BACKCASTING FOR TRANSFORMATIVE WATER MANAGEMENT

Tom van der Voorn

This research received funding from the European Commission under grant agreement 511179 - NEWATER

ISBN: 978-94-6469-537-3
NUR: 943

Omslag: Ron Zijlmans
Lay-out: RON Graphic Power | www.ron.nu
Printing: ProefschriftMaken | www.proefschriftmaken.nl

BACKCASTING FOR TRANSFORMATIVE WATER MANAGEMENT

BACKCASTING VOOR TRANSFORMATIEF WATERBEHEER

Thesis

to obtain the degree of Doctor from the
Erasmus University Rotterdam
by command of the
rector magnificus

Prof.dr. A.L. Bredenoord

and in accordance with the decision of the Doctorate Board.
The public defence shall be held on

Thursday 26 October 2023 at 10.30hrs

by

Tom Sugeng van der Voorn
born in Surabaya, Indonesia.

Erasmus University Rotterdam

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ABBREVIATIONS

ADM	Adaptive Delta Management
AM	Adaptive Management
AS	Action Situation
BC	Backcasting
BCAM	BackCasting Adaptive Management methodology
BOCMA	Breede-Overberg Catchment Management Agency
BOMWA	Breede-Overberg Water Management Area
CEO	Chief Executive Officer
CMA	Catchment Management Area
CMS	Catchment Management Strategy
DP	Deltaprogram
DPRED	Deltaprogram Rhine Estuary Drechtsteden
GHG	Greenhouse gases
HIWMC	US Initiative Water Management Committee
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
MLP	Multi-level Perspective
MTF	Management and Transition Framework
NFIP	National Flood Insurance Program
NWA	National Water Act
PoR	Port of Rotterdam
RBM	River Basin Management
RCP	Rotterdam Climate Proof
SES	Social-ecological systems
ST	Socio-technical
TM	Transition Management
US	United States
USD	United States Dollar
WMS	Water management strategy
WRM	Water resources management

CHAPTER 1

INTRODUCTION: THE CHALLENGE OF TRANSFORMING WATER MANAGEMENT IN THE FACE OF CLIMATE CHANGE

1.1 THE PROBLEM CONTEXT: THE CLIMATE CHALLENGE

1.1.1 Climate change

Anthropogenic climate change has emerged as one of the biggest environmental challenges that the world is facing. The impacts of climate change: increases in temperature and shifts in precipitation patterns and snow cover, lead to more frequent and intense extreme weather events, such as flooding and drought (Pörtner et al., 2022). In many parts of the world, the impacts of climate change can be observed. A recent example is the unprecedented monsoon rainfall triggering, from June to August 2022, the most severe flooding in Pakistan's recent history. The flood affected 33 million people and more than 1730 lost their lives (MPDSI, 2022). According to the Post-Disaster Needs Assessment conducted by the Pakistan Ministry of Planning, Development and Special Initiatives, it was estimated that the total damages exceeded USD 14.9 billion, and the total economic losses reached about USD 15.2 billion (MPDSI, 2022). The estimated needs for rehabilitation and resilient reconstruction are at least USD 16.3 billion, all of which does not include the much needed new investments extending beyond the affected assets that will be required to support Pakistan's adaptation to climate change and its overall resilience to future climate shocks. Another recent flood example was the intense precipitation along with the high water levels of July 2021 in the Netherlands and surrounding countries which amounted to an extreme and exceptional event with major societal impacts in the Dutch Province of Limburg (ENW, 2021). The recorded precipitation rates and river discharges have never been as large during summer. It is estimated that such an event occurs only once every 100 to 1000 years. The peak discharge on the Meuse River near the Dutch village of Eijsden and a number of tributaries was the highest discharge ever recorded. The estimated total damages caused by flooding amounted to 350 to 600 million euros and took was centered, to a large extent, in the river Geul valley (ENW, 2021).

Due to global warming, the occurrence of heat and drought is becoming more common, which makes water shortages more likely, while demand is increasing. During the summer of 2022, Europe experienced its worst drought in 500 years (BBC, 2022). A combination of record-breaking temperatures and low rainfall caused rivers to dry, wildfires to rage and crop failures to inflate the already high food prices. For example, The Po River basin in northern Italy experienced its worst "water crisis" in approximately 70 years, disappearing completely in some areas and leading to a 30% drop in the rice harvest (BBC, 2022). As this drought played out across Europe, fears of a global food security crisis grew. Elsewhere, the American west experienced its most extreme drought conditions in 1,200 years and stretches of the Yangtze – China's longest river – reached their lowest level since at least 1865 amid extreme temperatures and a "severe lack of rainfall" (Tandon, 2022).

Furthermore, global warming can make seawater expand and land ice melt, both of which can cause rises in sea level, all of which increases the impacts of coastal storms (Lindsey, 2022). From the South Pacific to the Caribbean, small island states such as Tuvalu, the Marshall Islands, and Tahiti are experiencing sea level rise and increasingly severe storms. Sea level rise is likely to accelerate in the next three decades (WorldBank, 2022). Along with a loss of homes, roads and other infrastructure, rising seas have serious legal implications for small island states because all of this endangers their territorial rights, access to resources, and raises questions about internal and external migration as residents seek higher ground. Adapting to climate change and increasing resilience to its impacts are becoming increasingly important matters (Nalau and Cobb, 2022).

The evidence that carbon dioxide emission is the main driver of climate change is indisputable, though other greenhouse gases and air pollutants also affect the climate (IPCC, 2012, 2014, 2018, 2022b, c; IPCC, 2001). Such emissions are deeply rooted in our economic systems which are, in turn, responsible for unsustainable human production and consumption triggered by population growth, urbanization and growing wealth with a subsequent sharp increase in production to meet the demand for energy, food (especially meat and dairy produce), and other products and services, including global travel. These factors have resulted in a loss of biodiversity, unsustainable food production systems, and an acceleration in greenhouse gas emissions that is increasingly influencing the climate and the Earth's temperature (van der Voorn et al., 2022). This vastly magnifies the greenhouse gases already naturally occurring in the atmosphere, thereby intensifying the greenhouse effect and global warming (Obergassel et al., 2020). Increased concentrations of greenhouse gases result from unstainable development, which is amplified by the current economic system that overvalues private wealth and undervalues the common good (van der Voorn et al., 2022). This underscores the failure of a prosperity model based on growth and dependency on consumption (Paech, 2013). In times when income, wealth and opportunity inequalities have been rapidly increasing and the effects of climate change have become increasingly more visible, it might be worth taking a look at the concept of post-growth economics, which can actually be sustainable in the long term (Van der Voorn et al., 2022). Combating climate change will require fundamental changes in existing production and consumption patterns and processes, technologies, individual values and behaviors (O'Brien, 2012; Pelling et al., 2015; Steffen et al., 2018; Tàbara et al., 2018).

Although the public and the media often use the terms 'climate change' and 'global warming' interchangeably, they are actually referring to different facets of the same phenomenon (Benjamin et al., 2017). Global warming is just one aspect of climate change. Global warming has to do with rises in global temperatures, mainly due to the increasing concentrations of greenhouse gases in the atmosphere. Climate change refers to increasing climate changes over longer periods of time – including precipitation, temperature, and wind patterns. As a side effect of global warming, climate change will continue to affect ecosystems as well as human health, livelihoods, food security, water supply, and economic growth in a range of ways. The impacts are projected to increase steeply as warming accelerates. For instance, warming up to 2 °C, compared with 1.5 °C, is estimated to push the number of people exposed to climate-related risks and poverty up to several hundred million by 2050 (IPCC, 2022c). However, it remains difficult to predict the societal impacts of the complex interplay of all the mechanisms driven by global warming, including more frequent and intense extreme events causing widespread adverse impacts such as floods and droughts and the related losses and damages to nature and people that go beyond natural climate variability. Much of the impact on human well-being will depend on societal responses.

1.1.2 Dealing with climate change

At the 21st UN Conference of the relevant Parties, held in Paris in 2015, the nations of the world adopted the Paris Agreement (UNFCCC, 2015) which aims at limiting global warming and strengthening the global climate change response by increasing the ability of all to adapt to the adverse impacts of climate change and adopt climate resilience. The agreement defines a global goal pertaining to the main strategies of climate adaptation and climate mitigation. The aim is to enhance adaptive capacity and resilience; to reduce vulnerability to the impacts of climate change and to contribute to sustainable development while ensuring an adequate adaptation response to keeping the average global warming level well below 2 °C and pursuing efforts to keep it below 1.5 °C (Hooper et al., 2018).

Climate mitigation aims at making the impacts of climate change less severe by preventing or reducing the emission of greenhouse gases into the atmosphere (IPCC, 2022d). Mitigation is achieved either by reducing the sources of these gases - e.g. by increasing the share of renewable energies, or by establishing a cleaner mobility system - or even by enhancing the storage of these gases – for instance by increasing the forest sizes. In short, mitigation is a human intervention that reduces the sources of GHG emissions and/or enhances the "sinks" (reductions) of GHG emissions, mainly targeting technical solutions for CO2-emission reduction (Grafakos et al., 2020; Klein et al., 2005a).

Climate adaptation involves anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage it can cause, or taking advantage of the opportunities that may arise. Adaptation measures, include large-scale infrastructure changes, such as building defenses to tackle sea-level rise and behavioral shifts, such as when individuals invest in green rooftops and rain barrels or get rid of garden paving. In essence, adaptation can be seen as the process of adjusting the environment to the current and future effects of climate change. Climate change adaptation is mainly about increasing resilience of social-ecological systems (SES). After Meuwissen (2019:2), resilience is defined from a social-ecological perspective: "*the ability of a system to ensure the provision of the system functions in the face of increasingly complex and accumulating economic, social, environmental and institutional shocks and stresses, through increasing capacities of robustness, adaptability and transformability, which are grounded in the literature on adaptive cycles and adaptive governance*".

The notion of SES is used to emphasize the interconnectedness of social and ecological systems through human and natural elements that closely interact and mutually constitute situations (Folke et al., 2016; Folke et al., 2005a). It is also very much applicable to today's rapidly changing and densely populated deltaic and coastal regions (Berkes et al., 2000). The concept of SES integrates humans as part of nature but complicates the assessing and predicting of the future exposure of societies to climate change (Fikret et al., 2003). Model-based climate impact assessment studies can improve our understanding of complex changes in SES that may be attributed to anthropogenically caused changes in the climate. However, for various reasons the explanatory capacity of these studies is rather limited, as for instance revealed by Brown and Rounsevell (2021). In the first place, climate impact models remain a simplified representation of reality and are therefore bounded through a restricted subset of potential future conditions (Berkhout et al., 2002).

In the second place, it is difficult for climate impact models to predict how SES will be affected by climate change and how they will develop and behave over time as they exhibit properties that are associated with self-organizing complex adaptive systems characterized by nonlinear dynamics, threshold effects, cascades and surprises (Fikret et al., 2003; Folke et al., 2005a; Scheffers et al., 2016).

In the third place, (model-based) climate impact assessment studies embrace largely irreducible uncertainties (Berkhout et al., 2002; Brown and Rounsevell, 2021). Uncertainty is usually defined as a situation characterized by indeterminacies and it refers to what we cannot know for certain in terms of the outcomes, effects or impacts of a particular event where the probabilities cannot be calculated (Walker et al. 2003), see (Haasnoot et al., 2013b; Isendahl et al., 2010; Kwakkel et al., 2016) for other typologies of uncertainties). In the last two decades considerable methodological progress has been made in the field of climate impact assessment studies (Schneider and Kuntz-Duriseti, 2002).

Whereas in the early days of climate science, uncertainty was often seen as challenging the authority of science itself thus causing discomfort among scientists (Mehta et al., 2019), there has been a noticeable shift from a focus on reducing scientific uncertainty to understanding and managing uncertainty (Schneider and Kuntz-Duriseti, 2002). Mehta et al. (2019), for instance, refer to the Fifth Assessment Report, where the Intergovernmental Panel on Climate Change (IPCC) acknowledges that there are uncertainties that we will never grasp and that the best strategy is to understand and cope with them (IPCC, 2014). This gave rise to the emergence of new adaptation approaches, such as robust decision-making that recognize diverse perceptions and responses to uncertainty (IPCC, 2014; Ranger and Garbett-Shiels, 2012) and emphasize the importance of more bottom-up climate assessment and adaptation methods (Conway, 2019).

Obviously, climate change affects water management in multiple ways, ranging from changes in precipitation and therefore seasonal and annual patterns in floods and droughts, water availability or dilution capacity and, it has major impacts. This imposes the need to embed climate mitigation and adaptation within the broader target of achieving sustainable water management and resilience transformations. Both adaptation and mitigation require substantial resources, investments, and careful planning (Hritonenko and Yatsenko, 2022). At the same time, climate adaptation and mitigation are complementary as they can reinforce each other in the exploring of shared climate goals, in the assessing of trade-offs and when seeking mutually supportive outcomes (Grafakos et al., 2020; Iacobuţă et al., 2022; Kim and Grafakos, 2019; Klein et al., 2005a; Nwedu, 2020). On a global scale cities, for instance, have taken on the role of leading climate change adaptation and mitigation actors, reflecting both a shift towards a more bottom-up approach to climate action in accordance with the Paris Agreement and the ability of urban policymakers to implement climate policies. Cities are major drivers of energy consumption and greenhouse gas emissions, as the sources of anthropocentric climate change, whilst also concentrating people, buildings, and infrastructures and therefore also the potential risk and impacts of the latter (Grafakos et al., 2020; Sullivan et al., 2013). As a consequence, planning for climate change in urban areas does not only provide opportunity, but it should also necessitate the consideration of interaction between mitigation and adaptation. However, existing research found that only in a minority of urban areas mitigation and adaptation are taken into consideration in all the climate action plans (Grafakos et al., 2020).

For several reasons the main focus of this thesis is on climate adaptation and water management. In the context of water management, climate adaptation is mainly about enhancing the resilience of social-ecological systems. Despite advances in climate adaptation research, climate adaptation scholars have pointed to knowledge gaps in our understanding of climate adaptation. These gaps form the backdrop to this thesis. For example, the extent to which adaptation actions reduce climate risk, and for whom, is not always clear. Another important question is whether adaptation actions may generate unintended consequences or side effects thus causing more harm than good; a phenomenon commonly referred to as maladaptation (Schipper, 2020). Built defenses, such as sea walls, might protect coastal areas in the short term but their construction can destroy coastal ecosystems, such as coral reefs. In the long term, such defenses can even increase risks to people living behind them as more families relocate to areas that are supposedly safe to live in – as long as the sea wall is not spilled over or destroyed. These knowledge gaps continue to grow, due to the increasing complexity of water systems which are not only self-organizing complex adaptive systems, but also unpredictable and non-linear in their response to intervention and climate change, all of which poses uncertainties regarding their management (Pahl-Wostl, 2007b). Other aspects contributing to the persistence of these gaps are: lack of financial resources, insufficient political commitment, lack of reliable information and little sense of urgency. In addition, climate adaptation and climate mitigation are dealt with in isolation, but are actually complementary. For example, a study conducted by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (2020) highlights the significant, but yet undervalued role of climate mitigation in water management. Sustainable water management, for instance, is critical for sustaining carbon-rich water-dependent ecosystems like peatlands. In this regard, nature-based solutions are considered relevant to climate adaptation and water management since such solutions can either complement or substitute adaptation measures that rely on engineering or hard infrastructure (Fedele et al., 2019). Moreover, water-sector utilities can reduce energy use through more efficient technologies and exploit biogas derived from sewage GIZ (2020). However, most wastewater treatment plants in Europe are still consuming vast amounts of energy, despite recent efficiency gains.

1.2 THE RESEARCH SCOPE

1.2.1 Setting the scene for climate adaptation

At present, climate change and the associated impacts of extreme weather events, such as floods and droughts, can be observed in coastal and deltaic regions of Europe, North America and Africa (IPCC, 2022a). The increase in weather and climate extremes has led to certain irreversible impacts as natural and social systems are being pushed beyond the ability to adapt. Across sectors in these regions, it is the most vulnerable people and social-ecological systems that are disproportionately affected by such extremes. Adapting to these extremes requires an analysis of the risks caused by climate change and the timely implementation of measures designed to reduce these risks.

These risks necessitate water management so that the impacts of a changing climate can be anticipated. In the past two decades, adaptive water management has become the main response in water management to the impact of climate change effected by making minor alterations in order to build the resilience of people and nature (Pahl-Wostl et al., 2007a; Pahl-Wostl et al., 2007b). However, climate change has clearly revealed the limitations of adaptive water management that is aimed at reducing the impact of climate change through resilience-building minor alterations. This responsive approach, which is based on incremental-based adaptation, proved to be insufficient or counterproductive in the face of more extreme weather events. Due to the increased complexity of the human-environmental context, in which the climate crisis is unfolding and the expected increase in the frequency and intensity of weather events, a shift is taking place in the dominant notions behind water management (Fedele et al., 2019). Water management and its strategies need to move beyond incrementalism – becoming more transformative - to maintain people's well-being in the long run in the face of the expected impacts of climate change.

The recently published IPCC Working Group II Report (2022a) has concluded that the awareness and assessment of current and future climate risks has increased worldwide. National and local governments as well as private sector and civil society acknowledge the growing need for adaptation (Huitema et al., 2016; UNFCCC, 2018). At least 170 countries and many cities now have adaptation included in their climate policies and planning processes (IPCC, 2022a). Pilot projects and localized experiments are being implemented in different sectors. The report also states that adaptation is essential to the reduction of harm, but if it is to be effective, it must go hand-in-hand with ambitious reductions in greenhouse gas emissions because with increased warming the effectiveness of many adaptation options diminishes. With the Paris Agreement prizing the ambition to limit the global temperature increase to 1.5 °C above pre-industrial levels, there is growing international momentum to reduce carbon emissions and mitigate the impacts of climate change (Hooper et al., 2018).

In spite of increased awareness, actions on assessing and communicating risks, as well as on implementing adaptation are considered to be insufficient, given the rate and scope of climate change impacts, according to The IPCC Working Group II

Report (2022a). Current adaptation-related responses across all sectors and regions often involve minor modifications to standard practices or measures for dealing with extreme weather events, all of which merely result in small or locally contained reductions of risks. Whilst this may suffice in the short-term, the long-term risks may require more extensive, transformative changes in water systems, including infrastructure. The IPCC Working Group II Report states that the ambition, scope, and progress in reducing climate risks are noticeable, but still insufficient. Substantial adaptation gaps continue to exist, especially among lower income populations. At the current rate of planning and implementation, these adaptation gaps will continue to grow. According to The IPCC Working Group II Report (2022a), the world is currently unprepared for the coming climate change impacts, particularly beyond 1.5°C global warming.

1.2.2 The central research problem

Both climate change adaption and mitigation have been criticized for focusing more on adaptive change than on transformative change (Holscher et al., 2019a). Transformative change entails reducing the root causes of vulnerability to climate change in the long-term by shifting systems away from unsustainable or undesirable trajectories (Fedele et al., 2019). Without transformative change, climate adaptation remains incremental in relation to climate change, failing to achieve radical system change for transformative adaptation (Holden et al., 2016). Transformative change can therefore be seen as a prerequisite to transformative adaptation (van der Voorn et al., 2012a), see also the FUTURES paper. Climate adaptation therefore needs to be aligned with the transformative changes in the physical environment, including SES (Holscher et al., 2019a).

Within the climate change adaptation research community, a growing tendency has been observed to discuss adaptation using the language of transformation hence reflecting a sense that the current status quo will not secure a sustainable future, especially in the light of the lack of sufficient progress to mitigate the causes of anthropogenic climate change (Lonsdale et al., 2015; Pelling, 2011; Revi et al., 2014a). Terms such as 'transformative' (Park et al., 2012), 'transformational' (Kates et al., 2012), 'transformative agency' (Westley et al., 2013) and 'transition' Tompkins et al. (2010) suggest a more fundamental change within and across systems thereby emphasizing the current adaptation deficit in the search to move away from a perception that 'incremental is enough'. Instead, transformative adaptation promises 'transformation of broader aspects of development through adaptation activity' (Few et al., 2017a). This means that there exists, alongside the goal of reducing climate risk, the goal of simultaneously addressing issues of social justice and the root causes of risk (Pelling et al., 2015; Ramos-Mejía et al., 2018).

