DPIJ bureau
17	Policy document	Deltaprogramma 2012 - Bijlage A: Samenvattingen probleemanalyses deelprogrammas - IJsselmeer	2011 Sept.	Ministries (national level)
18	Research report	Een snelle KEA voor DP IJsselmeergebied - Achtergronddocument	2012	CPB (governmental planning bureau)
19	Advice	Een snelle KEA voor DP IJsselmeergebied	2012	CPB
20	Policy document	Terugblik fase 1	2012 Mar.	DPIJ bureau
21	Project document	Het Nieuwe Peil - Resultaten fase 2 van het Deltaprogramma IJsselmeergebied	2012 May	DPIJ bureau

22	Project document	Op weg naar het aanbod van het IJsselmeergebied - Plan van aanpak fase 3	2012 July	DPIJ bureau
23	Policy document	Deltaprogramma 2013 - Bijlage B4 Deltaprogramma IJsselmeergebied	2012 Sept.	Ministries (national level)
24	Minutes of meetings	Naar een veilig en veerkrachtig IJsselmeergebied - Verslag IJsselmeerdag 26-11-2012	2012 Nov.	DPIJ bureau
25	Minutes of meetings	Verslag IJsselMeertop 27 maart 2013	2013 Mar.	DPIJ bureau
26	Project document	Het Nieuwe Peil - Resultaten fase 3 van het Deltaprogramma IJsselmeergebied	2013 June	DPIJ bureau
27	Policy document	Deltaprogramma 2014 - Bijlage A3 Deltaprogramma IJsselmeergebied	2013 Sept.	Ministries (national level)
28	Research report	Governance Assessment Deltaprogramma IJsselmeergebied	2013 Nov.	UT Twente
29	Project document	Vragen en antwoorden rond bestuurlijke consultatie IJsselmeerdag 9 december 2013	2013 Dec.	DPIJ bureau
30	Research report	Economische optimale waterveiligheid in het IJsselmeergebied	2014	CPB
31	Letter	Antwoordbrief aan besturen over eerste bestuurlijke consultatieronde fase 4	2014 Apr.	DPIJ bureau
32	Project document	Vragen en opmerkingen uit eerste bestuurlijke consultatieronde en antwoorden daarop	2014 Apr.	DPIJ bureau
33	Policy document	Deltaprogramma 2015 - Bijlage B5 Een veilig en veerkrachtig IJsselmeergebied - Synthesedocument	2014 Sept.	Ministries (national level)
34	Policy document	Deltaprogramma 2015 - Werk aan de delta - De beslissingen om Nederland veilig en leefbaar te houden	2014 Sept.	Ministries (national level)
35	Policy document	Ontwerpplan tussentijdse wijziging van het nationaal waterplan	2014 Sept.	Ministries (national level)
36	Policy document	Bestuursovereenkomst Deltaprogramma - Borging deltabeslissingen en voorkeursstrategieën	2014 Sept.	Ministries, provinces, regional water authorities, municipalities

Appendix E. Interviews Chapter 6.

1. Policy advisor at the Staff of the national Delta Commissioner
2. External consultant involved in developing adaptive delta management
3. Strategist (1) at the DPIJ bureau
4. Strategist (2) at the DPIJ bureau
5. Policy advisor at a regional water authority
6. Policy advisor at the Province of Flevoland
7. Strategist (2) at the DPIJ bureau
8. Two policy advisors from the national water authority
9. Policy advisor at the Province of Overijssel and manager at the DPIJ bureau
10. Policy advisor at the Ministry of Infrastructure and the Environment
11. Manager and strategist at the Delta Programme Rivers
12. Focus group, with contributions from personnel of the DPIJ bureau and staff Delta Commissioner

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Appendix G. List of Tables

S

Summary

Samenvatting

Summary

This thesis investigates how adaptiveness is understood in spatial planning and how it is used in planning practices to deal with uncertainty. The study was prompted by the attention given to adaptive planning in the Dutch Delta Programme, a programme designed to develop long-term strategies for water management and spatial adaptation. As varied and contrasting understandings of uncertainty have become evident in planning theory, these understandings call for clarification. Additionally, since uncertainty is itself a reasoned justification for adaptiveness in planning, clarity about what uncertainty entails is relevant to both theory and practice. It is particularly important to consider uncertainty and adaptiveness when planning for interventions in deltas. Deltas, which are made up of interlinked socio-environmental systems, face pressing challenges caused by climate change and urbanisation. To address these challenges, long-term intervention and investment strategies are needed. These strategies will define how deltas can develop and transform in the near and distant future and will offer direction for investments in climate change adaptation and in infrastructure necessary to sustain existing land uses and water-related functions. Uncertainty complicates devising interventions and strategies for these challenges. Adequate interventions are here understood as appropriate to account for the uncertainty planners are confronted with. For planners, adaptiveness holds the promise that uncertainty is adequately accounted for in their interventions.

Against this background, the purpose of this research was threefold. The first objective was to investigate what uncertainty is in the context of planning for interventions and long-term spatial transformations. The second was to obtain insight into what adaptiveness is and how it can help planners decide on interventions amid uncertainty. The third was to examine the applicability of adaptiveness in planning practice. These objectives were addressed by the following research question: **What differentiation of uncertainty helps planners decide on interventions in delta areas, and to what extent does adaptiveness contribute to handle this uncertainty?**

Two theoretical explorations led to a conceptual understanding of *uncertainty* and *adaptiveness*. Uncertainty is a concept which comprises different types of uncertainty, the understanding of which offers insight into adequate and warranted planning interventions. To draw out

insights for planning, this thesis examines planning frameworks that explicitly recognise uncertainty and uncertainty descriptions found in environmental risk and climate change literature. This thesis addresses the implications of different characteristics of uncertainty and offers a description of how planners can handle uncertainty, based on the nature, level and location of uncertainty. Furthermore, this thesis makes the argument for a plural-unequivocal characterisation of uncertainty to help planners devise adequate and warranted interventions.

A plural-unequivocal characterisation helps specify the appropriate interventions, based on the level and location of uncertainty, to deal with each of the distinct natures of uncertainty. These distinctions, which are unequivocal as to their consequences for planning, reflect the nature of the uncertain phenomenon and the possibility to reduce the uncertainty. Thus, uncertainty may have an ontic, an epistemic or an ambiguous nature, and the planner can determine the distinct interventions most adequate to address the prevalent uncertainty. Ontic uncertainty implies that an uncertainty is irreducible and can best be handled by adjusting the object of planning to the conditions of the uncertain phenomenon. Epistemic uncertainty implies reducibility and can best be handled by gaining more knowledge. Ambiguity implies conflicting frames, which can be partly incorporated into the planning process to build a common knowledge base and to align frames. The level of uncertainty offers pointers about the knowledge that can be derived about an uncertain variable. The location of uncertainty indicates the place where an uncertainty manifests itself. Insight in the level and location of uncertainty constrain and specify planners' choices of interventions. The level and location become particularly important when determining where and how to intervene. For example, a planner can choose between interventions in the institutional setting (is co-construction of knowledge by multiple stakeholders a feasible solution?) or the physical environment (is a different dyke alignment adequate?) of a planning practice. Based on the location of uncertainty, a planner can also choose on the scale of an intervention (a dyke reinforcement or a change in a river's discharge distribution). Each of the characteristics of uncertainty implies something about the adequacy or inadequacy of specific interventions and indicates whether an intervention is warranted with regard to its projected outcomes.

Adaptiveness is a concept that allows planners to deal with uncertainty. While adaptiveness is increasingly discussed within the context of

planning, its operationalization often remains unspecified. This thesis distinguishes three domains in which planners can use adaptiveness when dealing with uncertainty. The first of these domains is adaptive management, which is based on trial and error and experiments, and on interventions supported by the insights derived from these experiments. This is adaptiveness through constant readjustment and learning how a system responds to interventions. The second domain of adaptiveness involves increasing a system's adaptive capacity, which is the inherent capacity of a system (such as an ecosystem or city) to adapt to changing circumstances. A system's adaptive capacity can be enhanced by establishing and enforcing internal learning mechanisms, by supporting and utilising institutional structures that respond to stakeholder needs, and on increasing system resilience through creative, possibly ad hoc, flexibility. The third domain is adaptive planning, through which planners create leeway for anticipating unforeseen events and for mapping possibilities for future interventions. Adaptive planning is deliberately anticipatory and helps planners to implement interventions responsive to possible future scenarios.

Because these two theoretical explorations would give an incomplete answer to my research question, I studied three aspects of spatial planning practices in order to understand and evaluate how adaptiveness is used to handle uncertainty in planning practice. First, I compared two planning approaches. The water diplomacy framework and adaptive delta management both originate from the audacious attempt of practitioners to plan for situations fraught with uncertainty. Second, I studied the application of a tool that aims to support planning: adaptation pathways. This tool was created to help planners develop policy strategies for the long term, which is deeply uncertain. The tool's use was studied in climate adaptation planning practices in Portugal, the Czech Republic and the Netherlands. Third, I studied how planners effectuated adaptiveness in a collaborative, strategic planning process for the IJsselmeer area in the Netherlands. Approaches and tools are of particular importance when planners take uncertainty consciously into account. In planning processes, the use of approaches and tools is influenced by actors operating at different institutional levels and with conflicting stakes.

The comparative study of the water diplomacy framework (WDF) and adaptive delta management (ADM) showed how planners and water managers use adaptiveness in planning approaches to handle

uncertainty. The thesis shows that the approaches differ in their conceptualization of uncertainty and that the approaches build on different types of adaptiveness. While WDF builds on adaptive *management* as a set of on-going adjustments and continuous and collaborative learning to handle uncertainty, ADM builds on adaptive *planning* by anticipating possible future adaptations. To do so, ADM uses a set of tools that allow for seizing future opportunities and avoiding lock-in and lock-out mechanisms. Based on the analysis of its characteristics with respect to the different sorts of adaptiveness, ADM should more properly be called adaptive delta *planning*. WDF focuses on ambiguity and epistemic uncertainty, while it neglects ontic uncertainty about long-term change. ADM focuses on ontic uncertainty but is not concerned with epistemic uncertainty or ambiguity. Both approaches may benefit from greater specificity about what uncertainty and adaptiveness entail in the development of water management strategies. To handle all uncertainties, planning approaches should offer a coherent package that addresses the nature of the uncertainty, identifies the implications of these uncertainties for the problem at hand, and provides the necessary tools to handle each of the uncertainties. The conclusion is that neither of the approaches studied in this thesis is fully able to handle the three natures of uncertainty.

Adaptation pathways was studied as example of a planning tool intended for handling uncertainty. This tool is used in designing adaptive policies to handle climate change uncertainty of an ontic nature. Ontic uncertainties cannot be reduced. To gain insight in the use of adaptation pathways, a comparison was undertaken of four climate adaptation planning initiatives in three countries (one in Portugal, one in the Czech Republic and two in the Netherlands). In each initiative particular design choices were made, relevant for their specific contexts. This thesis indicates six design choices which should be considered when adjusting the adaptation pathways tool to a specific case. To design adaptation pathways choices were made about the geographic scale, the sectors included, the generation and delineation of adaptation options, the specification of possible pathways, and the related performance metrics and the type of assessment. Design choices are themselves interdependent, and they further depend on contextual aspects: institutional diversity, planning culture and the framing of planning objectives. The comparison of the four cases shows that the adaptation pathway tool is flexible enough to be adjusted for diverging planning practices. However, the adaptation pathways tool is best suited to

deliver local adaptation solutions. Its adequate use depends on the determination of uncertainty about future change, consensus about the adaptation problem, and the setting of objective thresholds. Based on the study of the water diplomacy framework and adaptive delta management, as well as the four initiatives using adaptation pathways, this thesis concludes that understanding the customised use of planning instruments for local planning practices is essential for their adaptive design.