Regarding the central research problem, what I place at the core of this thesis is the fact that climate change has exposed the boundaries of adaptive water management. The climate crisis is also a water crisis, as the changing climate is felt through a change in water management. In the last decade, the water crisis has become more acute and the context in which the water crisis is unfolding has become even more complex. For example, water systems facilitate societal functions such as drinking water supply, waste disposal, hydropower (generally generated by dynamo water turbines) and navigation, which have become more interconnected and integrated through human intervention, for instance as a result of water engineering (Jakobsson 2002). What is typical for social-ecological systems is that water systems contain social, technical and ecological elements, which are highly interconnected, interact closely and are mutually constituting (Folke et al., 2005a). Due to their strong interconnectedness, water system have become more vulnerable to the cascading impacts of climate change and all the associated extreme weather events (Niggli et al., 2022). For example, the impacts of drought (i.e., water scarcity and loss of biodiversity) can permeate numerous sectors, including agriculture, water, energy and food provision, with far-reaching consequences (Dolan et al., 2021) (e.g. one can think of competing water uses that could lead to armed conflicts (Schillinger et al., 2020)). With more frequent extreme weather events, floods and droughts included on the horizon, the current adaptive approaches in water management may prove insufficient. As climate change raises sea levels and increases the occurrence of extreme weather events, so the adaptations required among coastal communities like, for example, building higher seawalls may become ineffective (Fedele 2019).

A different approach to water management is needed if we are to deal with these more frequent and intense extreme weather events in the future (van Duuren et al., 2019). Transformative adaptation might be an appropriate approach in the case of major shifts in social and ecological conditions triggered by climate change. Transformative adaptation provides solutions that are commensurate to the challenge, as it targets deep, systemic and sustainable change with large-scale impact (Fedele, 2019) (see Section 2.2.2). Transformative adaptation can support the shift from accommodating change to deliberately implementing more sustainable and forward-looking strategies. Such adaptation will strengthen the capacity of people and nature to adapt to the long-term, while addressing the root causes of vulnerability (Fedele, 2019). Due to a lack of financial and human resources together with the power dynamics that are required to switch from business-as-usual practices, transformative adaptation has not yet been included in present-day climate adaptation plans or strategies to reduce the impacts of climate change (van Duuren et al., 2019). If water management is to implement transformative adaptation, a transformation in water management will be required.

Another factor impeding the use of transformative adaptation is people's limited understanding of what transformative adaptation actually entails, when to consider this type of adaptation, and what it is like in practice (Fedele 2019). Transformative adaptation is, in its essence, a kind of practice that is deeply embedded in culture and institutions. It is also all about the ability to capture momentum in order to establish systemic changes in water systems (see Section 2.2.2). It is against this backdrop that this research on backcasting for climate adaptation helps to contribute to a better understanding of the potential for transformative adaptation and how it could be applied in practice (see Section 2.2.1). Backcasting provides an approach to looking forward and backward from an assumed set of conditions at a future point in time. In its essence, backcasting is a reflexive and iterative approach because it does not assume that a group of experts or a group of stakeholders can develop a complete vision of the future, which will then act as a fixed utopia (Quist, 2007). Instead, it assumes that both vision and pathway development encompass processes of higher order learning (Vergragt & Quist, 2011). These features enable water managers to seek opportunities to invest in long-term solutions that effectively reduce climate change risks and to furthermore develop their own agenda. Backcasting studies usually involve these types of exercises on a small scale (Quist et al. 2011), but much can be learnt from their potential for water management, including how such studies can be conducted in the broader context of what still needs to be done in terms of water management (see Chapters 5 & 6).

Transformative adaptation requires governance-related transformative capacity, which is emergent through the formal and informal collaboration and learning processes between multiple actors and how they interact with their institutional and organizational context, including governmental institutions, politics and other social worlds directed towards solving collective problems (Holscher et al., 2019c). Calls for transformative adaptation to climate change demand that attention be paid to the types of transformative capacities and capacity building required in the absence of the capacities that can support it (Ziervogel et al., 2022). Current adaptation policies do not devote sufficient attention to this issue (Ziervogel et al., 2022). Consequently, further investigation is needed to provide further insight into how capacities and capacity building can support the informing and empowering of transformative adaptation.

1.3 TRANSFORMING WATER MANAGEMENT DURING CLIMATE CHANGE

Given the increasing frequency of the term transformation in relation to adaptation and the different ways in which it is defined and interpreted, it can be asserted that there is no universally agreed upon definition of transformative adaptation (Musteling and Handmer, 2013). Building on the findings of Meuwissen et al. (2019) and (Holscher, 2019), it helps to understand what is actually being changed through the process of transformational adaptation and what factors, processes and interaction shape that development trajectory (*transformation of what?*). Furthermore, within the context of water management, transformative adaptation will serve to contribute to more sustainable and resilient water management (*transformation for what purpose?*). Moreover, the transformative perspective draws attention to the complex, cross-scale and cross-sectoral driving forces and dynamics involved in transformation in the face of climate change, which are long-term and which generate deep uncertainty and threshold effects (*How do transformation processes occur?*). Transformation may occur across different levels, sectors and scales (spatial and temporal), mediated by various power relations, but it usually involves a systemic or paradigm shift, possibly triggered by intolerable losses (Lonsdale et al., 2015). Finally, transformations in relation to climate change are politically contested, as actors are affected in different ways and decisions about what direction for transformation is desirable reflects multiple, partially competing and contradictory interests and goals (*transformation for whom?*). Following Meuwissen et al. (2019) and (Holscher, 2019), I would add these two further questions: 'what are the transformation capacities and what or who enhances transformation?' in order to address the capacity of multiple actors to navigate their structural contexts by mobilizing, creating and removing governance conditions see Hölscher et al. (2019b).

1.3.1 Transformation of what, for what purpose and for whom?

Addressing climate change as a transformation challenge for water management reveals the systemic, complex, and long-term characteristics of climate change and places the implications of climate change within the dynamics of transformations whilst allowing the implications for water management to be considered (Hölscher et al., 2019a).

Climate change cannot be addressed without understanding the broader context of transformative change and how this affects sustainability, resilience and adaptation (Holscher et al., 2019a). Transformative change entails reducing the root causes of vulnerability to climate change in the long-term by shifting systems away from unsustainable or undesirable trajectories (Fedele et al., 2019). In some cases and contexts, the magnitude of vulnerabilities and risks may exceed normal conditions thereby overwhelming current water resource systems. Recent increases in the severity of hurricanes of unprecedented strength damage systems unaccustomed to such extremes (Eppinga and Pucko, 2018). In view of the fact that these extreme events will become more frequent in the future, such uncommon situations require transformational rather than incremental adaptations or even a naïve belief in restoring systems to their pre-impact or disaster states (Filho et al., 2022). Although this type of transformative thinking could be considered to be in its infancy, evidence of the benefits as well as potential benefits of transformational adaptation are starting to emerge (Filho et al., 2022; Pelling et al., 2015; Ziervogel et al., 2022). Without transformative change, climate adaptation remains incremental in adaptation to climate change thus failing to achieve radical system change for transformative adaptation (Holden et al., 2016). Transformative change can be seen as a prerequisite to transformative adaptation (Van der Voorn et al., 2012a). Climate adaptation therefore needs to be aligned with the transformative changes in the physical environment, SES (Holscher et al., 2019a).

Although transformational adaptation is usually presented as being opposite to incremental adaptation, the criteria used for making this distinction vary, which complicates the matter of clearly and reliably identifying what constitutes transformational change in different situations (Nelson et al., 2007). It is argued that climate adaptation only becomes 'real' in situations (Collins and Ison, 2009) where the concept can be contextualized, as both adaptation and climate resilience are 'referent' terms requiring an understanding of who or what adapts to climate change (Carpenter et al., 2001; Smit et al., 2000). In most definitions, neither incremental nor transformational adaptation is proposed as a single strategy but more usually as a number of interacting processes that may have been anticipated and, indeed, intentional or in reaction to significant change (and possibly unexpected change). They may also occur either in response to climatic or non-climatic factors (Nelson et al., 2007; Thornton and Manasfi, 2010). Building on the comparison of many definitions of transformation from recent literature by Mustelin (2013), Lonsdale et al.(2015) have provided criteria to distinguish between incremental and transformational adaptation. Table 1.1 presents an updated overview of the literature cited by Lonsdale et al. (2015).

Lonsdale et al. (2015) present transformational adaptation as something quite different to incremental adaptation as it requires a 'paradigm shift' in the way the issue is *framed* (complicated versus complex, wicked or super wicked), and because it tends to focus on larger, more profound system changes. (Pérez-Català, 2014) propose two main distinctions in the literature on transformational adaptation as 'fitting to' and 'fitting with' the environment, although others refer to this as 'adapting to' and 'adapting with' change (Collins and Ison, 2009; Pelling, 2011). Using the model of organizational learning developed by (Argyris, 1978), Lonsdale et al. (2015) stressed the importance of learning both in terms of incremental and transformative adaptation. In this model, single loop is associated with becoming more efficient at learning to do the same thing, which is congruent with incremental adaptation. Double loop learning occurs when experience leads to change in how something is approached or even in the goal itself. Triple loop learning occurs when the framework or context for observing and analyzing is questioned, which is likely to be the case in transformative adaptation (see also e.g., Pahl-Wostl, 2009).

In 'adapting to' framing, the environment is external, and the focus is on how the existing system is responding to increased risk and vulnerability by developing adaptation responses that focus on increasing the *scale* of existing approaches (Kates et al., 2012; Rickards and Howden, 2012). In 'adapting with' framing, socio-ecological systems are co-developing responses to change and such framing thus emphasizes the need to consider the causes of vulnerability within society (Kates et al., 2012; Pelling, 2011).

On a temporal scale, incremental adaptation focuses on current conditions and short-term change and future uncertainty is acknowledged (Pahl-Wostl et al., 2007b). In transformative adaptation, the focus on future, long-term change and uncertainty in the future is acknowledged and built into decision-making (Filho et al., 2022; Lonsdale et al., 2015).

As argued by Lonsdale et al. (2015), the majority of definitions of transformational adaptation refer to how it addresses fundamental aspects of the system, often explicitly including aspects of *power* and *management*. On the subject of incremental adaptation, Handmer and Dovers (1996); (Pelling, 2011), for instance, describe the human urge to maintain the status quo where possible and to return systems to a previous state after disruption, rather than being open to major permanent changes. In their typology, Type I resilience refers to the resistance of a system to change. Transformative adaptation concerns Type II resilience which involves marginal changes to make a system more resilient; and Type III is when there is a high degree of openness, adaptability and flexibility within the system (Dovers and Handmer, 1992). Type III resilience is capable of transformative action due to its ability to 'change the basic operating assumptions, and thus institutional structures' (ibid). It thus openly challenges unfair or ineffective power structures, and strongly advocates participatory mechanisms in order to expand the responsibility and subsequent opportunities for wider inclusion in decision-making and in expanding the range of options.

Table 1.1 Criteria uses to distinguish incremental and transformational adaptation (adapted from Lonsdale et al., 2015).

Criteria	Incremental adaptation	Transformative adaptation
Framing	• Framed as 'complicated' (Ison et al., 2015)	• Framed as 'complex', 'wicked' or 'super wicked' (Ison et al., 2015)
Learning	• Single and double loop learning (Argyris, 1978)	• Triple loop learning (Pahl-Wostl, 2009)
Scale	• Smaller, discrete within system changes	• System-wide change or across many systems
Temporal	• Focus on current conditions and short-term change and future uncertainty is acknowledged (Pahl-Wostl et al., 2007b)	• Focus on future, long-term change and uncertainty in the future is acknowledged and built into decision-making (Filho et al., 2022; Lonsdale et al., 2015)
Power	• Generally greater control over outcome • Seek to operate within the status quo to maintain and/or increase efficiency of existing systems	• Outcome open ended or uncontrollable (and could be positive or negative) (Lonsdale et al., 2015) • Addresses power imbalance and the causes of social injustice to induce a step change /radical shift to the operation of the existing system (Ziervogel et al., 2022)
Management	• Reactive management of change, focusing on current conditions • Management of change is focused on finding ways to keep the present system in operation • Aim to address Type I (resistance and maintenance) and Type II (change in the margins) management problems (Handmer and Dovers, 1996)	• Anticipated, planned management of change (Filho et al., 2022) • Management of change includes questioning the effectiveness of existing systems and processes (Filho et al., 2022) • Aim to address Type III (openness and adaptability) management problems (Handmer and Dovers, 1996)

Transformative adaptation involves the transformation of broader aspects of climate resilient development through adaptation activity (Few et al., 2017b). This suggests that transformative adaptation serves the purpose of reducing climate risk, while simultaneously addressing aspects of sustainability e.g., social justice (Solomonian and Di Ruggiero, 2021), and the root causes of risk for increased resilience (Pelling et al., 2015). Climate change mitigation and adaptation have become important prerequisites for sustainability and resilience transformation (Holscher, 2019). As argued by Holscher (2019), sustainability and resilience can guide transformation, whereas transformations towards sustainability and resilience represent processes and not end goals (see also Kabisch, 2018).

Evidently, resilience has become a key way to approaching climate change adaptation, which is often referred to as climate proofing in order to protect valuable assets and reduce vulnerability (Holscher, 2019). As suggested by Holscher (2019), while resilience is in essence a non-normative system property (Elmqvist et al., 2019), decisions concerning resilience for whom, what, when, where and why is a contested process touching on different motivations, power dynamics, and trade-offs (Meerow et al., 2016). Resilience itself is constrained by an absence of normative meaning and by orientation towards a politics of restraints or limits, which is socially and politically unappealing (Fainstein, 2015). Limits may emerge from political or social resilience so provoking conservative and restrained responses to any but the most immediate, opportune and direct policy shift (Howlett, 2014). Resilience thinking, currently articulated and practised in resilience planning identifies ecological systems risks and mandates and imposes limits on human activity (Dovers and Handmer, 1992). As argued by Holden et al. (2016), this makes it very unlikely for any notion of resilience via harm reduction and imposed limits to appeal to more than a small, counter-cultural segment within society. This makes resilience insufficient as an organizing concept for planning, due to a lack of clear normative thrust and the insinuation of limits (Holden et al., ibid.). It is argued by Holden et al. (2016) that the limits approach embedded within resilience thinking embraces insufficient ambition for motivating path-breaking or transformative change (Holden et al., 2016). For example, Robinson and Cole (2015: 133) suggest that "*The logical goal of a harm-reduction agenda is zero harm, which does not prompt a search for more positive possible outcomes*".

Resilience dynamics should by no means be limited to rising to a challenge to "bounce back" from a disaster event to a pre-disaster state; an approach to resilience determined by conformity to a previously known outcome of stasis, but to actually "bouncing forward" toward a desired state, which has not been historically achieved (e.g., a climate resilient future), which only becomes perceptible or feasible following the disruption brought by disaster (Holden et al., 2016). The actual realization of "bounce forward" resilience outcomes in cities and communities requires more social and economic than environmental strategies (Shaw and Maythorne, 2013). Achieving these outcomes demands a meaningful social, economic and cultural narrative of progress, which recognizes the more attractive concept of opportunity rather than risk (Holden et al., 2016). This aligns with the concept of building adaptive capacity in society (Adger, 2003), rather than just seeking to pre-empt specific environmental threats.

1.3.2 How do transformation processes occur?

In the face of climate change, the management of water resources is currently undergoing a paradigm shift toward an adaptive management style (Pahl-Wostl, 2007b). Climate change has exposed the shortcomings of the dominant technocratic paradigm on which contemporary water management was hitherto based (Pahl-Wostl et al., 2007a,b; Pahl-Wostl et al., 2011). A water management paradigm refers to a set of guiding principles on which water management is based (Pahl-Wostl et al., 2007b). The technocratic paradigm generally relied on high predictability and controllability of the water systems to be managed but failed to account for the complexity and strong interconnectedness of the social and ecological components of these systems (Gleick, 2003a; Holling, 1996; Pahl-Wostl, 2005). Water systems can be characterized as complex adaptive systems that are unpredictable and non-linear in their response to human and natural influences. Limited predictability and controllability of these systems further complicates the assessing and predicting of their future exposure to climate change, which creates major uncertainties for their management (Pahl-Wostl, 2007). Uncertainties not only arise from climate change, but also from the interaction between the social and ecological components of water systems. Technocratic paradigms have also failed to adopt a long-term perspective that results in solutions that address the symptoms of problems (climate change) rather than their root causes, which reinforce investments in unsustainable lock-ins and mal-adaptation and induce higher costs in the long run (Pahl-Wostl et al., 2011; Pahl-Wostl et al., 2007b). This gave rise to the need for more adaptive management approaches to water management that pay more attention to the complexity of water systems. Adaptive management emphasizes the need not only to prioritize learning how to deal with uncertainty in resource management through monitoring and experimentation, but also the human aspects (e.g., stakeholder values, interests, and decision-making processes) required for successful implementation (Walters and Holling, 1990).

In the interests of sustaining livelihoods through the efficient and equitable use of water resources and the development of heat and drought tolerant crops while enhancing the resilience of vulnerable infrastructure, especially along coasts threatened by sea-level rise (Aguiar et al., 2018; Runhaar et al., 2018), the growing need to optimize climate adaptation has been debated for quite some time (Filho et al., 2022). In the last two decades, more adaptive water management approaches like, for example, co-management for socio-ecological complexity (Becker et al., 2015; Huitema et al., 2009), and adaptive delta management (ADM) (Deltaprogramme, 2011b, 2017, 2020) have been developed and are still being implemented to compensate for the perceived shortcomings in earlier management approaches.

Given the rate at which climate change has accelerated and its various impacts on comparatively complex societies, the effectiveness and sustainability of these optimized water management approaches has become questionable. By 'effective', I mean that they address the issue or issues they set out to address (such as flooding and food insecurity). By 'sustainable', I mean to say that they will endure and will not cease to be effective within a short time period. Sustainable adaptation is the end goal when climate change is the primary concern. These two requirements mean that the best (although not the cheapest or least disruptive) form of adaptation is transformative and sustainably reduces vulnerability by understanding, and addressing, the root causes (Fedele, 2019). In addition, the spectrum of adaptation ranges from short-term coping strategies, including strengthening infrastructure and relocating people living in exposed places, to systemic changes that imply paradigm shifts. In other words, instead of combatting the threat efforts should be made to redesign the conditions in order to live with it (Filho et al., 2022). When adapting ad-hoc or permanent infrastructure to withstand water flows, natural flood risk management approaches that use catchments for excess water storage may come to prevail over those that involve combatting the floods (Bracken et al., 2016; Termeer et al., 2017).

Against the backdrop of these two criteria and the spectrum of adaptation, the ADM approach shows limited effectiveness. Gersonius et al. (2016), for example, evaluated the application of ADM in the Dutch City of Dordrecht. They found that the ADM approach involved a time-consuming process that required detailed knowledge about the flood risk management system. They also concluded that success is not guaranteed, as the effectiveness of proposed strategies can only be measured after the future has unfolded, which in turn compromises their sustainability in the long run. Similar findings emerged from a study by McGray et al. (2007), who screened over more than 100 projects considered to be climate change adaptation initiatives in relation to developing countries. The beneficial outcomes of those projects made little difference to what could be seen as good development (Klein 2010). McGray et al. (2007) identified a continuum of actions that can be undertaken in order to address climate change impact and promote long-lasting adaptation. These range from pure development actions, with usually no intention of tackling climate change adaptation, to purpose- designed adaptation efforts. A 'no-regret, win–win' option is one in which the positive effect on adaptation resulting from a set of actions targeted at addressing vulnerabilities arises (Kelly and Adger, 2000). Otherwise, the actions targeted ato specific climate change impacts might not have any effect on development, unless they are effective at tackling climate change adaptation. As argued by Bapna, (2008:2), "*in between lies a broad spectrum of activities with a varying degree of emphasis on vulnerability and impacts*".

The most effective and sustainable way to minimize future climate change impacts on humanity is through transformative adaptation (Fedele et al., 2019). This approach redefines development by changing the fundamental attributes of SES in anticipation of climate change impacts (Clarke et al., 2018; IPCC, 2018). Such an approach, which fully accounts for the complexity of water systems and the uncertainties associated with climate change while making full use of the self-organizing properties of the systems to be managed, has yet to be realized (Whaley and Weatherhead, 2016). The emergence of such an approach requires yet another paradigm shift in water management in order to facilitate transformative adaptation. A paradigm shift is needed to account for the increased complexity of water systems and their implications for management (see e.g., Van der Voorn and Quist, 2018). Firstly, adaptive management approaches need to be targeted at making water infrastructure more climate resilient, but not in way that could contribute to the development of other sectors e.g., land-use, agriculture. Secondly, water is traditionally managed by water managers, but it has also become an essential aspect of other sectors (e.g., agriculture, land-use). This forces water managers to collaborate proactively with their counterparts from such sectors. Thirdly, water has become a broader socio-economic problem, involving water quality and quantity concerns. Limited water supply during long periods of drought, for instance, intensifies worries about water quality (Peña-Guerrero et al., 2020). Low water levels could lead to warmer stream temperatures as well as increased algal growth and more frequent toxin-producing algae blooms (Tewari, 2022). Variability in climate influences water quantity but may also influence water quality due to the increased intensity of precipitation events. Furthermore, water has become more political and societal in conjunction with increasing conflicts of interests. For example, long periods of drought may well lead to water scarcity, increasing the chance of competition and conflict when it comes to the allocation of water resources, thus making water security even more uncertain (Schillinger et al., 2020). Finally, the water sector needs to come up with solutions and an innovation agenda. Novelty and innovation help to develop sets of benefits that can be associated with transformative approaches. Transformative adaptation supports innovative concepts, which could be entirely novel or which could amount to an integrated combination of existing concepts and resources provided by various collaborators to be deployed across or within sectors (Filho et al., 2022). All in all, these aspects call for a different coordination mechanism and a long term transition perspective but what remains the question is: are water managers are sufficiently able to fulfill this need?