In addition to the comparative study of two planning approaches and four applications of adaptation pathways, this thesis also inquired how collaboration in a planning process influenced the handling of uncertainty. Here, this research focused on the development of strategies to manage water resources and flood risk in the Delta Programme for the IJsselmeer area (the Netherlands). This case shows how a fixation on certainty, different perspectives among actors, and unclear responsibilities between planning arenas affect the handling of uncertainty. It also showed that collaboration complicates the handling of uncertainty. The use of adaptive planning to support strategy development challenged current water uses and system functions. Adaptive planning specifies possible system alterations needed to cope with long-term climate change, hence creating resistance from actors. The thesis therefore indicates that to make adaptive planning successful in handling uncertainty, it is necessary to develop a common understanding of uncertainties and a shared perception of the problem, and to clearly demarcate the water system and its current uses, including its societal functions (such as sustaining flood security and ecological values). Such demarcation is necessary to create leeway for unforeseen events and to determine adequate thresholds for implementing interventions responsive to future situations, which will differ between water systems.

Building on the theoretical explorations and the empirical studies, the thesis concludes that planners must distinguish between different types of uncertainty in order to determine the most appropriate planning approaches or tools. Planners must distinguish between uncertainties of an ontic, epistemic, or ambiguous nature, as well as the level and location of these uncertainties. This enables planners to account for the different implications of these types of uncertainty. Interventions can then be assessed for their adequacy, which has implications for the type of adaptiveness desired in planning practices.

The three archetypal domains of adaptiveness that were distinguished (adaptive management, adaptive capacity and adaptive planning) have close ties to the three natures of uncertainty (ontic uncertainty, epistemic uncertainty and ambiguity). In a sense, each of the domains of adaptiveness is tailored to deal with uncertainty of a specific nature, but with some additional capacity for dealing with other types of uncertainties as well. While adaptive management enables planners to deal with epistemic uncertainty, it also helps planners to handle ambiguity by increasing the knowledge base - especially when done in collaboration and by mutual learning. Adaptive capacity emphasises the co-construction of knowledge, learning and responsiveness to stakeholder needs, which enable planners to deal with ambiguity, but also affects the handling of ontic uncertainty, because enhancing adaptive capacity increases the responsiveness to uncertain future change. Adaptive planning enables planners to deal with ontic uncertainty by anticipating future conditions through defining windows of opportunity and offering three types of flexibility (the flexibility to time, to adjust or to shift between interventions). Adaptive planning also contributes to the handling of epistemic uncertainty, because – for adequate adaptive planning – planners must determine the conditions for future interventions and the directions of possible change. This thesis shows that it is possible to tailor domains of adaptiveness to particular uncertainties, as long as planners are aware of the premises underlying their approaches and tools, and the functioning of both in collaborative planning processes.

The societal relevance of this thesis lies in its disentangling of the concepts of uncertainty and adaptiveness, which offers practitioners a way to more cogently develop strategies than without such distinction. The exploration of adaptiveness in planning approaches, tools and processes helps determine what works, as well as how to incorporate adaptiveness in planning practices while avoiding its downsides. With this thesis, those engaged in embedding adaptiveness in existing planning practices can tailor their efforts to the particular uncertainties they are confronted with. Knowing which understandings of uncertainty and adaptiveness exist, and which unequivocal implications for planning practice underlie these particular understandings, opens up new directions for strategic spatial interventions when planning delta areas.

Samenvatting

Dit proefschrift is de neerslag van mijn onderzoek naar hoe ruimtelijke planners het begrip 'adaptiviteit' uitleggen en gebruiken om met de onzekerheid waarmee ze geconfronteerd worden bij het maken van ruimtelijke plannen om te gaan. Het onderzoek is in de eerste plaats opgezet om inzicht te krijgen in adaptief plannen, zoals dat verwoord is in het Nederlandse Deltaprogramma. Het Deltaprogramma was een overheidsprogramma dat van 2010 tot 2014 heeft gelopen en in het programma werd samengewerkt tussen alle lagen van de overheid. Het doel van het programma was om voor heel Nederland strategieën te formuleren voor lange termijn watermanagement en ruimtelijke adaptatie.

Een tweede belangrijke reden om dit onderzoek op te zetten was dat ik verschillende, contrasterende visies op onzekerheid zag in de theorieën over ruimtelijke planning. Deze verschillende visies moesten in mijn ogen beter geduid worden. Onzekerheid als zodanig wordt namelijk als argument en rechtvaardiging voor adaptieve planning aangevoerd. Adaptief plannen is omschreven als een vorm van planning waardoor plannen en strategieën later aangepast kunnen worden mocht de toekomst toch anders uit blijken te pakken dan we nu denken. Dit zag ik terug in zowel de ruimtelijke wetenschappen als in de dagelijkse planningspraktijk. Goed inzicht in wat onzekerheid is, is daarom van belang voor zowel theorie als praktijk.