1.3.3 What are transformation capacities and what or who enhances transformation?

All climate adaptation decisions have ethical implications, but in transformational adaptation this is likely to be even more critical (Lonsdale, 2015). Whereas dominant adaptation approaches tend to be depoliticized, technocratic and accompanied by linear causal social impact pathways resulting from the physical environment, the transformational approach to adaptation requires fundamental change in the systemic structures that produce vulnerability, particularly power imbalance (Schulz, 2015). In this context the term pathway links up with a rational approach, whereas transformational adaptation requires something more revolutionary. (Lonsdale et al., 2015) suggests that to avoid path-dependency maladaptation later in the process, climate adaptation activities need to be embedded both in time (i.e., by creating pathways with continuous re-evaluation and learning) and in terms of the process i.e., through incremental decision-making embedded in longer-term transformational pathways (Barnett and O'Neill, 2010).

The growing interest in transformative adaptation to climate change impacts is triggered by the imperative to shift towards more equitable and climate resilient development pathways (Lonsdale et al., 2015; Pelling, 2011; Revi et al., 2014b). A proven approach to addressing the challenge of resilience in transformative adaptation is the concept of development pathways, which has the potential to create change at social and political levels (Pandey et al., 2021; Werners et al., 2021). The concept of a development path originates from the work of the IPCC Special Report on Emissions Scenarios on narrative storylines (Nakicenovic, 2000). This effort resulted in constructed prototype socio-economic and political world models, adapted to form four narrative storylines and quantitatively modelled into 40 scenarios with different implications for present development and development over the course of time. It is envisaged that such pathways will close the gap between mitigative and adaptive capacities and the underlying socio-economic, and technological development paths that give rise to those capacities.

Holscher (2019) proposed different types of governance capacities that I consider to be relevant to transformative adaptation: (i) stewarding capacity (anticipating and responding to uncertainty); (ii) unlocking capacity (recognizing and dismantling unsustainable path-dependencies); (iii) transformative capacity (creating and embedding novelties); and (iv) orchestrating capacity (i.e. coordinating multi-actor processes). By drawing attention to climate resilient development pathways, and the uncertain yet path dependent nature of societal organization, resilience can be shifted away from the political trap of applying restraint to the question of how to achieve a sustainable future through political, social, cultural and personal, as much as scientific means (Holden et al., 2016). This effort draws on stewarding capacity for systemic inquiry whilst simultaneously unlocking capacity to cultivate and embrace uncertainty.

Transformative adaptation supports anticipatory initiatives which involve planning for future risks long before they occur. The 2023 Dutch Delta Programme, for instance, predicts that the Netherlands will be climate-resilient and water-robust by 2050 (Deltaprogramme, 2022). This means that flood risk management, freshwater supplies and spatial planning must be coherently managed. Only then will it be possible for the Netherlands to continue to cope properly with the effects of climate change. Such visionary and well-thought-out long-term plans enable local authorities and residents to cope well with future risk scenarios so that they are able to enhance sustainability and resilience (Leal Filho et al. 2019). Such plans enable adaptation that goes beyond incremental 'change at the margins' to building more resilient systems with capacity for transformation. In addition, the capacity for experimentation has long been viewed as being integral to building resilience (Fikret et al., 2003) or adaptive capacity (Levine, 2011). The willingness to experiment is also a key capacity for the transformations (Olsson, 2006) needed to create radically new systems. This is particularly the case when incremental adaptation and adjustments are considered to be no longer feasible or desirable. Experimentation can draw on various approaches like storytelling and metaphors to represent alternative versions of the current situation (Küpers, 2013; Lakoff, 1980), thereby allowing it to be viewed in a new way while opening up new ways of seeing, new connections and new questions for further enquiry. Metaphors can evoke and suggest new ways of doing things (Cleary and Packard, 1992). Similarly, stories can also be used to re-shape our mental landscape and trigger new narratives or ways of operating. In this way, 'new' knowledge can be successfully created and transferred. Of course, stories can be manipulated and many different narratives are possible, but if we are interested in creating a more positive future then constructing a coherent, convincing and compelling story might be a good place to start (Marshall, 2014).

Furthermore, transformative adaptation also requires other capacities like, for example, transformation leadership (Clarke et al., 2018; Lonsdale et al., 2015). As argued by Lonsdale et al. (2015), transformational adaptation requires actors who are prepared to innovate and take calculated risks. This requires courage and the ability to draw on experience, which points to orchestrating capacity. This type of work can be rewarding but, equally potentially, demoralizing. It can inspire and catalyze positive change but it can also entail decisions that may be unacceptable to some and to which there may be strong resistance. This means that actors in the system of concern must change. Other key aspects that merit further attention include: where is the energy for action in the existing regime? Who has autonomy, influence, power over decisions, and the motivation and sustained energy to make the necessary changes? It is argued that effective social mobilization when paired with the right combination of policies and research and applied over time can help to enhance transformative adaptation and discover more just and resilient pathways (Biehl, 2015; Lubell and Niles, 2019).

As already discussed in Section 1.3.2, transformative adaptation supports the developing of innovative concepts. Novelty and innovation can help to develop the sets of benefits that typically emerge from transformative approaches. Transformative adaptation often entails the large-scale deployment of actions, yielding benefits to a greater number of actors than would be usual in such interventions. In transformational processes, learning should be seen as a constant activity, both for the actors involved and for intermediaries shaping the on-going process (Hargreaves et al., 2013). The capacity for systemic inquiry into benefits and novelties, for experimenting and for learning from practice can further enhance transformation.

1.4 CURRENT PROGRESS IN THE USE OF BACKCASTING FOR CLIMATE RESEARCH

In the current climate adaptation literature, substantial attention is given to the potential of the Futures Studies approaches, including forecasting and exploratory scenario planning, for climate adaption an3d mitigation. However, both climate adaption and mitigation have been criticized for focusing more on adaptive change rather than on transformative change (Holscher, 2019) and for neglecting the potential of normative approaches (Nalau and Cobb, 2022; Van der Voorn et al., 2017).

Compared to forecasting and exploratory scenario approaches, participatory backcasting and related vision-oriented approaches are the least applied normative foresight approaches in climate change adaptation (Van der Voorn et al., 2012b; Van der Voorn et al., 2017). A recent review by Nalau and Cobb (2022) shows that normative approaches are applied to climate adaptation but mainly involves visioning rather than backcasting. Normative approaches, such as visioning, have become mainstream in engaging stakeholders in the co-production and co-development of climate change adaptation futures (Nalau and Cobb, 2022). A large range and diversity in backcasting studies and methodologies can be found in the current literature, which reflects the different ways in which backcasting traditions and practices have evolved over the course of time (Vergragt and Quist, 2011). Other approaches like TM and road mapping also use future visions and pathways to get there, sometimes without explicitly referring to the term backcasting, which makes the variety even greater (Quist et al., 2011; Quist et al., 2013). This diversity has enriched the literature, but surprisingly few attempts have been made to evaluate and compare the different concepts and methods used by backcasting scholars and practitioners (Van der Voorn 2017). The same holds for visioning for climate adaptation (Nalau and Cobb, 2022). In contrast to the impact of visioning studies, limited effort has been made to systematically evaluate the impact of backcasting studies, and more work is yet needed if current and future backcasting practices are to be improved (Vergragt and Quist, 2011).

In this thesis, I focus on backcasting approaches and their potential for use in climate adaptation research, because there is little research in which backcasting is applied to climate adaptation. I propose that participatory backcasting has significant potential and useful assets for climate adaptation planning. To assess current progress in the use of backcasting in climate adaptation, a bibliometric analysis of publications using the SCOPUS database has been conducted (see Table 1.2). A search query with the keywords "backcasting" and "climate adaptation" results in merely a few publications. Adding "OR adaptation" to the query leads to a larger variety of backcasting studies across various domains and sectors, addressing climate-related topics, but also introducing less relevant studies. The first query shows that backcasting has been applied in the field of climate adaptation but that there are few studies (4 mentions) where backcasting has been explicitly applied to climate adaptation (Table 1.2). For example, Van der Voorn et al. (2012) proposed a methodology for backcasting in combination with adaptive management and how this could be used for implementing adaptation strategies and policies, with an example taken from South Africa. Van der Voorn (2017) evaluated three cases on vision-based approaches for climate adaptation in coastal regions in three different continents. The second query shows a larger number of backcasting studies (26 mentions) across various domains and sectors, addressing climate-related topics. The third query highlights many backcasting studies (25 mentions) that focus on low-carbon futures and climate change mitigation. Banister and Hickman (2013), for instance, applied different backcasting scenarios in order to explore potential transport futures. The fourth query resulted in 134 studies, linking backcasting to other kinds of climate-related topics (e.g. sustainability, biodiversity and conservation). Grêt-Regamey and Brunner (2011), for example, suggested that a methodological framework for backcasting could be introduced to support spatial adaptation and predict climate change. The fourth query involved 109 studies using visioning, but sometimes without explicitly using the term backcasting. Nalau and Cobb (2022) reviewed the current progress in the use of visioning approaches for climate adaptation. Their review includes cases that mainly report on visioning, some of which form part of a backcasting approach. Although the search queries include several backcasting-related climate adaptation studies, the above-mentioned examples refer to studies that explicitly used backcasting for climate adaptation. Finally, there is some overlap between the fifth and sixth query, showing six studies mentioning both visioning and backcasting for climate adaptation (2 studies) or mitigation (4 studies).

As at present only a few research papers are reporting on backcasting for climate adaptation, the relevance of backcasting for climate adaptation remains an insufficiently researched topic. Key questions requiring further investigation include: (i) how to advance backcasting for climate adaptation by making use of insight from the use of backcasting for climate mitigation; (ii) what is needed to apply backcasting to climate adaptation while making use of the widely acknowledged strengths of backcasting as well as identifying elements that could add value to the topic of climate adaptation?

Table 1.2 The results of the search queries in the SCOPUS database

Search query	Records
TITLE-ABS-KEY ("backcasting" OR "back-casting" AND "climate adaptation")	4
TITLE-ABS-KEY ("backcasting" OR "back-casting") AND ("climate adaptation" OR "adaptation")	26
TITLE-ABS-KEY ("backcasting" OR "back-casting") AND ("climate mitigation" OR "mitigation")	25
TITLE-ABS-KEY ("backcasting" OR "back-casting") AND ("climate")	134
TITLE-ABS-KEY ("visioning") AND ("climate")	109
TITLE-ABS-KEY (("backcasting" OR "back-casting") AND "visioning") AND "climate"	6

Further research is also needed to gain in-depth insight into key aspects of backcasting studies. Moreover, we also looked into what approaches have been applied in different contexts? What approaches have been applied in different contexts? These investigations will contribute to a better understanding of what constitutes successful backcasting and should build a strong case for participatory backcasting in climate change adaptation.

1.5 RESEARCH AIM AND QUESTIONS

In the current literature, a large variety and diversity in backcasting studies and methodologies can be found, all reflecting the different ways in which backcasting traditions and practices have evolved over time (Vergragt and Quist, 2011). Other normative approaches like transition management and road mapping also use future visions and pathways to get there, sometimes without explicitly referring to the term backcasting, which makes the range even greater (Vergragt and Quist, 2011). Sometimes the term backcasting is used for the entire methodology and sometimes it is confined to the backcasting step in the methodology. Similarly, the terms backcasting and visioning are often used interchangeably in the literature. Backcasting refers to the entire methodology of which visioning is an integral part. In sustainability science, it is much more about visioning itself, often without a clear reference to backcasting (see for example Wiek and Iwaniec, 2014). Despite the divergence in the use of both terms, visioning and backcasting share the same focus on long-term visions for change.

The aim of the research is to improve our understanding of the relevance of normative approaches, particularly visioning and backcasting approaches in relation to transformative climate adaptation.
In the light of the research aim, my main research question is as follows: ***How can visions, visioning and backcasting enhance transformative adaptation in water management?***

This central question can be further broken down into a number of sub-questions:

1. What is the role of visions and visioning in long-term water management transitions and what is their relevance to current water management challenges?
2. How can vision-oriented approaches and climate adaptation approaches be combined to develop visions for climate adaptation planning?
3. How can visioning and backcasting for climate adaptation be systematically evaluated and compared and what results and impacts have been realized?
4. How can backcasting for climate adaptation be further developed and what is needed for advancing backcasting for transformative adaptation?

1.6 STRUCTURE OF THE THESIS

The thesis is paper-based, which means that it has been mainly compiled in the form of scientific papers that were published between 2012 and 2023. Table 1.2 provides an overview of those papers. The thesis is furthermore structured as follows: The introductory chapter provides the framing of the study within the real-world problem of water governance and the challenge of adapting water management to climate change. Chapter 2 provides the theoretical embedding of the study. Chapter 3 presents a historical perspective on the role of emerging visions, agency and niches in water management transitions and their significance to the current challenge of adaptive water management. Chapter 4 describes how robust climate adaptation strategies and policies can be developed amid uncertainty using Backcasting Adaptive Management (BCAM) methodology. Chapter 5 presents an evaluation of cases on vision development for robust climate change adaptation planning and the evaluating of the outcomes concerning their potential for further development of normative approaches in climate change adaptation planning in general and for the BCAM methodology in particular. Chapter 6 presents a multi-case study on 10 cases reporting on the use of backcasting and visioning approaches for climate change adaptation planning. Chapter 7 concludes the thesis by synthesizing the insights, responding to the research questions and critically reflecting on the contributions and implications of this research.

This paper-based thesis provides a storyline that is divided into individual chapters that have been submitted as separate papers. Each paper contributes to the narrative as a whole. Due to the iterative nature of this study, the methodological and implementation aspects of climate change adaptation were first investigated. This was followed by an enquiry into vision development processes in terms of historical water management transitions. As presented in Table 1.3, the historical perspective will be used as a starting point in order to position the study within the context of transformation research.

Table 1.3 Overview of the papers included in this thesis.

Chapter/ paper	Authors, paper titles, and journal
Chapter 3 Water paper	Van der Voorn, T. and J. Quist (2018). "Analysing the Role of Visions, Agency, and Niches in Historical Transitions in Watershed Management in the Lower Mississippi River." Water 10(12): 1845. DOI: https://doi.org/10.3390/w10121845
Chapter 4 Futures paper	Van der Voorn, T., Pahl-Wostl, C., Quist, J., (2012). "Combining backcasting and adaptive management for climate adaptation in coastal regions: A methodology and a South African case study." Journal of Futures 44(4): 346-364. DOI: https://doi.org/10.1016/j.futures.2011.11.003
Chapter 5 MITI paper	Van der Voorn, T., Quist, J., Pahl-Wostl, C., Haasnoot, M., (2017). "Envisioning robust climate change adaptation futures for coastal regions: A comparative evaluation of cases in three continents." Mitigation and Adaptation Strategies for Global Change 22(3): 519-546. DOI: https://doi.org/10.1007/s11027-015-9686-4
Chapter 6 CLRM paper	Van der Voorn, T., Quist, J., Carlsson-Kanyama, A., Svenfelt, A., Kok, K., Hickman, R., , Sheppard, S., Banister, D., (submitted). Recent progress in the use of participatory backcasting and visioning approaches for climate change adaptation planning: A comparative study of 10 cases in 3 continents. Journal of Climate Risk Management. 100559, DOI: https://doi.org/10.1016/j.crm.2023.100559

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Biehl, J. (2015). "Bookchin's revolutionary program." ROAR Magazine **1**: 132-151.

Bracken, L. J., et al. (2016). "Flood risk management, an approach to managing cross-border hazards." Natural Hazards **82**(2): 217-240.

Brown, C. and M. Rounsevell (2021). "How can social–ecological system models simulate the emergence of social–ecological crises?" People and Nature **3**(1): 88-103.

Carpenter, S., et al. (2001). "From Metaphor to Measurement: Resilience of What to What?" Ecosystems **4**(8): 765-781.

Clarke, D., et al. (2018). "Place attachment, disruption and transformative adaptation." Journal of Environmental Psychology **55**: 81-89.

Cleary, C. and T. Packard (1992). "The Use of Metaphors in Organizational Assessment and Change." Group & Organization Management **17**(3): 229-241.

Collins, K. and R. Ison (2009). "Jumping off Arnstein's ladder: social learning as a new policy paradigm for climate change adaptation." Environmental Policy and Governance **19**(6): 358-373.

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CHAPTER 2

RESEARCH DESIGN AND METHODOLOGY

2.1 INTRODUCTION

As discussed in Chapter 1, the central research problem at the core of this thesis is how to support the transformation of water management in order to facilitate transformative adaptation that can purposefully contribute to more sustainable and resilient water management. The research problem addresses critical knowledge gaps (Section 1.2.2) which requires insight from the research areas of Futures Studies, sustainability transitions and water management research. In the search to address these knowledge gaps, I proposed a set of research questions (Section 1.5). The present chapter outlines the methodological approaches proposed to address the knowledge gaps, along with my suggestions on how I intend to fill these gaps.

2.2 POSITIONING THE THESIS/RESEARCH

This section introduces three main research areas within which this thesis is positioned involving Futures Studies research and transformation research. These perspectives have guided the learning process and research experiences resulting in this thesis and influencing my positioning of myself as a Futures Studies researcher on transitions in water management. The perspectives allow me to bring together various insights, frameworks and approaches from a diversity of research strands that share common interests in transformation processes in water management.

2.2.1 The research area of Futures Studies

The research area of Futures Studies draws on insight, methods and approaches drawn from various foresight in the Futures Studies domain that helps to address different kinds of long-term aspects and uncertainties associated with climate change (Rickards et al., 2014; Van der Voorn, 2017; Van der Voorn et al., 2012b). In this domain, three main types of approaches can be identified: forecasting and exploratory and normative foresight approaches (Quist, 2007; Vergragt and Quist, 2011) (See Figure 2.1).

Forecasting approaches focus on predicting likely futures. They are, by definition, projective as they rely on trend extrapolation and both qualitative and quantitative historical data (Quist, 2007). This deterministic approach treats the future as something similar to the past yielding a 'surprise free' future connected to the present in a straightforward way (Sardar, 1999). Obviously, most people find themselves mentally anchored in the past from which they do not easily deviate when contemplating the future. However, the past may manifest itself as an obstacle when constructing the future, distorting and narrowing our vision of the future (Bell, 2002). Therefore, fore-

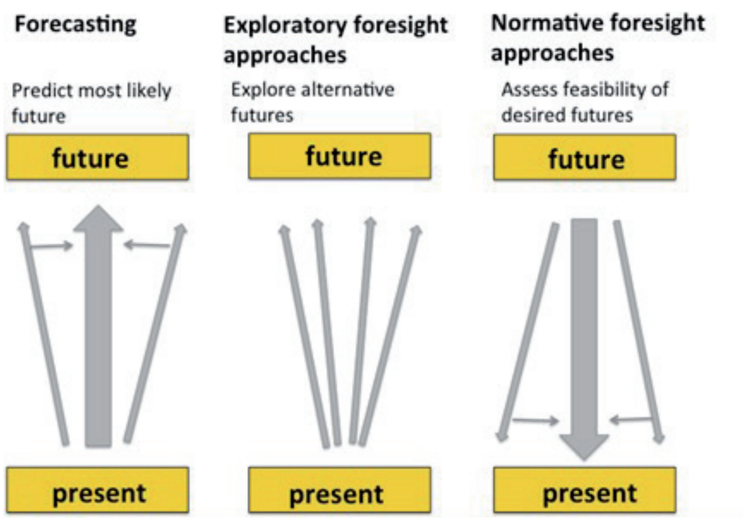

Figure 2.1 Topology of futures studies approaches.

casting approaches are often criticized for treating the future as a continuation of the past and for being oblivious to the past as a potentially misleading guide to the future. Another drawback of this perspective is its limited reliability. That is to say, such reliability is only secured in the short-term and in cases of well-defined and relatively stable systems like, for example, existing markets (Quist, 2007).