Onzekerheid is extra belangrijk als planners naar de lange termijn kijken. Een lange termijn gaat over meer dan 10 jaar en kan zomaar 100 jaar zijn. Een voorbeeld zijn gemalen voor de waterafvoer die vaak vele decennia blijven liggen en hoge aanlegkosten met zich meebrengen. Daarom heb ik in dit proefschrift specifiek aandacht voor de ontwikkeling van plannen en strategieën die planners voor de lange termijn maken. Dergelijke plannen hebben bijvoorbeeld lange termijn implicaties voor de ruimtelijke inrichting van een land, bijvoorbeeld door het aanleggen van infrastructuur die tientallen jaren blijft liggen.

In dit proefschrift focus ik op de planning van ingrepen in deltagebieden, zoals de aanleg van dijken, het graven van kanalen of het instellen van waterpeilen. Dit doe ik omdat in delta's onze maatschappij en de fysieke leefomgeving in constante wisselwerking zijn. Deze wisselwerking is in delta's specifiek wat we noemen 'hoog-dynamisch', doordat water, klei en

zand beweeglijk zijn, zelfs als we die proberen vast te maken met dijken of asfalt. Dit heeft gevolgen voor de bestaande ruimtelijke inrichting en de organisatie daarvan. Grote vraagstukken zoals klimaatverandering en verstedelijking zetten deze inrichting echter onder druk. Ook zijn het vraagstukken die alleen door grote investeringen het hoofd geboden kunnen worden. Ingrepen en investeringen die nu gedaan worden bepalen daarbij ook hoe in de nabije en verre toekomst delta's kunnen ontwikkelen en transformeren naar een andere vorm van ruimtelijke inrichting. Daarvoor zijn strategieën nodig.

Strategieën geven vorm aan hoe we willen ingrijpen en investeren in de ruimtelijke inrichting van dergelijke gebieden en hoe we dat organiseren. Het gaat dus om lange termijn strategieën die de doelen en inrichting op hoofdlijnen beschrijven. Op basis daarvan kunnen planners bepalen welke klimaatadaptatiemaatregelen of investeringen in waterinfrastructuur noodzakelijk zijn. Planners hebben bijvoorbeeld als doel om landgebruik en verschillende functies van watersystemen, zoals waterveiligheid, stabiele bodems, schone steden en landbouw, te behouden of om veranderingen te sturen in de richting die de samenleving voor ogen heeft. Het ontwikkelen van zowel strategieën als adequate ingrepen in de ruimtelijke inrichting wordt echter sterk bemoeilijkt door onzekerheid. Een ingreep is alleen adequaat als die is toegespitst op de onzekerheid waarmee planners geconfronteerd worden. Er wordt geclaimd dat adaptiviteit hiervoor een mogelijk concept is. Mijn proefschrift begint met het signaleren dat het een gangbare aanname is dat adaptiviteit ruimtelijke planners in staat stelt om adequate strategieën en ingrepen te bepalen die met onzekerheid om kunnen gaan. De vraag is echter of dit daadwerkelijk zo is.

Het doel van dit onderzoek was daarom drievoudig:

1. Onderzoeken wat voor mogelijke typen onzekerheid er zijn als het over ruimtelijke planning gaat.
2. Inzicht krijgen in wat adaptiviteit is en wat het kan betekenen als planners moeten besluiten over ingrepen, terwijl ze geconfronteerd worden met onzekerheden over bepalende parameters.
3. Bestuderen of adaptiviteit daadwerkelijk toepasbaar is in de planningspraktijk om tot adequate strategieën en ingrepen te komen om met onzekerheid om te gaan.

Deze doelstellingen zijn vervat in mijn onderzoeksvraag: **Welk onderscheid in typen onzekerheid helpt planners om te beslissen over ingrepen in deltagebieden, en in hoeverre kan adaptiviteit een bijdrage leveren om met die onzekerheid om te gaan?**

Dit heeft geresulteerd in twee theoretische studies die inzicht geven in respectievelijk onzekerheid en adaptiviteit. Ik beargumenteer dat onzekerheid conceptueel uit verschillende typen bestaat. Goed begrip van die typen en met name de verschillende implicaties van elk type voor planning geeft ruimtelijke planners inzicht in wat adequate en gerechtvaardigde ingrepen zijn. Om dit inzicht te krijgen heb ik verschillende kaders voor ruimtelijke planning die inzicht geven in onzekerheid vergeleken. De uitkomsten hiervan heb ik kritisch tegen het licht gehouden aan de hand van beschrijvingen van onzekerheid in risicostudies en literatuur over klimaatverandering. Deze heb ik samengebracht om inzicht te bieden in de implicaties die verschillende karakteristieken van onzekerheid hebben. De karakteristieken die ik uit de literatuur gebruik zijn de aard, het niveau en de locatie van onzekerheid. Elke karakteristiek geeft inzicht in hoe er met onzekerheid om kan worden gegaan.

Het onderscheid in typen onzekerheid gebaseerd op deze drie karakteristieken noem ik een meervoudig-eenduidige duiding van onzekerheid. Hiermee geef ik aan dat er meerdere onzekerheden zijn te onderscheiden, die elk in principe een eenduidige set van implicaties voor de ruimtelijke planning hebben. Ik heb hier voor gekozen om expliciet aan te geven waar het niet om gaat: een enkelvoudige duiding van onzekerheid. Hiermee wordt onzekerheid namelijk een containerbegrip, wat kan leiden tot onjuiste strategieën of verkeerde ingrepen om ermee om te gaan.

Het onderscheid van typen onzekerheid naar aard, niveau en locatie geeft richting om adequate en gerechtvaardigde ingrepen te bepalen. De aard van onzekerheid kan ontisch, epistemisch of ambigue zijn. Een ontische onzekerheid betreft een variabele die inherent niet reduceerbaar is, zoals het voorspellen van het weer een jaar in de toekomst. Dit is simpelweg onmogelijk. Alleen door aanpassingen in de ruimtelijke inrichting of de organisatie daarvan kan met dergelijke onzekerheden omgegaan worden. In dit proefschrift gebruik ik daarvoor het voorbeeld van een dijk. Een dijk voorkomt dat het water van een rivier, als die buiten zijn oevers treedt, het omliggende land overstroomt. De hoeveelheid water

is onzeker. De enige manier om daarmee om te gaan, vanuit de dijk gezien, is de dijk te verhogen of te versterken. Hier gaat het dus om ontische onzekerheid. Epistemische onzekerheid is naar zijn aard juist wel reduceerbaar. Het kan namelijk gereduceerd worden door het vergroten van kennis of het reduceren van fouten in wat we weten. Als je onzeker bent over waar een dijk kan falen is een adequate ingreep het beter doormeten van die dijk om locaties waar de dijk kan falen in beeld te brengen. Verhogen of versterken zou een slechte investering zijn, terwijl dat voor ontische onzekerheid juist een adequate ingreep is. Ambigue onzekerheid komt naar zijn aard voort uit verschillende visies of perspectieven. Een adequate handelingswijze is om die visies bij elkaar te brengen of om ingrepen te zoeken die passen binnen verschillende visies. Als er onzekerheid is over het noodzakelijke veiligheidsniveau dat een dijk moet bieden, dan is daarover een gedeelde visie ontwikkelen een logische ingreep. Zomaar verhogen of versterken, of het doormeten op waar de dijk kan falen zijn dan geen adequate ingrepen.

Naast de aard zijn ook het niveau en de locatie van onzekerheid van belang. Het niveau van onzekerheid geeft aan op welk niveau er iets over een onzekerheid gezegd kan worden, bijvoorbeeld in probabilistische termen of alleen in denkbare scenario's. De locatie van onzekerheid geeft aan waar een onzekere variabele zich manifesteert. Niveau en locatie van onzekerheid begrenzen en specificeren hiermee de mogelijke keuzes voor ingrepen. Zoals ik in het voorbeeld schetste kan een planner kiezen voor een ingreep waardoor verschillende visies op wat voldoende veilig is bij elkaar worden gebracht, of voor een ingreep in de fysieke omgeving door het versterken van een dijk. Het niveau geeft aan hoeveel speelruimte er is binnen beide ingrepen (niveau van de mate waarin wereldvisies uit elkaar liggen versus een mogelijk probabilistisch bepaalde bandbreedte waarmee de mogelijke hoogte van het water in een rivier gespecificeerd kan worden). De locatie geeft een indicatie van de schaal waarop een ingreep wordt gedaan, bijvoorbeeld visies op landelijk niveau of in een stadsbuurt, of het aanpassen van de hele rivierafvoer (door stroomopwaarts aanleg van retentiegebieden of rivierverruiming) of het plaatselijk aanpassen van het dijktracé. Elk van de karakteristieken van onzekerheid geeft informatie over ingrepen in de ruimtelijke planning. Op basis van die karakteristieken valt ook te zeggen of het een adequate ingreep is.

Adaptiviteit is een concept waarmee beoogd wordt met onzekerheid om te gaan. Hoewel het concept al vaak bediscussieerd en beschreven

is, blijft de uitleg en toepassing ervan ongespecificeerd. Om het concept goed te begrijpen heb ik eerst op een abstract niveau onderscheid in drie domeinen van adaptiviteit gemaakt: adaptief managen, adaptieve capaciteit en adaptief plannen. Adaptief managen is gebaseerd op experimenteren en door al doende te leren van gemaakte fouten of opgedane kennis. Dit is adaptief door constant te itereren om optimale ingrepen te doen. Door te itereren kan geleerd worden hoe een systeem werkt en reageert op steeds effectievere ingrepen. Adaptieve capaciteit is gebaseerd op het versterken van een systeem. Dit kan door mechanismen om het leren van externe ontwikkelingen te borgen en door structuren zo te veranderen dat het systeem met calamiteiten of verschuivende behoeften en perspectieven van stakeholders om kan gaan. Dit is adaptief door het vergroten van vaardigheden om een systeem creatief te laten aanpassen aan onverwacht veranderende omstandigheden. Adaptieve planning is gebaseerd op het anticiperen van veranderingen of calamiteiten door nu al ruimte te creëren voor toekomstige ingrepen in het systeem. Dit is adaptief door bewust toekomstgericht te anticiperen op basis van mogelijke scenario's en veranderingen. Elk van deze domeinen geeft inzicht om te bepalen wat goede strategieën en verstandige ingrepen zijn in de ruimtelijke planning.

De uitkomsten uit deze twee theoretische exercities geven een incompleet antwoord op mijn onderzoeksvraag. Daarom heb ik mijn theoretische bevindingen getoetst aan de praktijk, en zo de inzichten in hoe adaptiviteit bijdraagt aan het omgaan met onzekerheid verdiept. Drie aspecten van de ruimtelijke planning staan centraal: benaderingen, instrumenten en processen. In een benadering proberen planners een alomvattend stappenplan te ontwikkelen voor de omgang met vraagstukken die binnen de ruimtelijk planning opgepakt worden. Instrumenten zijn toegespitst om op specifieke onderdelen hiervan aanvullende afwegingen te maken. Beide moeten worden ingezet in een proces om samen met betrokkenen de juiste keuzes te maken. Planningsbenaderingen en instrumenten zijn specifiek van belang om te bestuderen omdat planners ze gebruiken om gericht met onzekerheid in hun activiteiten om te gaan. In planningsprocessen komen de invloeden (van de externe omgeving, actoren, etc.) op het gebruik van benaderingen en instrumenten tot uiting.