Exploratory foresight approaches focus on exploring alternative futures. Unlike forecasting, exploratory foresight approaches postulate the future rather openly (Kahn and Weiner, 1967). To think about our future is to think the unthinkable, by breaking with or even forgetting our past and present (Koriat et al., 1980). This requires creative thinking about the unknown in an a priori manner independent of empirically verifiable explanations of the past (Ringland, 2002). However, arguments for treating the past as a misleading guide to the future emerge from social learning processes that often occur in the aftermath of major discontinuities (Diamond, 2005; Gilovich, 1981; Ponting, 1991). What happens in the future partly depends on what has happened in the past, which may instill multiple conjunctures of causal conditions in time and space triggering discontinuous changes in the future (Brooks, 1986). Such changes cannot be fully anticipated by forecasting, but they are more likely to result from scenarios (Quist, 2007; Sondeijker et al., 2006; Van der Heijden, 1996). Exploratory foresight approaches have proved useful for exploring and anticipating the future in varying research contexts e.g., transition research (Kemp and Rotmans, 2001; Sondeijker et al., 2006), climate change mitigation (Daioglou et al., 2019; Girod et al., 2009), food security (Mason-D'Croz et al., 2016; Vervoort et al., 2014), and transport (Banister and Hickman, 2013; Hickman et al., 2011). Exploratory foresight approaches are well-equipped for mapping uncertainties, but often fail to account for normative aspects like preferences or desirability.

By contrast, normative foresight approaches focus on desirable or undesirable futures. Normative vision-oriented approaches include, for example, backcasting and transition management, and even road mapping. Robinson (1990) has argued that these approaches are not only about how desirable futures can be attained, but also how undesirable futures can be avoided or anticipated (Robinson, 1990). It has been argued by Dreborg (1996) that forecasting is based on dominant trends and is therefore unlikely to generate solutions to problems of discontinuity such as trend breaks. Sustainability problems (Dreborg, 1996) and sustainability transitions (Loorbach, 2006a; Loorbach et al., 2017a) clearly share these characteristics. Due to their normative and problem-solving character, normative vision-oriented approaches are considered to be much better suited to addressing long-term problems and sustainability solutions (Quist, 2007). However, normative approaches have their limitations too. It is argued that normative approaches are most likely to be effective where a widely shared goal already exists, and where foresight can then help make visions of the future explicit. In cases when a long-term goal already exists normative approaches can provide powerful inputs into priority-setting and other elements of decision-making i.e., by providing pathways and indicators that can be used to monitor progress towards the desired future. In other cases, normative approaches may be considered insufficiently objective or less effective when there is a lack of consensus about shared goals, which is particularly the case in the early stages of the foresight process. This could compromise the legitimacy and plausibility of the outcomes granted by those affected in the foresight process (Andersen, 2014). Nevertheless, the limitations of normative approaches prevail over those associated with forecasting and exploratory approaches. The problem context of climate adaptation described in Chapter 1 argues in favor of normative foresight approaches for dealing with high degrees of uncertainty and complexity and addressing normative aspects such as different worldviews, norms and values, and preferences, which are also key to transition management. In the process, it is still necessary to account for the limitations of normative foresight approaches.

As discussed in 1.4, backcasting is the least described and evaluated approach in the field of climate change adaptation, especially in water management. In addition, limited effort has been made to systematically evaluate the impact of backcasting studies, and more work is still needed to improve the current and future backcasting practices (Vergragt and Quist, 2011).

Nevertheless, backcasting proves to be compatible with approaches that have already become mainstream in climate change adaptation planning: robust decision making (Lempert et al., 1998; Lempert and Groves, 2010), adaptive policy making (Walker, 2001), adaptation pathways (Haasnoot, 2012; Haasnoot et al., 2013a), and Adaptive Management (Foxon, 2009; Jacobson, 2009; Pahl-Wostl, 2006, 2007a, b). However, what has not been sufficiently addressed is just how these approaches, when combined with backcasting, could empower transformative adaptation.

2.2.2 The research area of sustainability transitions

Various perspectives on and applications of transformation research have emerged across various research fields linked to sustainable societal change. In an attempt to categorize the field, some scholars (Markard et al., 2012; van den Bergh et al., 2011) have identified several dominant schools of thought based on four central analytical concepts: the socio-technical multilevel perspective, the technological innovation systems approach, strategic niche management, and transition management. Although these approaches certainly relate to dominant concepts that are associated with the sociotechnical perspective, they are part of a broader research perspective on sustainability transitions (Loorbach et al., 2017b), namely: the socio-technical, socio-institutional, and socio-ecological approaches. A major analytical lens associated with the socio-technical approach is the Multi-Level Perspective (MLP) that explains transitions by the co-evolution of dynamics at three level (Geels, 2002; Loorbach and Rotmans, 2010; Rip and Kemp, 1998). These are the levels of niches, socio-technical (ST) regimes and landscape. The MLP takes as a starting point the fact that novelty emerges and develops at niche level, which can eventually result in the transformation or replacement of ST regimes. Regimes can be conceptualized as consisting of actors, institutions and (socio-technical) systems (Geels, 2004). At landscape level gradual developments and sudden shocks like natural disasters or economic crises might put pressure on existing ST regimes and may well create windows of opportunities for niches to break through.

In transformation research, transformation entails a fundamental, systemic, multi-dimensional and radical structural change (Brand, 2016; Feola, 2015; Patterson et al., 2017). It helps to describe and understand the various processes, interaction and dynamics that manifest themselves in coastal regions as complex socio-technical systems and social-ecological systems which shape development trajectories (van der Brugge et al., 2005). This also helps me to position climate change in the context of transformations in water systems. That is to say, how climate change is driven by existing social-ecological and socio-technical development trends and dynamics, but also how climate change impacts can add considerable pressure risk and uncertainty to transformation dynamics in water systems. Moreover, the transformation perspective provides a normative orientation for overcoming persistent sustainability problems and purposefully steering water systems towards sustainability and resilience (Loorbach et al., 2017a; Pahl-Wostl et al., 2007b).

Along with the growing interdisciplinary field of transformation research, diversity has given rise to some ambiguities of concepts and meanings (Holscher et al. 2019). Holscher et al. (2018), for example, observed that in sustainability transitions community, 'transition' is commonly used rather than the term transformation in a similar, but often interchangeable way to understand and support systemic and radical societal change. However, the preference for one of these terms largely depends on the particular epistemic communities rather than on a substantive difference in meaning. Whereas 'transition' is the preferred term in sustainability transitions and socio-technical systems studies, 'transformation' is widely employed to describe both the process and outcome of changes in the structure of systems (Wolfram et al., 2016). Following Holscher (2019), in this thesis, the focus is on the latter as it allows me to draw insight from work across various disciplines and explore how backcasting can influence the process and outcome of changes in systems.

Transformation research is normatively oriented towards societal problems by studying and actively supporting societal transformations in a sustainable direction. Sustainability often involves a generic vision on how everyone can live happily, safely and in accordance with environmental protection. Such a vision has to be co-created and shared. The normative nature of transformation research is considered to be congruent with the use of normative approaches for climate change adaptation planning such as visioning and backcasting. As in backcasting, visions are also seen as important for transitions because they provide a common reference point for action whilst guiding actors in their actions and behaviour in reaching that point (Berkhout, 2006a; Loorbach, 2006a; Quist, 2007; Van der Voorn and Quist, 2018). Various vision concepts can be found in the literature on innovation studies and transitions towards sustainability, while a distinction is made between different levels like niches or projects (micro), networks and sector (meso), and society at large (macro) (Quist et al., 2011). Various authors e.g., Smith et al. (2005) have emphasized the important role of guiding visions in transitions. In transition management (TM), visions are referred to as: "a framework for formulating short-term objectives and evaluating existing policy (…) these visions must be appealing and imaginative and supported by a broad range of actors" (Rotmans et al., 2001).

TM builds on complex system theory and innovation studies, but it also emphasizes the governance aspects, technological innovation, and sustainability transitions

(Loorbach et al., 2017a; Rotmans et al., 2001). Both TM and backcasting share a strong focus on stakeholder involvement, stakeholder learning and the development and assessment of desirable future visions, including turning long-term visions into actions and action agendas (Quist et al., 2013). Despite these similarities, TM is rooted in transition theory building like, for instance, the multi-level perspective which stresses that novelty starts in niches and may replace or adjust the dominant regime (Geels, 2002, 2004; Grin, 2010b) or paradigm (Van der Voorn and Quist, 2018). By comparison, backcasting is not rooted in a particular social system theory and is obsolete if novelty starts in a niche or in the regime itself (Vergragt & Quist 2011).

Significantly, the focus on experimentation and the generation of follow-up activities is one of the key aspects of TM, while within backcasting diffusion activities contributing to bringing about the generated desirable sustainable futures are still an add-on (Quist et al., 2013). The emergence of follow-up and spin-off effects comes with the diffusion of the visions generated in the backcasting experiment (Quist et al., 2011). Quist et al. (2011) have conceptualized the impact of visioning and backcasting experiments as all follow-up and spin-off effects resemble what is called a *niche* in Strategic Niche Management (Raven, 2005a; Smith, 2006) and in Transition Management (Grin, 2010b; Loorbach, 2007; Rotmans et al., 2001). Impact refers to a mechanism that could be summarized from vision phase to niche outcome. Vision development takes place in the backcasting experiments and it grows into a niche during the follow-up and spin-off phases (Quist et al., 2011). According to Quist et al. (2011), successful network formation accompanying all follow-up and spin-off stages may lead to the diffusion of and guidance provided by visions and instances of institutionalization in which existing institutions may change. The visions provide orientation ideas (where to go) and guidance (what to do).

Guiding visions play a vital role in the framing of problems, but also in motivating actors to seek to solve them. Even in transition contexts where end-points or end-states are highly contested or are only partially understood or remain uncertain, contestable visions on what might be or what ought to be are essential for possibility and for motivating the pursuit of change (Smith et al., 2005). Much is known about how transitions are preceded by niche developments, see e.g. Grin et al. (2010b), but little is known about how visions are developed and may influence the further development of transitions. Visions often emerge in niches, providing protected environments in which they further mature through small networks of actors whose support is essential if niches are to achieve momentum in changing the water management regime.

2.2.3 The area of water management research

Research into water management involves the whole range of activities focused on analyzing and monitoring as well as developing and implementing measures to retain the state of our water resources at a desired level. The coordinated development of water management within a river basin perspective is linked to river basin management (Harsha, 2012; Molle, 2017; Van der Zaag, 2005). The key difference between water management and river basin management lies in the spatial and ecosystem focus of river basin management, which emphasizes that river basins (and sub-basins) are the natural hydrological units within which sustainable water resource management can best be organized (Jones, 2006). In this way, river (and river basin) management can be seen as a sub-set of water resources management tending to stress the need for integration at all levels, regardless of any particular spatial scale or hydrological unit.

In the context of water management, climate adaptation is mainly about enhancing the resilience of social-ecological systems (SES) (see Section 1.1.2). In so doing adaptive water management is seen as the main responsive approach in water management. In the face of the present climate change, the management of water is undergoing a transition to a more adaptive management style. Adaptive water management first emerged as a response to the shortcomings of the technocratic management paradigm that is based on prediction and control mechanisms (Pahl-Wostl et al., 2007). Adaptive Management (AM) has been advocated as a concept in ecosystem management for quite some time (Holling, 1978, 1986; Lee, 1999). This management approach assumes that ecological systems are self-organizing complex adaptive systems, and that management must be able to adjust to change or surprise in ecological systems (Gunderson and Holling, 2002). AM takes on the challenges to manage social-ecological systems, building on adaptive and flexible structures and strategies in order to prepare for and cope with ongoing and future changes. AM has to do with a systematic process for continually improving management policies and practices by learning from the outcomes of implemented management strategies (Pahl-Wostl 2007). AM is about learning how to manage different types of uncertainties. This implies making a shift from a control-based approach towards an adaptive and learning approach in order to deal with uncertainty. This is reflected in more flexible modes of decision-making where experimenting, monitoring, evaluation, learning and adaptation all play an important role.

The development and implementation of *adaptive management approaches* requires structural changes in *water management* regimes. Such changes take a long time, as water management regimes have evolved over decades, and changing them also takes time (Huntjens et al., 2010; Pahl-Wostl, 2007c; Xia and Pahl-Wostl, 2012). A water management regime is connected to the whole complex of technologies, institutions, environmental factors, and paradigms that are highly interconnected and essential to the functioning of the management system being targeted to fulfil a societal function like, for instance, water supply or flood protection (Pahl-Wostl et al., 2007). Water management regimes do not easily change due to the strong interconnectedness of the regime elements that serve to provide stability to regimes (Huntjens et al., 2010; Pahl-Wostl, 2007c). The regime elements and their links come as the result of the actions of the actors that produce them (Geels, 2002). Changes in water management regimes typically result from regular patterns of cumulative and largely incremental developments, whereas a transition requires a fundamental change in the water management regime or paradigm (Pahl-Wostl et al., 2011; Van der Voorn and Quist, 2018).

Due to scholarly advancements in transition research, much is known about the evolution (Rotmans, 2000, 2001) and dynamics of transitions (Geels, 2002, 2004; Geels and Kemp, 2007). However, little is known about the role and functions of the visions behind water management transitions. This calls for more research into how visions are developed in the area of water management, what kind of impacts they have led to and how methods and knowledge can be used to facilitate visioning and visions for transitions to adaptive water management. Moreover, an improved understanding of the role of visions in historical transitions in water management can provide further insight into how visions and visioning can support the current transition to adaptive water management. Building on the existing literature on transition management and backcasting, this study aims to provide further insight into the relevance of visions and visioning to water management transitions in general and to the transition to adaptive water management in particular.

2.2.4 Overview of the key concepts

In the previous sections, various terms and concepts from different research areas have been introduced. Figure 2.1 presents a Venn-diagram that shows the key terms and concepts for each research area. Of particular interest are the ones that pertain to all areas (situated in the overlapping space) because they also show up in the empirical parts of this study. The terms and concepts in overlapping area A are addressed in Chapters 4 and 5. The overlapping area B includes terms and concepts are addressed in Chapters 5 and 6 . The overlapping area C includes terms and concepts that are addressed in Chapter 3.

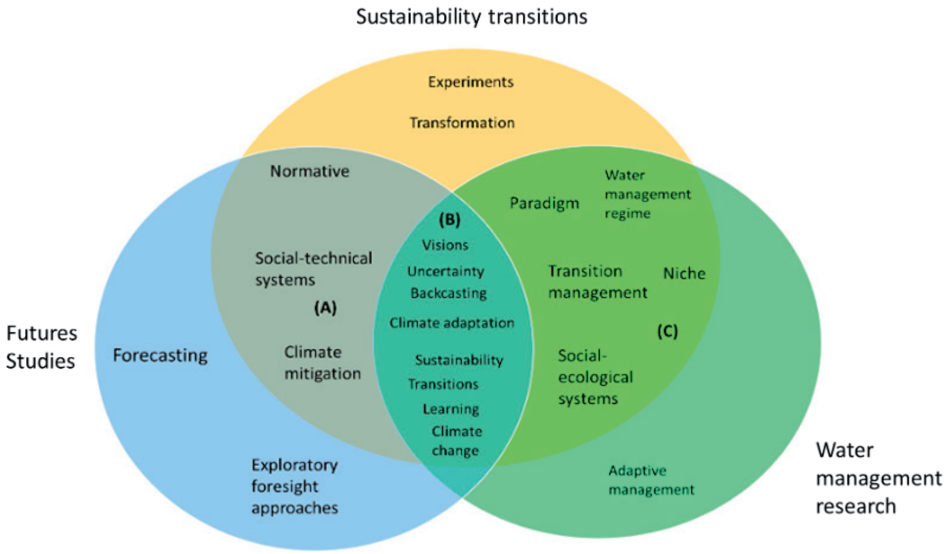

Figure 2.2 Overview of the key terms and concepts.

2.2.5 My experiences with backcasting research

In 2008, my research journey started at The Institute of Environmental Systems Research atThe University of Osnabruck in Germany, where I enrolled in the EU-funded New Approaches to Adaptive Water Management Under Uncertainty (NeWater) project (Jan 2005 – December 2008) that was drawing to a close. This project has greatly influenced the way I developed as a water management researcher. At that time the NeWater project was ahead of its time because it studied and fostered Adaptive Integrated Water Resources Management as a novel concept guiding theory and practice. Taking up the interdisciplinary challenge of managing the river basins as social-ecological systems, NeWater reflected the diversity of perspectives and potential through 37 project partners drawn from Europe, Africa and Central-Asia. The project had a societal impact as it supported the capacity building of the stakeholders in seven different case study basins. Following this project, my research initially focused on adaptive forms of water management. As time went on, I began to recognize that adaptive water management was receiving much criticism for being too incremental and ignoring the fundamental changes that are needed if water management is to address the long-term challenges of climate change. As such, my research focus gradually shifted to transformative adaptation.

Ultimately, the changes in my research focus and aims that have occurred over the course of time are reflected in my papers: in 2012, the focus was on backcasting for climate adaptation, which resulted in the Backcasting Adaptive Management methodology published in the 2012 Futures paper. That was followed by a multiple case study, involving the evaluation of cases on visioning and backcasting which was published in 2017. To connect the past with the present and the future, I have drawn inspiration from historical water management transitions through a historical analysis that was published in 2018. After 2018, my focus started to shift from incremental-based adaptation to transformative adaptation. This shift is apparent in the fourth paper as well as in this thesis.

2.3 RESEARCH DESIGN

This section describes the logic behind this research by determining the "logical sequence that connects the empirical data to a study's initial research questions and, ultimately, to its conclusions" (Yin, 2009).

2.3.1 Research paradigm

It was Kuhn (1962), who first used the word paradigm in his seminal work "The Structure of Scientific Revolutions" to offer a philosophical way of thinking[1]. The term has its origin in Greek, where it means pattern. Others have used the term paradigm to describe a researcher's worldview thus reflecting the perspective or way of thinking, or school or thought, or even the set of shared beliefs that inform the meaning or interpretation of research data. Lather (1986), for instance, explains that a research paradigm inherently reflects the abstract beliefs and principles that shape how a researcher sees the world; how she or he interprets and acts within that world. A paradigm provides the conceptual lens through which researchers examine the methodological aspects of their research project to determine the research methods that need to be used and how the data will be analyzed. To Guba and Lincoln (1994), a paradigm relates to a basic set of beliefs or worldview that guides any research action or to an investigation. Likewise, Denzin and Lincoln (2000) define paradigms as human constructions, dealing with basic principles and indicating the researcher's point of view so that meaning embedded in data can be constructed. The paradigm, thus, defines a researcher's philosophical orientation according to his beliefs and principles thereby influencing what should be studied, how it should be studied, and how the results of the study should be interpreted. This has significant implications for every decision made in the research process, including the choice of methodology and the methods (logic of inquiry).

1. The term research paradigm coined by Kuhn (1962) differs from the term water management paradigm applied in Chapter 3 and in the first paper.

Lincoln and Guba (2000) , distinguished five types of paradigms of inquiry: positivism, post-positivism, critical theory, constructivist and participatory paradigms. The positivist paradigm is based on a number of principles, including a belief in an objective reality, knowledge of which is only gained from sense data that can be directly experienced and verified between independent observers. Positivists believe that there is a single reality that is possible to gauge and understand. It has been argued by Orlikowski and Baroudi (1991) that positivism appears to be a weak or inadequate foundation for research and investigation in any case in the concluding realm.

Reality exists in Post-positivism, but due to the insufficient human intellectual mechanisms and the fundamentally intractable phenomena, humans cannot fully grasp reality, but can only understand it imperfectly and probabilistically (Guba and Lincoln, 1994). Post-positivism evaluates reality from the critical perspective; also sometimes referred to as critical realism. In critical theory, reality is shaped by social, political, cultural, economic, ethnic and gender factors and values, which are crystallized over time (Guba and Lincoln, 1994). Critical theory's ontology is also known as historical realism – as reality that can be understood through historical analysis. Critical theory has a transactional and subjectivist epistemology, as the researcher and the research object are linked and the researcher's values influence the inquiry[2].

By comparison, constructivists believe that there is no such thing as a single reality or truth, but that there are rather multiple realities. According to the constructivism paradigm, realities are constructed through the shared construction of social and cultural factors (Guba and Lincoln, 1989). Schwandt (2001) regards constructivism as strong and weak. The two types differ in their epistemological and ontological stances. The epistemology of strong constructivism is considered to be similar to that of critical theory: transactional and subjectivist, while creating knowledge through interaction between the researcher and his respondents. Strong constructivism creates and develops findings in the investigation process and its results are reached through consensus and individual constructions regarding those of the investigator. Like critical theory, the interpretation of theory in constructivism is shaped by a researcher's experiences, views and background.