In dit proefschrift heb ik twee planningsbenaderingen vergeleken: het 'water diplomacy framework' (WDF) en 'adaptief delta management' (ADM). Deze zijn beide ontstaan uit de vermetele poging van planners

om met onzekerheid om te gaan. Ook heb ik een instrument bestudeerd dat ontwikkelt is om met onzekerheid om te gaan als planners lange termijn strategieën willen formuleren: de adaptatiepadenmethode. Ik heb het gebruik van dit instrument in Portugal, Tsjechië en Nederland onderzocht. In mijn kader is de adaptatiepadenmethode een instrument en geen aanpak, omdat het velerlei vraagstukken om binnen de ruimtelijke planning tot een strategie, plan of beleid te komen buiten beschouwing laat. Als derde heb ik het planningsproces in het Deltaprogramma IJsselmeer onderzocht. Ik wilde daarmee ontdekken hoe adaptiviteit vorm gegeven werd om tot een lange termijn strategie voor waterbeheer en overstromingsbescherming in het IJsselmeergebied te komen. Ik ga hierna achtereenvolgens op elk van deze drie deelstudies in.

De vergelijking tussen WDF en ADM laat zien hoe adaptiviteit op verschillende manieren gebruikt kan worden in planningsbenaderingen. De conceptualisering van onzekerheid en de domeinen van adaptiviteit waarop ze zijn gebaseerd verschilt tussen de benaderingen. WDF gebruikt adaptief managen en beoogd continue aanpassingen en doorgaand leren door samenwerking. ADM gebruikt adaptief plannen en beoogd anticipatie van mogelijke toekomstige ingrepen en aanpassingen. De benadering die met ADM wordt voorgestaan bestaat uit het in kaart brengen van de mogelijkheden om in de toekomst in te grijpen in de ruimtelijke inrichting. ADM wil ook, deels door middel van de adaptatiepaden, het ongewenst opsluiten (lock-in) op een ongewenste ontwikkelpad, of afsluiten (lock-out) van een gewenste ontwikkeling van de ruimtelijke inrichting in beeld brengen en voorkomen. Ik concludeer dan ook dat wat nu adaptief delta management heet beter adaptieve deltaplanning zou kunnen heten.

Ten aanzien van onzekerheid focust WDF op het omgaan met ambigue en epistemische onzekerheid, maar negeert ontische onzekerheid over de lange termijn. ADM focust juist op die ontische onzekerheid, maar geeft geen inzicht in hoe planners met de benadering met epistemische of ambigue onzekerheden om kunnen gaan. Beide benaderingen kunnen profiteren van een specifiekere duiding van wat ze wel en niet beogen. Dat biedt planners de mogelijkheid scherpere keuzes te maken als ze voor hun situatie strategieën en handelingsperspectieven willen ontwikkelen met deze benaderingen. Om met alle onzekerheden naar hun aard om te gaan verdient het aanbeveling beide benaderingen te integreren. Een dergelijke geïntegreerde planningsbenadering zou

voor adequaat gebruik minstens inzicht moeten geven in de typen onzekerheid, de implicaties van die onzekerheden moeten identificeren voor het specifieke planningsprobleem en voldoende en adequate instrumenten moeten bieden om met die onzekerheden om te gaan. Ondanks dat ze beide claimen de planner te voorzien in de mogelijkheid om met onzekerheid (als enkelvoudig concept) om te kunnen gaan, concludeer ik dat geen van beide benaderingen volledig in staat is de planner te helpen om tegelijkertijd met alle typen onzekerheden om te gaan.

De adaptatiepadenmethode is ontwikkeld om onzekerheid een plek te geven in het ontwerp van watermanagementstrategieën of -beleid. Het is primair gericht op het formuleren van adaptief beleid voor het omgaan met klimaatonzekerheid met een ontische aard, dus onzekerheid die niet gereduceerd kan worden. Ik heb het gebruik van de adaptatiepaden in vier situaties met elkaar vergeleken om generieke ontwerpkeuzes in het toepassen van het instrument te vinden. Door vier situaties te vergelijken verkreeg ik ook inzicht in de contextuele aspecten die dergelijke ontwerpkeuzes beïnvloeden. Zes ontwerpkeuzes bleken overwogen te moeten worden door planners als ze de adaptatiepaden toepassen. Dit zijn keuzes omtrent de geografische schaal, de op te nemen sectoren, het genereren en afbakenen van adaptatieopties, het specificeren van mogelijke ontwikkelpaden, de te meten prestatie-indicatoren en de wijze waarop de planner de effectiviteit van de adaptatiepaden wil beoordelen (bijvoorbeeld kwantitatief, kwalitatief, op welke termijn en met wie?). Deze keuzes zijn wederzijds van elkaar afhankelijk. Ook bepalen contextuele aspecten de invulling van de adaptatiepaden. Bepalende contextuele aspecten zijn de invloed van de vorm van institutionele diversiteit, de lokale planningscultuur en de wijze waarop doelen en onzekerheden uitgelegd worden.

De conclusie uit de vergelijking is dat de adaptatiepadenmethode flexibel genoeg is om aangepast te worden aan verschillende planningspraktijken, maar dat het instrument vooral geschikt is om adaptieve oplossingen op lokale schaal in kaart te brengen, mits de zes ontwerpkeuzes gehanteerd worden. Tevens is de conclusie dat adequaat gebruik afhangt van het bepalen van het type onzekerheid, de realisatie van consensus over het probleem en het vaststellen van objectieve drempelwaarden voor verschillende ontwikkelpaden (de waarde die bepaald wanneer planners een ingreep moeten doen om aan de gestelde doelen te voldoen). Gebaseerd op zowel het deelonderzoek

naar de planningsbenaderingen en de adaptatiepaden concludeer ik dat het gebruik van adaptiviteit sterk afhangt van een goede inpassing van planningsbenaderingen en instrumenten voor specifieke planningspraktijken.

Naast deze twee studies heb ik ook het strategievormingsproces in het Deltaprogramma voor het IJsselmeergebied bestudeerd. Dit proces was gericht op zowel waterbeheer als overstromingsbescherming. Samenwerking met verschillende publieke en private actoren was in het proces leidend. Dit was een belangrijke reden om dit proces te bestuderen, omdat samenwerking mogelijk de omgang met onzekerheid beïnvloedt, wat de studie inderdaad bevestigt. Drie factoren zijn hiervoor specifiek van belang: een fixatie op zekerheid, verschillende visies op de ontwikkeling van het gebied en een onduidelijke verdeling van verantwoordelijkheden tussen groepen overheden. Door deze drie factoren bemoeilijkt samenwerking het omgaan met onzekerheid.

Uit de studie kwam ook naar voren dat het ontwikkelen van een strategie voor systeemverandering door middel van adaptieve planningsbenaderingen het huidig watergebruik en systeemfuncties, zoals waterveiligheid of ecologie, beïnvloedt en uitdaagt. Door adaptief te plannen worden mogelijke veranderingen in het systeem namelijk uitgespeld. Veranderingen zullen vaak afwijken van het huidig gebruik of bestaande functies en daarmee weerstand van actoren oproepen. Om adaptieve planning succesvol te maken is het dus nodig om voor een gezamenlijk beeld van de onzekerheden en een gedeeld probleembesef te zorgen. Daarnaast is het noodzakelijk om wat het systeem is en welke gebruiken en functies er vanaf hangen duidelijk en expliciet af te bakenen. Afbakening is bijvoorbeeld noodzakelijk om ruimte te creëren om met onverwachte ontwikkelingen om te gaan en om drempelwaarden voor toekomstige aanpassingen van het systeem adequaat te bepalen.

Op basis van deze deelstudies concludeer ik dat verschillende typen onzekerheid moeten worden onderscheiden om te bepalen wat adequate ingrepen zijn en om bruikbare benaderingen en instrumenten in de ruimtelijke planning te kiezen. Het verschil tussen ontische, epistemische en ambigue onzekerheden, samen met het niveau en de locatie biedt hiervoor houvast. Planners kunnen verantwoord omgaan met de implicaties van elk type onzekerheid. Op basis van dit proefschrift kunnen hun voorgestelde ingrepen en adaptieve werkwijze beoordeeld

worden ten aanzien van de geschiktheid voor het omgaan met onzekerheid.

De drie archetypische domeinen van adaptiviteit (management, capaciteit en planning) zijn nauw verbonden aan de verschillende onzekerheden, onderscheiden naar hun aard. Op een bepaalde manier is elk van de domeinen van adaptiviteit specifiek geschikt voor het omgaan met ofwel ontische, epistemische of ambigue onzekerheid. Elk van de domeinen heeft echter ook een neveneffect dat planners in staat stelt effectiever de andere typen adaptiviteit toe te passen. Adaptief managen stelt planners in staat met epistemische onzekerheid om te gaan, maar het verbreedt ook de kennisbasis die nodig is voor het omgaan met ambigue onzekerheid. Gezamenlijk leren en kennis ontwikkelen verhoogt deze meerwaarde van adaptief managen. Adaptieve capaciteit benadrukt het gezamenlijk ontwikkelen van kennis, het vergroten van leervermogen en responsiviteit ten aanzien van de belangen van actoren. Planners kunnen hiermee met ambigue onzekerheden omgaan. Het versterkt ook de omgang met ontische onzekerheid omdat een snellere reactie mogelijk wordt als er onzekere verandering plaats vindt. Adaptieve planning helpt planners om ontische onzekerheid een plaats te geven in hun ingrepen door het anticiperen van toekomstige condities. Anticiperen kan bijvoorbeeld door vast te leggen hoe en wanneer je kunt ingrijpen (op basis van het definiëren van kansen en tijdvensters) en om ruimte te behouden door flexibiliteit in te bouwen: om eerder of later in te grijpen, om een andere ingreep te doen of om je ingreep te wijzigen. Adaptieve planning heeft ook voordelen voor de omgang met epistemische onzekerheid, omdat voor adequate adaptieve planning zowel de condities voor toekomstige ingrepen als de richting van mogelijke verandering in kaart moeten worden gebracht. Het is mogelijk om elementen uit de verschillende domeinen te gebruiken om ruimtelijke planning in te richten om met specifieke onzekerheid om te gaan. Planners moeten zich hiervoor wel bewust zijn van de aannames en veronderstellingen inherent aan benaderingen en instrumenten. Ook moeten ze secuur omgaan met het inpassen van de gekozen planningsbenaderingen en instrumenten in planningsprocessen, zeker als daarin wordt samengewerkt tussen veel actoren en instituten.

De maatschappelijke relevantie van deze uitkomsten ligt in de eerste plaats in het uiteenrafelen van de concepten onzekerheid en adaptiviteit. Dit biedt planners en beleidsmakers nieuwe inzichten als ze strategieën willen maken voor problemen die onderhevig zijn aan verschillende

onzekere variabelen. Dit proefschrift geeft inzicht in wat vanuit de drie adaptieve domeinen wel en niet werkt. Ook biedt het ontwerpkeuzes die relevant zijn als planners instrumenten willen implementeren in nieuwe, andersoortige planningspraktijken dan waar een instrument voor bedoeld is. Hiermee kan de bijdrage van instrumenten aan het omgaan met onzekerheid gemaximaliseerd worden. Kennis van onzekerheid en adaptiviteit, en weten welke implicaties de karakteristieken van onzekerheid hebben, opent nieuwe perspectieven voor ruimtelijke planners. Ze kunnen hiermee betere strategische ingrepen plegen in deltagebieden.