In addition to Guba and Lincoln's categorization of paradigms of inquiry, Heron and Reason (1997) introduced the participatory paradigm. This paradigm maintains that mind and primeval reality (cosmos) co-create the world together and that reality is

2. In research, critical theory can be defined by the particular configuration of methodological postures it embraces. The critical researcher might design, for example, an ethnographic study to include changes in how people think; to encourage people to interact, form networks, become activists, and form action-oriented groups; and to help individuals examine the conditions of their existence (Madison, 2005; Thomas, 1993)

the result of cosmos and mind. The participatory paradigm draws on subjective and objective reality, as argued by Heron and Reason (1997: 279): "*Cosmos is known as a subjectively articulated world; whose objectivity is relative to how it is shaped by the knower, but, this is not all, its objectivity is also relative to how it is inter-subjectively shaped*". The epistemology of the participatory paradigm requires critical subjectivity, which is formed with experimental, presentational, propositional and practical knowing. Practical and theoretical knowledge co-create findings in the emerging context.

It is important to note that these are observations of paradigms in their pure forms. Such purity does not exist in practice, nor is it used in its pure form, because these are human constructs. In practice, researchers usually draw selectively from both paradigms. In this research, I adopt the participatory paradigm, in which my research is embedded. I consider this paradigm to be appropriate for my research, because it enables me to design my research to derive knowledge from the current practice in water management, while acknowledging that the same practice is informed by knowledge in an ongoing process which lies at the core of action research. This paradigm provides an adequate framework for examining our present situation/practice in a contemporary, postmodern context.

The participatory paradigm is congruent with the complex adaptive systems paradigm, which underlies thinking about the role of adaptive management (AM) in environmental and natural resource management. Since the first formal articulation of AM in the 1970s (Holling and Walters, 1978; Walters, 1986), major contributions have been made from social ecological systems research to develop an understanding of water resources and their management as complex systems. The increasing awareness of the complexity of environmental problems and of human–technology–environment systems has encouraged the development of new management approaches based on the insight that the systems to be managed are, in broad terms, complex, non-predictable and characterized by unexpected responses to intervention (Pahl-Wostl, 2002; Pahl-Wostl et al., 2011; Prato, 2003). Such complex adaptive systems (CAS) are characterized as hierarchies of components interacting within and across scales with emergent properties that cannot be predicted simply by knowing the components (Lansing, 2003). This holistic way of understanding CAS, by looking at the whole in context, is congruent with the participative paradigm (Hughes et al., 2013).

Instead of trying to change the structure of CAS to make them controllable by external intervention, innovative management approaches aim to make use of the self-organizing properties of the systems to be managed. Learning and self-organization are key to such processes (Pahl-Wostl et al., 2007). As argued by Bormann et al. (1993), AM involves learning to manage by managing to learn. In this respect, learning encompasses a wide range of processes that span the ecological, economic, and socio-political domains in the testing of hard (engineering-based) and soft (non-engineering-based) approaches (Gleick, 2003b; Pahl-Wostl, 2002). Pahl-Wostl et al. (2007) define AM as a systematic process designed to improve management policies and practices by learning from the outcomes of management strategies that have already been implemented. AM emphasizes the importance of the management process rather than focusing on goals, whilst the process is not an end in itself (Pahl-Wostl et al., 2007). This is congruent with the purpose of action research and learning through action that subsequently leads to change. Consequently, action research is an experiential learning approach to change, where the goal is to continually refine the methods, data, and interpretation in view of the understanding developed in previous cycles (O'Leary, 2004).

Following from this view, the epistemological standpoint of this research is that understanding reality relies on capturing and understanding the perspectives of and their meaning to the social actors who experience it. To understand the beliefs, motivations, and reasoning of individuals in a social situation, it is essential to decode the meaning of the data that can be collected around a phenomenon. Nevertheless, it still abides by the ideals of research objectivity and the researcher as a passive collector and expert interpreter of data, which is clearly not the case in my research.

2.3.2 Logic of the inquiry

In this research, I have applied a mixed-methods strategy of inquiry involving a purposeful mixing of methods in data collection, data analysis and the interpretation of the evidence. An essential step in the mixed methods approach is data linkage, or integration at an appropriate stage in the research process (Ivankova et al., 2006). Purposeful data integration enables researchers to seek a more panoramic view of their research landscape, examining phenomena from different viewpoints and research lenses. A mixed methods strategy is thought to be appropriate for answering research questions that neither quantitative nor qualitative methods alone could answer (Wisdom, 2013). A mixed method approach allows a better understanding of connections or contradictions between qualitative and quantitative data to be constructed; they can provide opportunities for participants involved in the research to have a strong voice and to share their experiences across the research process, and they can facilitate different avenues of exploration that could enrich the evidence and enable questions to be answered more deeply (Tashakkori and Creswell, 2007).

A mixed-method approach is congruent with process-oriented approaches like visioning, backcasting and transition management, which can be put into practice through action research. In general, action research can be seen as the collaborative production of scientifically and socially relevant knowledge, transformative action and new social relations achieved through a participatory process (Reason and Bradbury, 2008; Bradbury and Reason, 2003). An important feature of action research is that it implies "learning by doing", which involves a group of people identifying a problem then doing something to resolve it, judge how successful their efforts have been and, if not satisfied, trying again. While this touches upon the very essence of the approach, there are other key features of action research that differentiate it from the common problem-solving activities that we all engage in every day. In applying a process-oriented approach, researchers can take on different roles and activities to create and maintain space for societal learning. Wittmayer et al. (2014) for example, identified the ideal-types roles of researchers: reflective scientist, process facilitator, change agent, knowledge broker and self-reflexive researcher.

A more succinct definition of action research is provided by Gilmore et al. (1986:161), who state that: "*Action research…aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co-learning as a primary aspect of the research process*".

Action research distinguishes itself from other general professional practices, consulting, or daily problem-solving the emphasis being on scientific study, in which the researcher studies the problem systematically and ensures that the intervention is informed by theoretical considerations. A researcher spends most of his time refining the methodological tools to suit the exigencies of the situation, and collecting, analyzing, and presenting data on an ongoing, cyclical basis. O'Brien (2001) identified other attributes that distinguish action research from other types of research. A fundamental feature is its primary focus on turning the people involved into researchers, helping them to learn best and to willingly apply what they have learned, when they do it themselves. Another feature is its social dimension. Action research takes place in real-world situations and sets out to solve real problems. Finally, the initiating researcher, unlike in other disciplines, makes no attempt to remain objective, but openly acknowledges his bias to other participants.

Action research is mainly concerned with practical improvements, but the theoretical angle is also important as all research seeks to build theory. Action research is generally inductive rather than deductive. That is to say, it is more about data collection than testing or building theory (O'Brien, 2001). At the same time, a researcher always starts with a particular theoretical notion but should be open to what the research yields, and to reflect upon it. Grounded theory is a good example of a mixed approach where the emphasis is on theory building (Datt, 2016). This approach is suitable for predicting and explaining behavior, whilst the research is initiated with the development of a theoretical framework. New theories are developed on the basis of that theoretical framework. However, it is argued that the use of theory in this study contrasts both with the traditions of theory building through inductive reasoning and theory testing through deductive reasoning, which represent more linear research (Bettini, 2013; Blaikie, 2007). Action research tends, by nature, to be iterative and cyclic (Zuber-Skerritt, 2001).

Due to the iterative and cyclic nature of the reflection process, action research is similar to grounded theory in that it involves going back into the field after looking at data with a clearer understanding of the key issues and then developing further understanding through more research (Marcinkoniene and Kekäle, 2007). (Meyer and Lunnay, 2013) claim that applying solely deductive inference in qualitative data analyses may be limiting for researchers interested in theory development. They emphasize that in theory-driven research, deductive analysis requires the researcher to compare data with the initial theoretical framework. Data that are not part of the initial framework are often excluded from the analysis. Therefore, Meyer and Lunnay (ibid.) propose abductive inferences as complementary approaches which allow for a more comprehensive analysis of theoretically-driven data. To put it simply, abduction means analyzing data that fall outside of an initial theoretical frame or premise. Like deduction, abduction requires the researcher to move between theory and data. There is an aim to identify data that are beyond the initial theoretical premise or model. However, data that are not in sync with the initial theoretical framework become significant when discussing the findings.

In line with these views, I consider abductive logic to be appropriate for my research. By using abduction I can develop, make use of and extend a conceptual basis to explain how something might turn out (Holscher, 2019). Abduction is a mode of inference used to broaden knowledge and stimulate the research process (Habermas, 1978). Abduction introduces new ideas. When conducting theory-driven research, the findings may or may not fit the theoretical framework (Meyer and Lunnay, 2013). In essence, abduction is a means of forming associations that enable the researcher to discern relations and connections that are not otherwise evident or obvious. This in turn, allows the researcher to formulate new ideas, to think of something in a different context, and to 'see something else' (Danermark, 1997). Abductive research has been described by Schwartz-Shea and Yanow, 2012: 12) as a "*puzzling-out process, in which* *the researcher tacks continually, constantly back and forth in an iterative recursive fashion between what is puzzling and possible explanations for it, whether in other field situations […] or in research-relevant literature".*

In line with Holscher (2019), abductive logic is particularly useful when a research question has hardly been explored and a model needs to be made of the 'reality' under study. I propose that this could also apply to my research, which is on transformative climate adaptation (specifically in coastal regions) in terms of visions where the gathering of knowledge in the research draws on accessing the tacit and non-tacit knowledge of actors. To this end, I shall broaden the scope adopted by Holscher (ibid.), by including non-tacit knowledge e.g., formal, codified or explicit knowledge.

My role as a researcher

My research consists of empirical research, which includes multiple case study research. This empirical research includes the evaluation of cases which show varying degrees of action research. In these cases, I adopted various roles that are congruent with the ideal-type roles of (Wittmayer et al., 2014) . The South African case has been designed as a qualitative ex-post case study evaluation of a vision-based, regional Catchment Management Strategy development process. In the process, I acted as knowledge broker (as a backcasting expert) and process facilitator, co-designing the research design but also as reflective researcher (a distant observer) reviewing internal documents and reports and building on the workshops (for more details see Section 4.2.2). In the US case, a participatory action-based research approach for vision development was applied consisting of two stakeholder discussion meetings preceded by an online standardized survey. In that case, I took on the role of knowledge broker (backcasting expert) and reflective researcher (participant observer) (for more details see Section 4.2.2). In the Dutch case, visions from various participatory processes were fed into stakeholder workshops, in which I participated as a knowledge broker (backcasting expert) (for more details see Section 4.2.2).

2.3.3 Quality insurance of the research

Stance on normativity and subjectivity

In this research, I assisted practitioners in the improving of their own practices, which in turn could enhance their working environment, but also the working environments of those, who are part of it – e.g., stakeholders. My purpose when undertaking action-based research is to bring about change in a specific context. Through their observations and communication, those involved in the process are continually making informal evaluations and judgements about what it is they do (Parkin, 2009). Such instances of self-reflection are based on subjective accounts. As Reason and Bradbury

(2001) stated, action research involves working towards practical outcomes as well as creating new forms of understanding because action without reflection and understanding is blind, just as theory without action is meaningless and the participatory nature of action research makes it only possible with, for and by persons and communities, ideally involving all stakeholders both in the questioning and sense making to inform the research, and in the action which lies in its focus. From a normative viewpoint, action research can be seen as a process, involving people and social situations, the ultimate aim being to change an existing situation or practice for the better (Meyer, 2000; Meyer and Lunnay, 2013).

Even within the participatory paradigm, Heron and Reason (1997; 2008) pointed out that very little is asked of the epistemic participation of those who are encouraged to participate in knowledge co-production. As reasoned by Heron and Reason (ibid.), epistemic participation is one of the core principles of co-operative inquiry. They maintain that any propositional knowledge resulting from research is rooted in the expertise of the researchers. This proposition has implications for the way in which I account for normativity and subjectivity in my research. First, while building on the notion of epistemic participation regarding researchers I take note of when communities become co-researchers while any propositional knowledge that results from co-operative research ought to be grounded by all co-researchers in all of their specific expertise. For this reason, I have questioned all who participated in the co-production of knowledge about their goals, values, frameworks and strategies. Secondly, in line with the participatory paradigm, knowledge production processes are not only influenced by the critical subjectivity of researchers like myself, but also by all those involved in the knowledge production process (Heron and Reason, 1997; 2008). Heron and Reason (1997:283) refer to critical subjectivity as: *"a self-reflexive attention to the ground on which one is standing, which means that all perspectives are transparent to the context of their operations, are open to the context of that context"*. It has been argued that this concern regarding the epistemic participation of communities in research remains unaddressed in most theoretical and operational manifestations of participatory research. Hence, following from this, it is equally important to manage the development of 'living knowledge', as well as normativity and subjectivity.

Validity of the research results

Action researchers need to meet the traditional research requirements of high standards, high quality and constituting an original contribution to knowledge in the field (Zuber-Skerritt and Fletcher, 2007). In addition, action researchers have to demonstrate the requirements of action research by explaining and justifying the action research paradigm (plural ways of knowing), appropriate methodologies, their choice and use of qualitative research methods, different standards of ethics and values, and evidence of learning, reflection as well as a contribution to knowledge both in theory and practice (Zuber-Skerritt and Fletcher, 2007) (cf. Bradbury, 2001) . Coghlan and Brydon-Miller (2014) suggest that the rigor in an action research study provides the means by which knowledge outcomes have to comply with four important qualities of trustworthiness: credibility, transferability, dependability and confirmability.

Credibility is achieved when the research rigorously synchronizes the consequences of actions in terms of the problem under examination and the theory underlying the formulation of the action (Coghlan and Brydon-Miller, 2014). For example, I tested initial research findings and observations from earlier literature reviews with the stakeholders involved in the research process. In action research, transferability implies that further use of the knowledge must account for the unique features of the setting in which the study was conducted. For transferability, future researchers must be well-informed to be able to decide whether the results from a previous action research study are relevant in a novel research setting. To achieve transferability, I ensured that my research results provide sufficient documentation of the social setting to enable someone to compare them with a future social setting in order to appraise the differences and potentially adjust the action, or even the theory, to a novel setting. Dependability compels a researcher to ensure that the knowledge offered in an action research study will operate successfully in the future. Just as with an experiment, an action research study will usually be able to show that both its theory and action are known to work only once. To ensure reliability, I have provided transparency on the data collected as well as the research approach and methods, which will enable future researchers to replicate things in a similar research setting. Finally, confirmability prescribes that an action research process can be reconstructed, even though it cannot be repeated. This means that there has to be sufficient documentation to support an independent audit of the action research process, but also an auditor who can review the procedures and the data in order to confirm that the research was conducted properly. Confirmability of my research was secured by a commissioning authority, who undertook such a review. To some extent, peer-reviewers also contributed to confirmability, by critically reviewing my research as it was published in journal papers.

Soundness (quality) of the research process

Zuber-Skerritt and Fletcher (2007) identified the quality characteristics of critical action research and action research. They developed a theoretical framework of action research known as, the Critical-Reflexive-Accountability-Self-evaluation-Participatory (CRASP) model. According to this model, the action research process has to meet the following quality criteria: it needs to (i) facilitate a critical (and self-critical) collaborative enquiry by being (ii) reflexive through practitioners, who are held accountable for making the results of their enquiry public, (iii) they must self-evaluate their practice and (iv) be engaged in participative problem-solving and continuing professional development. These criteria were all met in my research.

Providing that these criteria contribute to the soundness of the action research process, the involvement of an action researcher in this process must be subjected to quality insurance (Robertson, 2000). For example, the way in which I deal with inclusivity and reflexivity in the process of action research is essential. Inclusivity concerns selecting participants so as to capture a diversity of perspectives of knowing, actor perspectives, interests and power positions (Jhagroe, 2016). I explicitly included participants who will be affected by the results of the research and who are willing to improve their current practice. Whereas Giddens (1976) described reflexivity as self-awareness, Gouldner (1970:493) further elaborated on what this actually means in the research process for the search for knowledge: "*In a knowing conceived as awareness, the concern is not with 'discovering' the truth about a social world regarded as external to the knower, but with seeing truth as growing out of the knower's encounter with the world*". Reflexivity relates to my self-awareness regarding how I dealt with my own biases that reflect my experiences, involvement, and values as well as how I communicated my research. Reflexivity made me aware of my position in the research context and allowed me to reflect on my findings.

Societal relevance and impact of the research results

The societal relevance of my action research lies in its focus on generating solutions to practical problems and its ability to empower practitioners by engaging them in research and the subsequent development or implementation activities (Meyer and Lunnay, 2013). To achieve societal impact, the research outcomes need to go beyond single case scenarios to achieve broader impact as part of the research itself. The most common approach is to rely on the power of the research project to immediately reach out to new practical users (Gustavsen, 2014). Action research enabled me to directly communicate with new practitioners, allowing the research to go through its practical manifestations (Koshy et al., 2011). Besides developing and advancing concepts, publishing scientific articles and presenting at scientific conferences, I aim to translate my insights into actionable knowledge that supports actors seeking to make well-informed decisions in a specific context. This also helped me to generate recommendations about how to support and guide transformative climate adaptation.

2.4 RESEARCH STRATEGY

The overall research strategy builds on transformative mixed methods in order to conduct qualitative research. A mixed-methods design is useful when either the quantitative or qualitative approach alone is inadequate for best understanding a research problem or when the strength of quantitative and qualitative research can provide adequate understanding (Creswell, 1999, 2016). The strategy includes four main steps: (i) the development of a conceptual framework through the use of theory; (ii) transition analysis based on a single case study; (iii) comparative analysis of three cases; and (iv) broader comparative analysis of ten cases.

2.4.1 Use of theory

The theory used in a mixed-methods research strategy includes inductive theory as in a merging qualitative theory or pattern (Creswell, 1999, 2016). Such an approach treats theory as a theoretical lens or perspective to guide the study. In contrast to theoretical orientation in quantitative studies, theory or a broad explanation becomes the ultimate goal in qualitative studies. It is an inductive process of building from the data to broad themes and then on to a generalized model or theory (Punch, 2005). I followed two qualitative approaches of inquiry: conceptual framework development and the case study approach. The former approach allowed me to develop a conceptual framework based on the relevant literature and theories. This framework served to report and interpret the empirical results of the case study research. It involved using multiple stages of data collection and the refinement and interrelationships of categories of information (Charmaz, 2006; Strauss and Corbin, 1990, 1998). This approach is also congruent with the abductive logic of the research (Section 2.2.2), as it involves the constant comparison of data with emerging categories and theoretical sampling of different groups to maximize the information similarities and differences. Furthermore, I applied the case studies as an inquiry approach to explore in depth a process involving multiple stakeholders. The cases were limited by time and activity, which provided a certain timeframe in which to collect detailed information using a variety of data collection methods and procedures (Stake, 1995). I will elaborate more on this approach in Sections 2.4.3 and 2.4.4. I deem both approaches appropriate for my qualitative research, because they are suitable for improving our understanding of a little-researched phenomenon (Creswell, 2016).

Building empirically ground theory requires a reciprocal relationship between data and theory (Cresswell, 2016). Lather (1986:267) described the use of theory as follows: "*Data must be allowed to generate propositions in a dialectical manner that permits use of a priori theoretical frameworks, but which keeps a particular framework from becoming the container into which the data must be poured in*". This thesis builds on theoretical understanding of sustainability transitions, normative foresight approaches and resilience so as to develop an understanding of transformative adaptation. These scientific approaches were chosen as they provide rigorous and rich insights into sustainability transitions and agency in the context of transformative adaptation. I consider these insights to be both consistent and complementary. Sustainability transitions focus on persistent cultural constraints underlying shifts towards sustainable systems of service provision and lifestyles, facilitating radical change (Rotmans and Loorbach, 2010; Markard et al. 2012). Resilience approaches focus on governance institutions and activities for enhancing the ability of social-ecological systems to respond to uncertainty and disturbance (Folke, 2016). Normative foresight approaches provide knowledge on how to explore desired futures, including the relevance of visions, paradigms and agency in an endeavor to achieve these futures.

2.4.2 Qualitative historical single case study research

The empirical part of my research comprises a qualitative historical single-case study for learning from historical transitions, by studying processes and tracing specific causal-event chains within their own context (Mahoney, 2003b). Transitions are complex processes involving multiple conjunctures of causal conditions in time and space to yield a given outcome. Even though causality may well exist, it remains quite difficult to clearly indicate the cause producing the outcome of interest (Mahoney, 2003b; Ragin, 2014). This case study facilitated the development of a framework for analyzing water management transitions and emerging visions and niches and it builds on the Multi-level Perspective (MLP) presented by Geels (2002), an analytical lens associated with the transitions approach. This served to addresses my **first research question** involving the role of visions and visioning in water management and their significance for the current challenge of transformative adaptation in water management. The first 'what' part of the question entails a historical case study on how visions have come into being and have been implemented in the past. It was designed as a longitudinal study on the role of visions in water management transitions in the Lower Mississippi River. This study draws on various historical accounts to determine the appropriate time span for each narrative (Barry, 1998; Lonnquest et al., 2014; Sabatier, 2005; Wright, 2000b). The second 'what' question enables a critical reflection on the relevance of visions and visioning for adaptive water management.

Causal narratives have been used to explain certain outcomes of historical events sequences which are linked together by a central theme. Causal narratives helped to trace unfolding processes and to study event sequences, timing, and conjunctures (Pedriana, 2005b). My interest lies in the interplay of factors and influences across the landscape, regime and niche levels. Each narrative captures complex interaction between agency and visions (at niche level) and changing contexts (at landscape and regime level), timeframes, event sequences, the making of moves in games and changing identities. However, causal narratives need to be guided by 'heuristic devices' that specify a certain plot (Geels, 2011). The principal mechanism for niche-driven regime change will then be used as a central plot for the narratives.

Rationale for case selection

The relevance of the Lower Mississippi River lies in its rich history pertaining to major flood disasters and damages in conjunction with a wide array of enactments by US Congress and policy developments and the wide availability of the secondary historical sources reporting on these events (Van der Voorn, 2012b).

Data collection and analysis

Secondary historical sources such as scholarly books and papers were collected and used to draw on the overall picture and patterns over a much longer period of time. Geels, (2011) emphasizes the exploratory and illustrative character of transition studies. In transition research, it is common practice to use secondary sources and a framework as a lens in order to look at these sources in a transparent and systematic way see e.g., (Geels and Raven, 2006; Geels, 2002; Geels, 2005a; Verbong and Geels, 2007). Therefore, I developed a framework to analyze the interplay between visions and actors to describe niche-driven change in water management regimes. The framework builds mainly on the MLP. It includes the following building blocks:

- The Multi-Level Perspective which explains the niche-regime-landscape dynamics.
- The concept of transition experimentation supporting the analysis of transition experiments that can contribute to a transition towards adaptive water management.
- Water management regimes that are embedded in an SES connected to ST-systems.
- Guiding visions are important for transitions. They create a common reference point for action and guide actors in their actions and behavior in reaching such a point.
- Emerging visions that face competition from other emerging visions.

Congruent with an abductive logic of inquiry, triangulation has been applied to construct the narratives with a beginning, middle phase and an end, focusing on historical events as well as on underlying factors, (see e.g., Jepsen et al., 2015b). Data triangulation was applied to ascribe the narratives a beginning, middle point and an end, focusing on historical events as well as on underlying factors (see e.g., (Jepsen et al., 2015a). Triangulation involved the comparison of various historical accounts (i.e., Barry, 1998; Lonnquest et al., 2015; Sabatier et al., 2005; Wright, 2000a) to determine the appropriate time span for each particular narrative. This inquiry and data triangulation is based on multiple interpretations extracted from secondary sources. We will evaluate and compare the narratives in terms of the criteria presented to identify recurring patterns.

2.4.3 A single descriptive case study research with methodology development

The empirical part of my research comprises a descriptive case study in order to investigate the desirable futures or normative foresight approaches, in particular the vision-oriented ones that can be used to develop more robust climate strategies in coastal regions (see the second paper and Chapter 4) . The aim of the study is to explore how backcasting and adaptive management can be integrated into a single methodology which can in turn, be considered a novel contribution to the literature on backcasting. This case study addresses my **second research question** on how visioning methods and processes and adaptive management can be combined to support adaptive water management. It involves a 'how' question motivating a review of the futures studies literature for methodology development. The applicability of the combined methodology has been described for the South African Breede-Overberg coastal region, where a Catchment Management Strategy was developed in 2010 through a participatory process. In this descriptive case study analysis, precisely how the methodological method chosen for the Catchment Management Strategy development process deviated from the combined methodology is described.

2.4.4 Multiple case study research on the impact of backcasting studies

The empirical part of my research involves a multiple case study designed to investigate cases on the development and implementation of visions in three coastal regions. This study served to expand work on the further methodological development of normative scenario and visioning approaches for climate change adaptation planning and just how this can be combined with management-oriented frameworks like Adaptive Management. This study evaluated cases on vision and strategy development for robust climate change adaptation planning. It investigated the outcomes in relation to their potential for the further development of normative approaches to climate change adaptation planning in general and for the Backcasting Adaptive Management methodology in particular. This study addresses my **third research question** of how visions have been implemented in water management and the impacts that have been realized. The 'how' part of the question will be addressed through a qualitative comparative case study on the development and implementation of visions in three coastal regions. The aim of the multi-case study research was to compare and evaluate cases on vision development for climate change adaptation planning. The 'what' part of the question involves proposition testing to investigate the type of impacts realized, which supports the improving of current visioning practice.

Rationale for case selection

According to Yin (1994), a comparative case study prescribes that a general theoretical design or model should be applied to the selected cases which, in turn, have to meet the same methodological requirements. In this comparative case study, Yin's perspective fulfilled a different role in the cases. It explains the methodological choices I made for each case in the research design which were then adapted to the participatory vision development processes, while ensuring the same theoretical (i.e. the potential of visions of the future for climate adaptation planning) and methodological (i.e. doing action research to explore desirable futures) point of departure for the cases.

For this study, the following cases were selected:

- The South African Breede-Overberg Catchment area: A joint project set up by the University of KwaZulu Natal (South Africa) and the Institute of Environmental Systems Research, entitled "Mainstreaming Climate Variability and Climate Change into Policy and Decision Processes for Adaptation in Water Resource Management". This project was funded by the German Federal Ministry of Education and Research and the South African National Research Foundation.
- The United States Lower Mississippi River: Research collaboration between the Horizon Initiative Water Management Committee and the Bard Urban Studies Program in New Orleans.
- The Dutch Rhine Estuary: Research collaboration with Deltares, a Dutch independent research institute for applied research in the field of water, subsurface and infrastructure schemes, within the context of the Dutch Deltaprogramme Rhine Estuary-Drechtsteden.

Table 2.1 shows some characteristics of the selected cases. To comply with Yin (1994), a comparative case study requires more similar cases rather than contrasting cases. The cases show a combination of common characteristics and some diversity concerning other criteria, which can be adequately dealt with through multi-case study design (Ragin, 1989; Yin, 1994). The common characteristics include: (i) historically vulnerable deltaic or coastal regions with changing climatic conditions and the associated increase of extreme weather events such as floods and droughts, (ii) a high level of economic activity in major cities or in the region and (iii) a long tradition in technocratic management paradigms in water resources management.

As described in Table 2.1, diversity is provided through (i) the continent (Europe, North America and Africa), (ii) case study design, (iii) the research methods applied (iv) the type of data collected and the (v) niches. Diversity results from a purposeful

Table 2.1 Governance characteristics of the selected case studies (Van der Voorn, 2017)

Case study	Breede-Overberg Catchment Management Strategy (South Africa)	Horizon Initiative Water Management Strategy (United States)	The Rhine-Meuse Estuary sub-programme of the Delta Programme (the Netherlands)
Governance context	Top-down governance by government	Market oriented	Polycentric & network oriented
Type of partici-patory process	Government initiated & empowerment oriented	Bottom-up initiated & facilitated by a private think tank	Government initiated & polycentric in different organizations

choice of cases to: (i) compare climate change adaptation planning efforts in different governance contexts and countries and (ii) to underline their relative advancement in these efforts. It is important to note that the selected cases can be seen as initiatives to build unlocking capacity, transformative capacity and orchestrating capacity.

As illustrated in Table 2.1, diversity is also present in governance contexts, which take into account the different actors and networks involved in formulating and implementing policy or policy instruments, and the types of participatory vision development process.

As presented in Table 2.1, the South African case has been designed as a qualitative ex-post case study evaluation of a vision-based, regional Catchment Management Strategy development process. In this case, the investigating researcher acted as a backcasting expert, co-designing the research design but also as a distant observer reviewing internal documents and reports building on the workshops. In the US case, a participatory action-based research approach to vision development was applied consisting of two stakeholder discussion meetings preceded by an online standardized survey. In this case, I took on the role of backcasting expert and participant observer. In the Dutch case, visions from various participatory processes were fed into stakeholder workshops, in which I participated as a backcasting expert.

Data collection and analysis

For the comparative evaluation, I developed a framework in which I distinguished six major dimensions of vision and pathway development for climate change adaptation planning: (i) inputs and resources, (ii) vision development, (iii) stakeholder engagement, (iv) pathway development, (v) methodological aspects and (vi) the impact.

A comparative case study helped me to evaluate each backcasting process within its own context, after which it was possible to look for general patterns and conclusions from the comparison of individual cases (Yin, 1994). To that end, I developed a set of propositions, which were validated against a set of criteria as part of an evaluation framework. At this point, I argue in favor of propositions instead of hypotheses, which

Table 2.2 Characteristics of the research design (Van der Voorn, 2017)

Case study	Breede-Overberg Catchment Management Strategy (South Africa)	Horizon Initiative Water Management Strategy (United States)	The Rhine-Meuse Estuary sub-program of the Delta Program (the Netherlands)
Case study approach	Qualitative ex-post case study evaluation	Participatory action-based research	Expert & stakeholder evaluation of existing visions and pathways
Research methods	Desk study, qualitative data analysis, informal interviews;	Desk study, qualitative data analysis, informal interviews, stakeholder workshops, participant observations, online standardized survey	Desk study, qualitative data analysis, informal interviews, stakeholder-expert workshops, participant observation, brainstorm sessions with experts,
Type of data collected	Meeting & project reports, project meeting, expert judgment	Meeting & project reports and expert judgment	Meeting & project reports, expert judgment, stakeholder opinions

is in line with Sabatier (1999) and my abductive logic of inquiry. It has been argued by Sabatier (ibid.) that scientists should develop clear and logical interrelated sets of propositions, some of which are empirically falsifiable so that fairly general sets of phenomena can be explained. Sabatier (ibid:5) bases his argument on Ostrom (1990) to distinguish between different stages of theory development and argues that propositions should be applied in the early stages of theory development. By contrast, hypotheses are better equipped for statistical evaluation and further advanced levels of theory development.

Each case study follows a triangulated research strategy since multiple research methods can be used and combined to improve our understanding of the same phenomenon under review (i.e., participatory vision development) (Denzin, 1970). Triangulation allows the most suitable research methods to be applied in order to gather data at different times (e.g., in the project phase) and in different research settings involving a range of stakeholders (Bryman, 2001). These aspects also reflect the ability of the investigating researcher to influence the research design thus affecting his choice of research methods and roles in the case in question (Table 2.2). Despite the great methodological range, the participatory vision development processes remain the unit of analysis. Triangulation also relates to the various types of data that were used for the qualitative data analyses and were collected through the various research methods presented in Table 2.2.

2.4.5 Qualitative multiple case study the focus being on best practices

A qualitative multiple case study on the use of participatory backcasting approaches was conducted to elaborate on the potential of backcasting for climate adaption. This addresses my **fourth research question** of how to advance backcasting approaches for climate adaptation planning by comparing various climate change adaptation studies that have made use of backcasting approaches. This evaluation builds on the evaluation framework that was applied to the qualitative comparative case study. Following an abductive logical line of inquiry, the framework has been extended to provide further insight into methodological variety in backcasting approaches. The aim was to further advance backcasting for climate adaptation, by drawing together the different backcasting approaches applied alongside water management, such as mobility, land-use management, transport and urban planning to thereby highlight key insights and lessons learnt from backcasting studies.

Rationale for case selection

This paper investigates ten climate change adaptation studies that reveal a combination of common characteristics but also a degree of diversity. The common characteristics include: (i) vulnerable regions with changing climatic conditions, a focus on (ii) climate change adaptation, (iii) the application of backcasting approaches, (iv) studies conducted before 2020, and (v) the availability of in-depth information and data on the cases that were accessible to the authors, who were knowledgeable on these cases due to their personal involvement. Conducted and finalized before 2020 was a relevant selection criterion, as it allowed me to identify possible impacts and spin-offs. Ten cases covering the continents of Africa, Europe and North America were included: (1) catchment strategy development in the South African Breede-Overberg Catchment region, (2) water management strategy development the US Mississippi Estuary, and (3) The Delta Program undertaken in the Dutch Rhine-Meuse Estuary, (4) climate adaptation in two Swedish municipalities, (5) understanding the consistencies and gaps between the desired forest futures in Sweden, (6) visioning and Backcasting for Transport CO_2 reduction in London, (7) the use of participative backcasting to develop adaptation pathways for possible futures concerning the Dutch Overijsselse Vecht, (8 & 9) two cases devoted to combining participative backcasting and explorative scenario development for envisioning the future of water in Europe, and finally (10), Envisioning local climate change futures in the Canadian municipality of Delta.

Data collection and analysis

Various types of data were collected in all the different cases to which different research methods were applied. Each case followed a triangulated research strategy since multiple research methods can be used and combined to investigate participatory backcasting processes. Triangulation was also applied to the various types of data that were used for the qualitative data analyses and was collected through the various research methods applied to the cases. Our study can be considered a secondary qualitative analysis of the case study data. Data sources included academic papers, reports, personal involvement or available personal contact, all of which culminated in the ten cases.

For the comparative evaluation, I developed a framework that proposes four main dimensions alongside which backcasting studies for climate adaptation can be evaluated: (i) inputs & project settings, (ii) stakeholder process and methods, (ii) results and (iv) the impact of backcasting studies. More details can be found in Section 6.3.

2.5 OVERVIEW OF THE RESEARCH COMPONENTS

Overall, I can retrospectively reconstruct six research steps that constituted the overall research process: (i) methodology development for integrating adaptive management and vision-oriented approaches; (ii) the development of the conceptual framework for analyzing transitions; (iii) a comparative case study of backcasting studies; and (iv) an expert review of backcasting studies to provide further insight into variety in backcasting approaches. Within each research section, I undertook different types of research activities, including desk research, interviews and data analysis (see Table 2.3 and Figure 2.2).

As a consequence of my logical line of inquiry (Section 2.2.2), the research parts were conducted in a highly iterative way. For the first part, I developed a conceptual framework to analyze the part played by visions, agency and niches in historical water management transitions in the case of the Lower Mississippi River. This subsequently resulted in my first (WATER) paper. In the second research part, I developed the methodology that combines adaptive management and backcasting. That provided input for the second step, namely: the conducting of a comparative case study of backcasting studies. This part then resulted in my second (FUTURES) paper. The third research part included evaluation framework development and a multiple case study on visioning and backcasting, which led to my third (MITI) paper. The fourth research part included a multiple case study, which built on the evaluation framework developed and the multiple case study conducted in the second research part. This multiple case study adopted a broader perspective as it compared various climate change adaptation studies that used backcasting approaches in contexts other than water management (e.g., forestry management, land-use, mobility and urban development). Overall, the timing of the research parts is congruent with a mixed-methods research strategy in which theory usually becomes the end point behind qualitative studies.

Table 2.3 Overview of research parts

Research part	Research activities	Results
Conceptual framework & historical case study on water management transitions	• Review of sustainability transitions, resilience literatures • Development of conceptual framework based on new insights from literature, discussion and empirical work	Scientific paper on synthesis of literatures for the development of frameworks for analyzing historical water management transitions in the US Lower Mississippi River (Chapter 3)
Methodology development & single case study	• Review of futures studies, adaptive management literatures • Development of a methodology on new insights from literature, discussion and empirical work	Scientific paper on the synthesis of literatures for developing backcasting and adaptive management methodology (Chapter 4)
Evaluation framework development & comparative case study	• Data collection (literature review, interviews, stakeholder workshops) • Data analysis • Qualitative comparative analysis of three backcasting studies	Scientific paper on a comparative study of three backcasting studies (Chapter 5)
Evaluation framework development & comparative case study	• Data collection of case materials • Data analysis • Qualitative comparative analysis of ten backcasting studies	Scientific paper on expert-based evaluation of ten backcasting studies (Chapter 6)

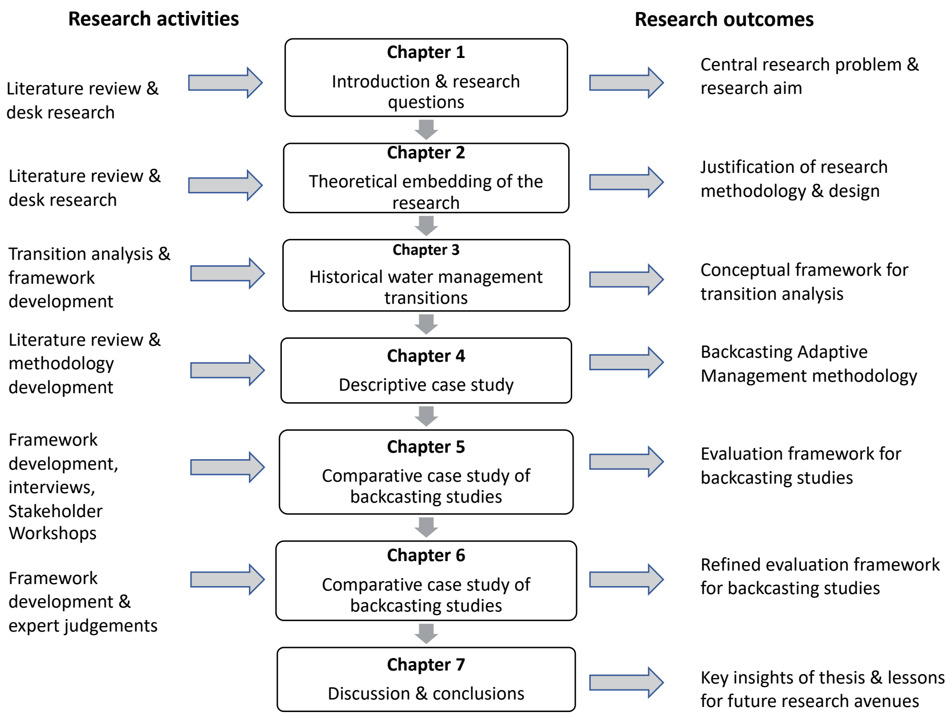

Figure 2.3 Overview of overall research process.

Whilst this is a cumulative dissertation, the overall research strategy is perceived to have put the papers together in a logical sequence. In this respect, defining the overall strategy is also recursive by nature, as the logical sequence was constructed recursively from the research questions presented in Chapter 1. Following the order of the research questions, I deem the historical single-case study to be the logical starting point for the research steps that can be framed as consecutive but which form complementary components of the action research in which the aim is to advance backcasting approaches for transformative adaptation.

The discrepancy between the actual research process and 'ideal' research design can be attributed to two factors: (i) progressive insights gained during my PhD project; and (ii) the timing and settings of the research projects within which I did the empirical work. This demonstrates that my research is truly a backcasting study in itself which compelled me to be reflexive and adaptive and therefore also corresponded with my logical line of inquiry.

2.5.1 Outline of the research process

The outline of the research process is presented in Figure 2.3. This thesis consists of 7 chapters. Chapter 1, 2 and 7 were written after Chapter 3, 4, 5 and 6 which relates to the 4 research parts.

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CHAPTER 3

ANALYZING THE ROLE OF VISIONS, AGENCY AND NICHES IN HISTORICAL TRANSITIONS IN WATER RESOURCES MANAGEMENT IN THE LOWER MISSISSIPPI RIVER

This paper analyses six major transitions in watershed management in the Lower Mississippi River from the early 19th century till present. A conceptual framework is developed for analyzing the role of visions, agency and niches in water management transitions and applied to a historical case on water management in the Lower Mississippi River. It is shown that water management regimes change over time and that major transitions were preceded by niches, in which new visions were developed and empowered. The case shows that: (i) emerging visions play an important role in guiding transitions; (ii) agency enables the further diffusion of visions and niches; (iii) vision champions play an important role in transitions, but are not decisive; (iv) each transition has led to an extension of the number of societal functions provided, which has led to more complex water management regimes in which functions are combined and integrated; and (v) external landscape factors are important, as they can lead to awareness and urgency in important decision making processes.
Keywords: transitions; water management regimes; niches; visions; agency;

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Van der Voorn, T. and J. Quist (2018). "Analysing the Role of Visions, Agency, and Niches in Historical Transitions in Watershed Management in the Lower Mississippi River." Water **10**(12): 1845.
DOI: https://doi.org/10.3390/w10121845

3.1 INTRODUCTION

From the 20th century onwards, the management of water resources has undergone at least four major paradigm shifts (White, 1998). At the beginning of this century, the dominant paradigm was single purpose water resources management in all industrialized countries. This means that each water resource was managed for a specific purpose. For example, streams were harnessed for generating hydroelectric power. Fields were irrigated from canals and diversion or storage reservoirs. Cities were served with domestic water from wells and storage dams, and streams were rendered navigable by channel works. However, this was done without taking the interconnectedness of different functions of rivers into account (Jakobsson, 2002). By the 1930s, the prevailing paradigm had become multi-purpose water resources management, which aimed at combining functions of rivers. In this period, it had become possible to build dams to generate hydroelectric power, while also storing water for other purposes like agricultural irrigation, increasing the security of fresh water and water safety.