Acknowledgements

I would like to take the opportunity of finishing my PhD thesis to thank some people for the support and acknowledge them for their impact on this thesis and my development as a scientists and person. First of all, I owe a great deal to my promotor and copromotores. Adri, while you were always critical on finding the proper research gap and working towards some closure of that gap throughout my academic work, you also supported the direction I took and helped clarify the next steps on my own path. Frans, thank you for being precise and concise, in all the instances I was not. Maarten, as my daily supervisor you took up a role more than solely an academic one. At some moments you were more of a mentor and mental coach, at others you showed keen insight in the topic of my thesis, and at yet other moments we searched for answers together. Thank you for the influence you had and have on my academic work and my personal development.

Over the past five years I have worked in the chair group of Landscape Architecture, although the Land Use Planning group was as close to both my topic and my office. I want to thank my current and former colleagues for the interesting discussions, coffee breaks, conversations, intellectual discussions and administrative support. At this place, I owe special thanks to Adrie and Monique who made the figures and designed the lay-out of this thesis, thanks for your critical eye and creative input to make this for some of my readers rather boring work a little more accessible. I also want to thank all colleagues I met during conferences, workshops and other (academic) venues. Without a doubt, without a living community of experts in climate adaptation, spatial planning and water management, this thesis would not have reached its depth it now has. A special thanks I owe to Shafiq and Larry for allowing me to stay in their research program and get inspired and challenged while working in the Boston area.

During my research I had a great committee of senior experts who critically asked about my research and pushed me in directions I sometimes did not foresee. My intellectual growth and search for the practical implications of my research I partly owe to Lilian, Hetty, Ralph and Ad. Thank you for sitting in my committee and allowing me to pursue my own interests, while being critical on the practical relevance of this thesis. Ad, thank you for the opportunity to join-in on the BASE team and the extensive discussions we had in writing up the results for

chapter 5. It greatly improved my vision on planning in an international context. The experience of contributing to such a large European research project is indispensable. Off course I also owe special thanks to my not yet mentioned coauthors in this thesis and my other academic work. Thank you André, Eliska, Femke, Gill, Ines, Jannes, Rutger, Saskia and Tjalling for the time to work together on writing projects, which sometimes culminated in extensive and elaborate discussions about the content of what we worked on, but always helped to get a clear focus on our goals.

Tot slot wil ik op deze plaats ook mijn familie en vrienden bedanken. Dank voor jullie support en ondersteuning, begrip tijdens het onbegrip over wat ik precies deed en al het plezier en de leuke momenten tussendoor. Jullie gaven vaak het broodnodige andere perspectief, dat van een leven buiten het schrijven van een proefschrift. Debora en Gerrit Jan, dank dat jullie als mijn paranimfen mij ook bij de verdediging willen ondersteunen. Harry, dank voor je steun en de mogelijkheid om een deel van dit proefschrift tijdens het meereizen aan boord te mogen schrijven. Je bent voor mij onnoemelijk belangrijk. Pap en mam, alhoewel het voor jullie soms veel gekost heeft doordat we elkaar niet zagen, wil ik jullie bedanken voor de ruimte om mijn eigen pad te volgen. Ruth, dat we samen dit pad ingeslagen zijn was een gezamenlijke keuze ondanks dat we onzeker waren wat het ons ging brengen. Het was een enerverende tijd en ik wil je bedanken voor al je steun, de vele uren dat je thuis de boel draaiende hield en alle keren dat je mij kritisch bevroeg op de echte noodzaak om, zeker in het laatste jaar, weer een uurtje aan mijn proefschrift te zitten. Je houdt me met beide benen op de grond en zonder jou waren ik of dit boek hier niet gekomen. Je bent een fantastische vrouw en moeder. Dank je wel. Roos en Eva, jullie maken het leven elke dag een feestje.

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- *Tackling uncertainty with planning approaches for water management.* Deltas in Times of Climate Change, 24-26 September 2014, Rotterdam, The Netherlands
- *Uncertainty in water management: the IJsselmeer case.* AESOP PhD workshop, 6-10 July 2015, Stara Lesna, Slovakia

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About the author

Mark Zandvoort (1987, Delfzijl) studied integrated coastal zone management (BSc) at Van Hall Larenstein, University of Applied Sciences. He wrote his thesis on marine spatial planning during an internship at the Dutch Second Chamber of Parliament (2010). He pursued his MSc in Environmental and Infrastructure Planning at the University of Groningen, which he finished with a thesis on collective private commissioning (2012). He wrote this PhD thesis at the Landscape Architecture Group of Wageningen University (2012-2017). During this time he closely collaborated with the research institute Deltares, at which he was involved in the EU FP7 project Bottom-up climate Adaptation Strategies towards a sustainable Europe (BASE), and the Dutch Delta Programme. During his PhD studies he was a visiting researcher at the Massachusetts Institute of Technology (MIT) and Tufts University, in their collaborative program on Water Diplomacy. He now works part-time as a postdoctoral researcher at the Landscape Architecture Group of Wageningen University and part-time as a consultant in water and infrastructure projects at the engineering firm Tauw BV. He is dedicated to sustain the quality of our living environments by seeking improvements in infrastructure planning and water management. He has a particular interest in managing and replacing existing infrastructure assets, both in his Tauw projects and his research and education activities.

Mark is married to Ruth Zandvoort-Kuipers, they currently live together with their daughters Roos and Eva in Wageningen.

The financial support for the research in this thesis by Deltares and the Dutch Deltaprogramme is gratefully acknowledged.

Colophon

Cover-design: Mark Zandvoort and Monique Jansen
Lay-out: Monique Jansen (mnqjnsn.wordpress.com)
Printed by www.proefschriftmaken.nl
ISBN 978-94-6343-715-8