By the 1970s a third paradigm emerged, due to the growing awareness of the full social and environmental impacts of river management re-shaping the natural landscape (Sabatier, 2005). This led to the implementation of more environmentally sound forms of water engineering approaches like floodplain management and conservation. All three paradigms were technocratic as they assured high predictability and controllability of the water systems to be managed. However, they failed to account for the complexity and strong interconnectedness of social and ecological components of these systems, also in disregard of potential risk of causing unexpected or unintended consequences (Gleick, 2003a; Holling, 1996; Pahl-Wostl, 2005b).

By the 1990s thinking about water management entered a fourth period (Biswas, 2004), as the shortcomings of the prevailing water management paradigms became evident. A key change was that water systems were increasingly characterized as complex adaptive systems, which are not only self-organizing, but also unpredictable and non-linear in their response to intervention what further complicates their management (Pahl-Wostl, 2007c). New and more integrated and adaptive water management approaches have been developed and are still being implemented to compensate for the perceived shortcomings in earlier management approaches (Pahl-Wostl, 2007b).

The discussion above makes clear that water management regimes have evolved over decades, and changing them requires time (Huntjens et al., 2010; Pahl-Wostl, 2007c; Xia and Pahl-Wostl, 2012). It includes changing their underlying paradigm – the set of guiding principles determining the internal logic of water management regimes and depends on the emergence of novel visions that provide guidance and orientation. Transitions in water management are complex processes, in which visions and actors play a vital role that needs further investigation to better understand and manage future transitions, for instance, toward adaptive water management regimes.

The relevance of guiding visions has been recognized in (sustainable) technology development (Weaver et al., 2000), in system innovations towards sustainability (Quist, 2007) and in transition studies (Berkhout, 2006b; Loorbach, 2006b; Loorbach et al., 2017b; Quist, 2007; Sondeijker et al., 2006). Despite increasing popularity of visioning approaches in the past two decades, theory development on the guiding potential of visions is still limited (van der Helm, 2009). Much is known on how transitions are preceded by niche developments (Grin, 2010a), but little is known how alternative visions emerge and further guide the development of niches and novel societal functions. As little research has been conducted on niche developments in successive transitions, our purpose is to provide more insight into such transitions based on a historical case on water management in the Lower Mississippi River. The aim of the paper is to develop and apply a framework for analyzing water management transitions and emerging visions and niches and to enhance our understanding on: (i) what is the role of emerging visions and niches in such transitions and (ii) what is the role of agency and how does it relate to vision development and niche formation? The paper is structured as follows: Section 3.2 presents an overview of various theoretical perspectives in the literature on transitions, agency and visions, which provides the theoretical foundation of our conceptual framework. Section 3.3. presents an inquiry into historical transitions in watershed management in the Lower Mississippi River, which analyses water management transitions covering several transitions in a time span over more than two centuries. Section 3.4 discusses major lessons from this inquiry, followed up with concluding remarks in Section 3.5.

3.2 MATERIALS AND METHODS

3.2.1 Theory

Multi-level perspective and socio-technical transitions

A major analytical lens associated with the transitions approach is the Multi-Level Perspective (MLP) that explains transitions by the interplay of dynamics at three levels (see Fig.1) (Geels, 2002; Loorbach and Rotmans, 2010; Rip and Kemp, 1998). These are the levels of niches, socio-technical (ST) regimes and landscape. The MLP takes as a starting point that novelty emerges and develops at the niche level, which eventually can result in transformation or replacement of ST regimes. Regimes can be conceptualized as consisting of actors, institutions and (socio-technical) systems (Geels, 2004). At the landscape level gradual developments and sudden shocks like natural disasters or economic crises might put pressure on existing ST regimes and may create windows of opportunities for niches to break through.

The emphasis in transition studies is generally on ST-transitions in provision systems that relate to one or multiple societal functions like water supply (Holtz et al., 2008; van der Brugge, 2005), food, or energy (Grin et al, 2010). These systems provide products and services to users through companies and markets and the focus is on the emergence and the rise of new technologies that bring new functionalities. The nature of change in ST-systems is evolutionary and path-dependent, while the dynamics of such systems are subject to risk and uncertainty, and thus inherently unpredictable. Geels and Schot (2007) have argued that transitions can only take place if a niche is sufficiently developed to take advantage of a window of opportunity. In the MLP niches represent alternative socio-technical configurations, which have not yet institutionalized but are potentially embryonic nuclei for the future. Other related types of niches can be found in the literature, ranging from backcasting niches (Quist et al., 2011) to technological niches (Hoogma, 2000), transition experiments (Van de Bosch, 2010) and market niches (Raven, 2005b).

Social-ecological transitions and management regimes

In addition to the sociotechnical perspective on transitions discussed in Section 3.2.1.1, there is a socio-ecological perspective on sustainability transitions (Loorbach et al., 2017; Smith and Stirling, 2010), which has similarities and differences with the ST-perspective, Similarities include that both perspectives conceptualize transitions as nonlinear disruptive systemic changes. The central notion in both perspectives is the concept of regime, which refers to a dominant and stable configuration in one of these systems (Loorbach et al., 2017). Like ST-systems, a socio-ecological system (SES) can be considered as complex adaptive systems, characterized by complex, dynamic, multiscale, nonlinear and adaptive properties posing common challenges to the regimes in governing transitions in these systems (Smith and Stirling, 2010). The concept of SES is used to emphasize interconnectedness of social and ecological systems through human and natural elements that are closely interacting and mutually constituting (Folke et al., 2005b), which is the case in water systems.

Similar to ST-regimes, water management regimes cover a wide range of interdependencies among actors and institutions, including the power relations and role constellations between different actors (Farla, 2012; Fuenfschilling and Truffer, 2016).

However, the ST and social-ecological perspectives conceptualize transitions in a different way, due to a different focus, unit of analysis, and system delineation. Social-ecological transitions relate to a large variety of human-ecosystem interactions that weaken or strengthen an ecosystem's resilience, which is its ability to withstand shocks, while maintaining its function, and transform, anticipating external pressures, shocks and threats (Berkes and Folke, 1998; Folke et al., 2004). The focus is on supporting resilience in existing system, or transform ecosystems into more desirable systems (Walker, 2004). Regimes dedicated to the management of SES are place-bound as they are embedded in a SES that provides the main unit of transition analysis, whereas ST-regimes operate simultaneously across clearly demarcated industrial sectors with multiple localities (Smith, 2010). Each management regime implicates different patchworks of SES through resource extraction, service consumption and waste assimilation.

Another difference entails the nature of the regime. Rather than using the term social-ecological regimes as proposed by Fischer-Kowalski (2007), we propose that the challenges of managing SES, for which technology can be used, can be associated with the notion of management regime. Management regimes provide stability of ecosystems by enhancing their capacity to deal with disturbances through transformation (Loorbach et al., 2017). To govern socio-ecological transitions, agency is needed just like in socio-technical transitions. A management regime can be seen as a conceptual configuration of social and ecological elements that condition human-ecosystem interactions, whereby ST-regimes can help to sustain SESs through technologies (Smith, 2010). After Smith (2010), we consider a management regime to encompass a patchwork of different ST-systems that evolve around a SES, which is typically rooted in a particular spatial context such as a watershed e.g., land-use management, waste management, resource management, and environmental management.

Water management regimes

Within the confines of water management, a management regime is embedded in a SES. Water management regimes have evolved around a particular SESs that provides essential ecosystem services (e.g. water). The emphasis in management regimes is on managing societal functions generally considered as public tasks. This focus is reflected in the definition of water management regime by Pahl-Wostl (2007c) (p. 8): "the whole complex of technologies, institutions, environmental factors, and paradigms that are highly interconnected and essential to the functioning of the management system that is targeted to fulfil a societal function such as water supply or flood protection". Paradigms refer to a set of guiding principles for water management (Pahl-Wostl et al., 2011).

Water management regimes are generally about balancing different and sometimes conflicting societal functions and interests, taking a public or governmental perspective. Water management regimes are not solely meant for delivering water-related products and providing functions to end-users. They are also about managing societal functions related to water that are relevant for several ST-regimes. Water management not only concerns flooding protection, but also transportation, water quality, production of drinking water, as well as water for industry and agriculture.

3.2.2 Visions in niches and transitions

Visions

Visions are considered important for transitions because they provide a common reference point for action and guide actors in their actions and behavior in reaching out to that point (Berkhout, 2006b; Loorbach, 2006b; Loorbach et al., 2017; Quist, 2007; Sondeijker et al., 2006). Various vision concepts can be found in the literature on innovation studies and transitions towards sustainability, while distinction is made between different levels like niches or projects (micro), networks and sector (meso) and society at large (macro) (Quist et al., 2011). Various authors (e.g., Smith et al. (2005) have emphasized the important role of guiding visions in transitions. In transition management, visions are referred to as: *"a framework for formulating short-term objectives and evaluating existing policy (…) these visions must be appealing and imaginative and be supported by a broad range of actors"* (Rotmans et al., 2001:23). Most vision concepts address emerging phenomena like the development and diffusion of new technologies, the rise of new scientific disciplines and transitions towards sustainability (Quist, 2007). Alternative visions like sustainability visions (Quist, 2007) or climate change adaptation futures (Van der Voorn, 2017; Van der Voorn et al., 2012b) are backed by alternative trend-breaking expectations about possibilities and may be based on different alternative worldviews.

Visions emerge in different contexts (e.g., organization, communities, research projects) and shapes, but show three common aspects (van der Helm, 2009): an image of the future, an ideal, and a desire for deliberate change. These aspects reflect the guiding potential of visions. Building on Grin (2000), Quist et al. (2001) and van der Helm (2009), we define a guiding vision as a shared multi-actor construction of a desirable future that may have the potential to guide actors in their actions and behavior to bring about that future, especially when generated in a participatory process. Visions can become more guiding once they are shared by a growing group of actors.

Agency

Agency is widely considered key to emerging visions and niches (Quist, 2007a). Emerging visions are connected to actors and networks that can either endorse or contest visions and when the vision changes the supporting network may change too (and vice versa). Actors can provide agency, influencing the speed and direction of transitions (Avelino and Wittmayer, 2016; Farla, 2012; Pesch, 2015). For agency in water management transitions we build on Smith et al (2005), who describe agency in transitions as the capabilities of actors to intervene and alter the balance of selection pressures bearing on a regime and their adaptive capacity.

Building on the guiding vision, which was originally proposed as the German Leitbild concept (Dierkes, 1992; Dierkes et al., 1996), Quist (2007a) has introduced the concept of a vision champion, which is a key individual or a group of key persons who are able to motivate and coordinate the collective pursuit of change. A vision champion can play a vital role in realizing major change like policy entrepreneurs who are individuals that instigate, implement and sometimes block transitions (Huitema and Meijerink, 2010; Huitema et al., 2011; Meijerink and Huitema, 2010), or system builder-entrepreneurs who lead and manage development and further growth of the large technical systems (Hughes, 1983). It should be noted that such key persons or key groups are often embedded in informal networks, typically governed by not yet institutionalized rules. Such networks are in the beginning informal and flexible in terms of membership, role, power of actors and connections, but their members can also be active in more formalized networks. Niches are created for setting up experiments and steering directions of experimenting, learning innovations and adaptation, which are mechanisms that underlie transitions (Loorbach, 2006b). These mechanisms relate experiments to other niches, either within or outside the domain or function of the experiment (Van de Bosch, 2010). Therefore, niches are closely connected to formal and informal networks, as they enable learning processes for (radical) innovations by providing access to new kinds of knowledge and supporting multiple ways of interpretations.

Emerging visions can be seen as seeds for change (co)shaped by a range of actors, that challenge rules that are deeply entrenched in existing structures and the actors supporting and protecting such structures (Grin, 2000). Visions are emerging phenomena, guiding activities and changes that eventually may alter the dominant regime (Quist, 2007). Emerging visions are usually rooted in entirely different beliefs, values and mental frameworks initially not shared by larger groups in society (Quist, 2007). Such visions are typically associated with outsiders, who are likely to conduct rule-breaking behavior (Ligtvoet et al., 2016; Van de Poel, 2000), because they pursue divergent and sometimes marginal perspectives (Cuppen et al., 2010). Learning is key to vision development and niche formation (Quist, 2007), but our focus is more on the interaction of visions and actors in niches and less on learning processes and knowledge.

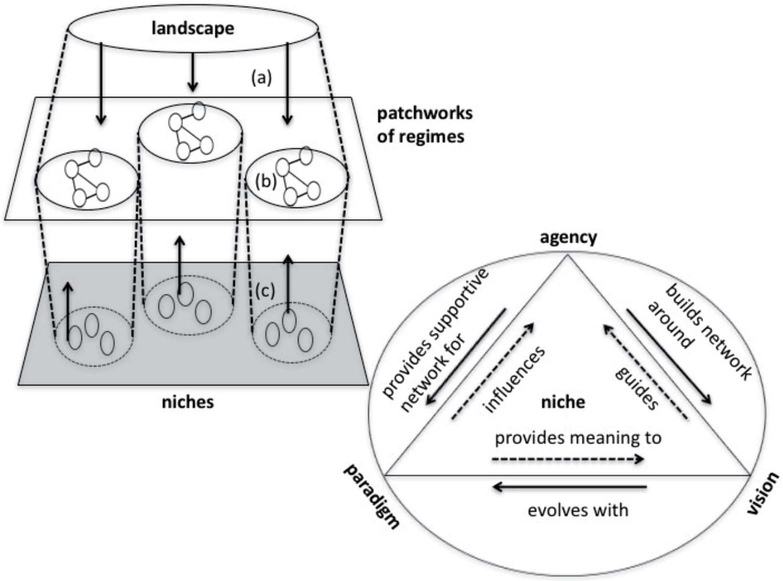

Figure 3.1 A graphical representation of mutual relationships between visions, guiding principles and actors in niche-driven change in water management regimes.

3.2.3 Framework and methodology

Conceptual framework

Building on the theoretical perspectives presented in the previous sections, we develop a conceptual framework for analyzing water management transitions. The framework builds on the MLP, as it provides a base for conceptualizing the interplay of niches, visions and agency. Following the MLP, Transitions are the outcomes of alignments and de-alignments between processes at the niche, regime and landscape level, which in turn enables the breakthrough of a niche. This requires the empowerment of the niche, in which visions and actors play a key role.

Our framework builds on the interplay of visions and actors to describe niche-driven change in water management regimes. The principal mechanism for such changes is triggered by alternative visions that emerge in niches, linked to supportive networks of actors, providing agency (see Figure 3.1). Actors develop niche visions, which introduce new guiding principles for water management that challenge the established rules e.g. the dominant guiding principles for water management. Actors need to support the niche visions, which evolve together with the development and testing of novelties in the niche through niche experiments. The niche vision that becomes shared and adopted by actors further guides the development of a niche and the actions of actors in the network to further empower the niche to challenge existing rules of the regime. The replacement of rules leads to a transition.

Table 3.1 Evaluation criteria of niche-driven innovations

Dimension	Variable	Criteria
Landscape	Landscape factors (Geels, 2002, 2004)	What were important gradual and disruptive developments?
Regime	Societal functions (Holtz et al., 2008; van der Brugge, 2005) Guiding principle(s) for water management	What were the societal functions? What were the dominant guiding principle(s) for water management?
Niche	Niche vision (van der Helm, 2009) Guiding principle(s) for water management Agency (Quist, 2007)	What was the desired change? What were the new guiding principle(s)? Who provided agency?

Based on the theoretical concepts discussed in Section 3.2.1, Table 3.1 shows the variables and evaluation criteria for each of the dimensions of our framework.

Research methodology

A qualitative historical single-case study allows for learning from historical transitions, by studying processes and tracing specific causal-event chains within their own context (Mahoney, 2003a). Transitions are complex processes of multiple conjunctures of causal conditions in time and space, yielding a given outcome. Even though causality may exist, it remains quite difficult to clearly indicate the cause producing the outcome of interest (Mahoney, 2003a; Ragin, 1989). The relevance of the Lower Mississippi River lies in its rich history of major flood disasters and damages in conjunction with a wide array of enactments by US Congress and policy developments and the wide availability of secondary historical sources that report on these events (Van der Voorn, 2012).

We here use causal narratives that explain certain outcomes of sequences of historical events, which are tied together by a central theme. Causal narratives help us to trace unfolding processes and study event sequences, timing, and conjunctures (Pedriana, 2005a). Our interest lies in the interplay of factors and influences across the landscape, regime and niche level. Each narrative captures complex interactions between agency and visions (niche level) and changing contexts (landscape and regime level), time, event sequences, making moves in games, and changing identities. However, causal narratives need to be guided by 'heuristic devices' that specify a certain plot (Geels, 2011). The principal mechanism for niche-driven regime change will be used as a central plot for our narratives.

Data sources

Secondary historical sources such as scholarly books and papers are used to draw the overall picture and patterns over a much longer period of time. Geels (2011) emphasizes the exploratory and illustrative character of transition studies. In transition research, it is common practice to use secondary sources and to use a framework as a lens to look at these sources in a transparent and systematic way see e.g., (Geels and Raven, 2006; Geels, 2002; Geels, 2005a; Verbong, 2007).

We applied data triangulation to construct our narratives with a beginning, middle and an end, focusing on historical events as well as on underlying factors see e.g., (Jepsen et al., 2015). Triangulation involved the comparison of various historical accounts i.e., (Barry, 1998; Lonnquest et al., 2014; Sabatier, 2005; Wright, 2000b) to determine the appropriate time span for each narrative. Our inquiry and data triangulation is based on multiple interpretations extracted from secondary sources. We will evaluate and compare the narratives in terms of the criteria presented in Table 3.1 to identify recurring patterns.

3.3 RESULTS: A CASE STUDY ON THE LOWER MISSISSIPPI RIVER

3.3.1 Historical context

Floods were part of the earliest recorded history of the Mississippi River. Since its foundation in 1718, New Orleans has been the epic center of floods, resulting from both hurricanes and extreme run-offs of the Mississippi River. About eleven flood events occurred on the Mississippi between 1849 and 2001, with catastrophic floods in 1927, 1936, 1973 and 1993 labelled significant enough to merit regional or national attention. From the settlements in the State of Louisiana in the early 1700's until the early 20th century, the principal and often only approach to flood damage reduction was the construction of levees. These flood disasters and the associated policy responses have played an important role in the evolution of US watershed management. Watershed management is a management planning process that seeks to balance healthy ecological, economic, cultural, and social conditions within a watershed, whereas water resources management includes the management related only to water resources (Wang et al., 2016).

Following Sabatier (2005), our historical inquiry covers five consecutive transition periods, which cover the key eras of water(shed) management in the US: the Manifest Destiny Era (early 1800s- 1890), the Progressive Conservation Era (1890-1928), the Federalism and New Deal Era (1929-1967), the Environmental & Flood Insurance Era (1968-1994) and the Watershed Collaborative Era (1995-present). Results for each period are summarized in Table 3.2.

3.3.2 The Manifest Destiny Era (early 1800s – 1890)

Landscape developments

The Manifest Destiny is a term for the period of American expansion where the US was destined to stretch from coast to coast in the 19th century. In this period, land was heavily exploited, especially in the West of the US. Due to disruptive events like the large floods of 1849 and 1850 in the Lower Mississippi Valley, US Congress enacted the Swamp Land Acts of 1849 and 1850. This gave rise to a gradual development of millions of acres for agricultural use, ultimately exacerbating the flood problem (Klein and Zellmer, 2007).

The existing regime

Although watershed management was essentially absent in the Manifest Destiny Era, rivers and lakes were envisioned as a source for fueling economic development (Sabatier, 2005). Property usable to waterpower was seized by private concerns. Mining companies practiced improper and wasteful mining practices. The overall societal function of water management comprised mainly the functions drinking water supply, waste disposal, hydropower, generally generated by dynamo water turbines, and navigation. In this single purpose era, these functions were not interconnected and managed separately. Without any attempts to reconcile or combine functions, water quality and habitat protection were on virtually no one's radar screen (Sabatier, 2005). This principle was institutionalized in the engineering work of the US Army Corps of Engineers (hereafter referred to as the Corps), as the principal federal authority in water affairs. The aim of water management was to tame the river for navigational purposes and commercial interests, by controlling, diverting, and damming it. The dominant guiding principle for water management was a single-purpose approach of navigational enhancement of the Mississippi River, by removing obstructions from the channels of the river (boulders and snags).

Niche developments

In this period, there were three niche visions on flood control: (i) building reservoirs, (ii) levees, and (iii) jetties for flood control. The key person for the first vision was Charles S. Ellet Jr., one of the best-known engineers of his time, who associated the growing flood problem with increased cultivation in the valley (Reuss, 1985). Ellet recommended the practicability and value of building reservoirs on the Mississippi's tributaries to reduce flooding. His vision and ideas were considered controversial and impracticable and were never adopted (Lonnquest et al., 2014).

The second vision gained more support and was based on the most extensive study on the Lower Mississippi River ever undertaken at that time, by Andrew A. Humphreys and Henry L. Abbot, two officers from the Army Corps of Topographic Engineers. Their study addressed the environmental impact of over-exploitation of swamp and overflow land. Their pioneering work challenged existing hydraulic theories and introduced a new universal formula and a method to explain river flow. It provided the scientific base foundation for their vision that proposed a desired change towards levee-based flood control, targeting at realizing levee construction along the Mississippi River (Reuss, 1985). Humphreys assumed that levees would not prevent the water from rising but, if sufficiently high, levees would prevent flooding.

Based on his new method for measuring and computing the river's discharge and flow, Humphreys proposed the new "levee-only" vision for flood control along the lower Mississippi. The novel vision was believed to achieve cost efficiency in flood control engineering. The novelty lies in the new guiding principle assuming that levees only could control flooding along the lower Mississippi River without costly reservoirs and river cut-offs (Reuss, 1985). When Humphreys became Chief of Engineers of the Corps in 1866, he played an important role in building a network and restructuring the Corps and its river engineering practices around the "levee-only" vision. Favorable factors for building support for his vision were: (i) private engineers and congressmen questioned the Corps' capabilities; (ii) the growth of professional engineering societies; (iii) increased demand of US Congress for public works projects.

The third vision was supported by the famous civil engineer James Buchanan Eads, who argued that levees would actually lower the bed of the river, as they would allow floodwater to scour a deeper channel. Eads envisioned that closing all gaps in the levees and then imposing a uniform width on the river by narrowing wide places through jetties would eventually secure a sufficient depth for navigation to yield levees unnecessary. Eads's successful accomplishments with jetties at the South Pass Channel triggered influential developments, which crumbled the Corps' responsibilities and reputation in river engineering. US Congress deprived the Corps from its right to conduct scientific expeditions in the West, after which it weakened the Corps' authority on the Mississippi River by establishing the Mississippi River Commission. The success of the jetties showed the Corp's incompetence in river engineering because its river engineering approach was based on the false assumption - that levees alone could adequately confine the Mississippi River (Reuss, 1985). This encouraged private civil engineers to break the Corp's monopoly on federal public works projects.

There was a fierce clash between the advocates of the second and third vision, which represented two river engineering schools. Due to commercial interests in navigation, the course of the dispute seemed to be determined in favor of the third vision supported by Eads. Ironically, despite Eads's successful accomplishments with jetties, the "levee-only" approach advocated by Humphreys became and remained the dominant guiding principle until the Great Flood of 1927 because many Corps officers supported this approach.

3.3.3 The Progressive Conservation Era (1890-1929)

Landscape developments

During the Progressive Conservation Era, the over-exploitation of natural resources for private gain was a key factor for change. Being a disruptive event, the Great Flood of 1927 unmistakably revealed the shortcomings of the prevailing 'levee-only' guiding principle, which shifted public opinion towards liability of federal government for flood damage (Barry, 1998; Klein and Zellmer, 2007). The flood caused over $200 million in property damage (about $2 billion in 2000 US dollars) (Barry, 1998). The public's gradually growing critical awareness of natural resources and environmental developments like the over-exploitation of natural resources for private gain, contributed to the growth of the Progressive conservation movement (McCool, 2005). The Progressive Conservation movement was a coalition of reformers who believed in mankind's ability to improve the environment and conditions of life, an obligation to intervene in economic and social affairs.

The existing regime

The overall societal function of water management comprised the functions described in Section 3.3.2.2. In this period, the set of functions expanded with flood control that was driven by the dominant guiding principle of "levee only" based flood control. Due to the rise of the Progressive Conservation movement, there was a tendency to strike a balance between economic and environmental objectives (Sabatier, 2005). In contrast to the federal level, the state and local levels were considered the appropriate levels at which water issues were tackled (Klein and Zellmer, 2007). Emphasis was put on the ability of experts and in the efficiency of government intervention for federal supervision of the nation's waterways and their preservation of those resources for future generations.

Niche developments

In this period, there was only one niche vision on federal government involvement in water affairs. The vision was strongly supported by Hoover, at that time the US Secretary of Commerce. The vision proposed a desired change towards treating each river as an integrated unit from source to mouth (Wright, 2000), targeting at realizing multi-purpose water program. As a summer student-assistant, Hoover had become a strong supporter of the underlying philosophy of this vision by Stanford geography professor John Wesley Powell, who appealed in his innovative 1878 Report on the Lands of the Arid Region of the US for planned development of water and land resources in the country. He had been the first who defined a watershed as an area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community (Powell, 1878). By the time Powell made his famous plea in 1890 for making local government boundaries coincide with hydrographical units, the jurisdictional decisions had long been made and he was ignored (Sabatier, 2005).

Inspired by the vision of Powell, Hoover supported a new vision for multi-purpose water resources management, which was based on the novel assumption that rivers were to be managed as bounded hydrological systems. The vision included a novel guiding principle of multi-purpose water resources management, prescribing that rivers need to be developed and managed in a systematic and consistent way, with the aim to reconcile navigation, flood control, irrigation, and hydropower. Under his presidential leadership, Hoover played a vital role in a series of political compromises that resulted in the adoption of the 1928 Flood Control Act (Barry, 1998). This happened rather quickly, as the 1927 flood disaster helped him to mobilize support for the new vision and also to become elected president (Klein and Zellmer, 2007).

3.3.4 Federalism and New Deal Era (1929-1967)

Landscape developments

The post-1928 flood control acts triggered macro-political developments that fragmented the governance landscape. These gradual developments drove public opinion in favour of strong state-based federalism, although states led in canal-building and flood control, with water issues resolved primarily at state and local levels (Klein and Zellmer, 2007). However, the 1928 Flood Control Act made the federal government responsible for the Mississippi River, but also immunized this government from any liability of any kind and for any damage from or by floods or floodwaters at any place.

An important disruptive event was the 1929 Great Depression, which led to the 1932 presidential election of Franklin Roosevelt (Barry, 1998). The New Deal continued large public works projects to alleviate poverty and unemployment between 1933 and 1936. The New Deal focused on what was called the "Three Rs" related to Relief, Recovery, and Reform: Relief for the unemployed and poor, Recovery of the economy to normal levels; and Reform of the financial system to prevent a repeated depression (Potter, 1985). The New Deal is the hallmark of state-based federalism, in which new federal institutions were established to enable an integrated planning approach for regional economic development, land use development and water resources management.

The existing regime

The overall societal function of watershed management comprised the functions described in Section 3.3.3.2. In this period, the set of functions expanded with land use planning. Strong federal government was seen as a requirement for watershed management (Wright, 2000). The Tennessee Valley Authority (TVA) was the first federal authority to broadly apply alternative approaches to control flood damage, choosing to add land use planning methods to the popular structural measures already used to control the paths of floodwaters. The TVA was envisioned as a blueprint for the integration of land and water as well as land use planning methods and existing measures that were already used to control the paths of floodwaters.

Meanwhile, the Corps refused to join the movement toward watershed management, preferring to conduct river management in a piecemeal fashion for the benefit of many local interests (Klein and Zellmer, 2007). Nevertheless, federalism in water affairs, including the guiding principle, was supported by emerging technologies like concrete dam building design (e.g., the Hoover Dam and Norris Dam) that could enable multi-purpose watershed management. Multi-purpose watershed management was envisioned to strike a balance economic and environmental objectives (Sabatier, 2005). During the Roosevelt administration, more administrative layers were added to the complicated variety of authorities for the construction and maintenance of flood control devices, which deviated watershed management further from Hoover's ideal of comprehensive watershed planning (Barry, 1998). This ideal was reflected in the dominant guiding principle that rivers are to be treated as bounded hydrological systems and the watershed or river basin was considered the appropriate scope of management. Multi-purpose watershed required (i) government to be active and strong as markets could not be trusted to manage water resources; (ii) multipurpose and region-wide planning as exemplified by the TVA; (iii) intergovernmental coordination in flood control.

Niche developments

In this period, there was only one niche vision on more human adjustment to floods. The vision was strongly supported and further developed by a renowned geographer and an influential proponent of an integrated planning approach, Gilbert F. White (Platt, 1995). He concluded that many water problems like floods, were the inevitable result of past human modifications of natural conditions set by the dominant guiding principle. The novel vision articulated the desired change to adjust human occupancy to the floodplain environment for effective use of the natural resources of the floodplain. Multiple human adjustments to floods or non-conventional flood control engineering measures were envisioned to protect the occupants of floodplains against floods and to aid them when they suffer from flood losses, and of encouraging more intensive use of floodplains (White, 1945).

The new vision was inspired by White's work, which assumed that flood plains were key to flood control (White, 1945). This implied that the integration of land-use restrictions, and forecasting and warning systems had to be part of watershed management. The vision included a new guiding principle of multiple adjustments to floods, combining conventional measures (e.g., levees and dams) and non-conventional measures (e.g., floodplain abandonment and flood insurance). Due to growing concerns about increasing floodplain occupancy, White's ideas and work reached a broader audience that allowed him to play a key role in building a supporting network for the new vision and his studies. White's cost-benefit analysis received support from Harvard professor Arthur Maass, who criticized the role of the Corps in its rivers and harbor activities and introduced his theory on the economics of water resources planning (Wright, 2000). Support also came from two US Geological Survey hydrologists, who revealed the major ineffectiveness of the Corps' upstream and downstream flood control measures.

White's studies received criticism from the Corps because it revealed the shortcomings of the conventional flood control engineering approach (Wright, 2000). The opponents, generally from an engineering background, found White's ideas on human adjustments highly controversial, and argued he promoted un-American ideas. They were great proponents of engineering as a panacea for solving all flood management problems (MacDonald, 2012). However, White's 1958 study Regulating Flood Plain Management and increasing loss of property and cost of flood damage, changed the course of the debate in White's favor. The new vision received federal support from the Council of State Governments and US Congress, as both were convinced that White's vision and guiding principle offered a real alternative to existing flood control practices. This led to the expansion of the Corps' role in broader flood control approaches in line with the new guiding principles. Endorsement of the recommendations of White's (1964) study Choice of Adjustments to Floods by US Congress led to enactment of land-use regulations for floodplains and flood hazard evaluation guidelines for federal executive agencies (Wright, 2000).

3.3.5 The Environmental and National Flood Insurance Era (1968-1994)

Landscape developments

Already five years after the enactment of the NFIP, White's admonition was validated. Flood losses were continuing to increase due to accelerated macroeconomic developments like floodplain development (Wright, 2000). The 1968 National Flood Insurance Act led to floodplain abandonment, but also triggered the perverse effect of stimulating the development of vulnerable areas and exacerbating the flood damages.

Both federal flood control construction and the availability of federally insured loans and grants for land acquisition and building were at fault. The disruptive event of the 1993 flood revealed that the federal government's emphasis on flood insurance and local floodplain management was insufficient.

The existing regime

White's plea for a national flood insurance program (NFIP) to involve federal, state and local governments and the private sector in recovering flood losses, led to the adoption of the 1968 National Flood Insurance Act. The adoption of the National Environmental Policy Act and the creation of the US Environmental Protection Agency (EPA) embodied the limitations of human occupancy in floodplains.

The overall societal function of water management comprised the functions described in Section 3.3.4.2. In this period, the set of functions was extended to floodplain- based flood control, which included arrangements imposed by a governing body (local, regional, or national) to restrict the use of floodplains, or flexible human adjustments to flood risk that do not involve substantial investment in flood-control engineering works (Tobin, 1997). The dominant guiding principle for water management was multiple adjustments to floods, combining conventional measures and non-conventional measures.

Niche developments

In this period, there were two niche visions: (i) floodplain conservation and (ii) integrated floodplain management. The first vision emerged in the aftermath of the 1993 flood, when Congress adjusted the NFIP and authorized buy-outs for some structures and cropland in the floodplain. Congress also appointed the Special Inter-Agency Floodplain Management Review Commission to assess existing flood control programs and make recommendations for radical change. The Commission, chaired by the former Corps Brigadier General Gerald Galloway, envisioned a more balanced approach to federal floodplain management, using both conventional (levees) and non-conventional flood-control engineering measures (wetland restoration for reduced peak flood flows). This vision differed from the dominant vision of multiple adjustments to floods, as it emphasized that more of the floodplain should be reserved for wetlands, forests and agriculture. However, the Commission failed to recognize a major role for wetlands in providing flood protection (Klein and Zellmer, 2007). Ironically, supported by new federal legislation, some communities successfully experimented with retreating from flood-prone areas rather than resorting to yet more mainstream flood control engineering (Klein and Zellmer, 2007). They learnt the hard lesson of the 1993 flood and realized that some floodplains are best left in their natural conditions (Wright, 2000).

A second niche vision on integrated natural resource management in floodplains and wetlands emerged, while the lesson on ecological restoration of floodplains at the grassroots level appeared on the radar screen of the Federal Interagency Floodplain Management Taskforce. The Taskforce's Chair, Frank Thomas, was inspired by Jon Kusler of the University of Wisconsin, who supported the new vision (Wright, 2000). This vision challenged the dominant guiding principle. It emphasized the need for environmental legislation, by targeting on addressing multiple measures or problems at a time, establishing interagency coordination, preventing endless litigation, and neglect social and economic impacts (Sabatier, 2005).

The new vision was based on the assumption that functions and resources of wetlands and floodplains need to be restored in order to reduce flood losses and environmental harm. New environmental protection goals were set for federal, state and local government agencies and interest groups and new targets were set for collaborative and integrated watershed management. The new guiding principles for watershed management included: (i) strengthening state, federal and local wetlands programs by facilitating and improving cooperation among these governmental entities; (ii) integrating public, private and academic efforts to achieve wetland protection and management goals; and (iii) identifying and quantifying the beneficial ecosystem functions of wetlands in order to improve their management and restoration.

Based on Kusler's effort to coordinate floodplain management and measures, the new vision rapidly acquired national attention and support to bring about changes in line with the vision. During the 1980s, Kusler played a key role in establishing a supportive network of representatives of the EPA's Office of Wetland Protection for the vision and to promote his work on integrating floodplain and wetland management approaches (Wright, 2000). The vision was endorsed by the Corps and other federal agencies because they had to step up to their environmental commitment. These agencies internalized an ethic dedicated to environmentally friendly water resources projects. In line with the new vision, US Congress further refined and expanded the Corps' environmental reach by authorizing it to protect, restore and create aquatic and ecologically related habitat, including wetlands.

3.3.6 The Watershed Collaborative Era (1995-present)

Landscape developments

In New Orleans and along the Gulf Coast, a convergence of natural and human forces set the stage for predictable and predicted environmental developments such as flood catastrophes. Once again, levees proved to be insufficient to secure settlement in the floodplain, which gave rise to a gradual development like increased vulnerability to flood disasters. The Mississippi River floods in the Midwestern states led to a flurry of rebuilding within the floodplain in the 1950s and 1990s, so did the Hurricane Betsy encouraged levees support floodplain development. In 2005, Hurricane Katrina revealed many of the challenges faced by planners and managers who attempt to understand and manage flood disasters (Gunderson, 2010). Being a disruptive event, Hurricane Katrina also demonstrated that a loss of coastal wetlands in Louisiana increased the vulnerability of the area to hurricane impacts (Day, 2007).

The existing regime

The overall societal function of watershed management comprised the functions described in Section 3.3.5.2. In this period, the set of sub functions was extended to wetland-based flood control (Sabatier, 2005) (see Table 3.2). The dominant guiding principle was to achieve increased collaboration between federal, state and local government agencies for environmentally sound collaborative watershed management (Section 3.3.5.3). Even stakeholders were considered to hold valuable local knowledge and expertise to participate in collaborative negotiations with their counterparts.

Niche developments

In the aftermath of Katrina, the Louisiana Coastal Protection and Restoration Authority was created. This post-hurricane development was based on the recognition that wetland ecosystems, whether forested or not, are critical buffers for mitigating the impacts of hurricanes in coastal areas (Gunderson, 2010). Although US Congress gave the Corps a specific ecosystem restoration mission in the 1990s, ecosystem restoration further complicates the problems water resource planners face (Gunderson, 2010; Reuss, 2005). A panel on adaptive management for resource stewardship served as a committee to assess the Corp's methods of analysis and peer review for water resources project planning (Council, 2004). Restoration requires an understanding of wetland ecosystems. Our understanding of these systems is limited because of their complex nature and behavior emblematic for complex adaptive systems (Section 3.2.1.2), which poses uncertainties for management (Wallis and Ison, 2011).

In the last two decades, water planners in the United States and around the world are attempting to develop "comprehensive" water management plans (Ballweber, 2006; Gleick, 2000). These niche developments are based on a vision for comprehensive water management reflecting the guiding principles for integrated water resources management (IWRM) (Kauffman, 2015; Reuss, 2005). However, the implementation of an IWRM approach that fully accounts for the complexity of ecosystems in watersheds has yet to be realized. New management approaches such as adaptive water management have been proposed as a promising way to deal with complexity and the related uncertainties (Godden et al., 2011; Jacobson, 2009; Pahl-Wostl et al., 2007b).

Table 3.2 Summary table of transition periods

Criteria	Transition period				
	Manifest Destiny Era (early 1800s-1890)	Progressive Conservation Era (1890-1928)	Federalism and New Deal Era (1929-1967)	Env. & Flood Ins. Era (1968-1994)	Watershed Collaborative Era (1995-present)
Dimension 1: Landscape factors					
Gradual developments	Increased land-use for agriculture	Increased environmental awareness	Strong state-based federalism	Increased floodplain occupancy	Increased vulnerability to flood disasters
Disruptive events	The 1849 & 1850 floods/ The 1849 & 1850 Swamp Land Acts	The 1927 flood disaster	The Great Depression	The 1993 flood disaster / NFIP	The 2005 flood disaster
Dimension 2: Regime					
Societal functions	Drinking water supply, waste disposal, hydropower, navigation	Drinking water supply, waste disposal, hydropower, navigation, flood control	Drinking water supply, waste disposal, hydropower, navigation, flood control, land use planning,	Drinking water supply, waste disposal, hydropower, navigation, flood control, land use planning, flood plain based flood control	Drinking water supply, waste disposal, hydropower, navigation, flood control land use planning, flood plain based flood control, wetland based flood control.
Dominant guiding principle	Single-purpose approach for navigational enhancement	Single-purpose; Levee based Flood control	Multi-purpose watershed management (systematic management of rivers)	Multi-purpose watershed management; Flood control engineering & multiple adjustments, flood insurance	Multi-purpose & collaborative watershed management based on IWRM principles
Dimension 3: Niche					
Niche visions	Reservoirs for flood control (Ellet) Levees for flood control (Humphreys) Jetties for flood control (Eads)	land use planning for comprehensive watershed management (Hoover)	Human adjustments to floods (White)	Floodplain restoration (Galloway) Wetland & floodplain restoration (Kusler)	Adaptive water management and disaster resilience

There are reports on relevant niche developments in the New Orleans region. Van der Voorn et al (2017), for instance, reported on a niche development around a vision on adaptive and integrated water management. This example coincides with other on-going regional niche developments, driven by visions that promote integrated approaches for coastal restoration, wetland protection, and flood protection, which articulate a change towards increased disaster resilience realized through adaptation to climate change impacts. These niche developments promote a novel guiding principle, based on a learning-based approach as the key guiding principle for the fulfil-

Table 3.3 Summary table of niche visions that became part of the regime

Criteria	Manifest Destiny Era (early 1800s-1890)	Progressive Conservation Era (1890-1928)	Federalism and New Deal Era (1929-1967)	Env. & Flood Ins. Era (1968-1994)	Watershed Collaborative Era (1995-present)
Niche vision					
Desired change	Secure navigation through cost efficient 'levee-only' flood control approach	Watershed as appropriate scale of management	Multiple adjustments to flood disasters	Integration of natural resources in floodplain & wetland management	Increased disaster resilience
Guiding principle					
New guiding principle(s)	Flood control through levees	Multi-purpose water management (systematic management of rivers)	Flood control engineering & multiple adjustments, flood insurance	Collaborative watershed management for integrated management	Learning based management approach
Actors					
Vision champion	A.A. Humphreys/	H. Hoover	G.F. White	J. Kusler	Not yet evident

ment of new goals like dealing with the assumed complexities and uncertainties due to climate change.

More research is yet needed on the potential of these strategies and approaches to help addressing the types of changes and challenges. Several avenues for further research can be found in the literature. For example, Kashem et al. (2016) evaluated the changing patterns of social vulnerability in New Orleans and integrated neighborhood change theories with theories of social vulnerability. Govind (2016) reported on the lesson from Katrina with managing SES in an uncertain future affected by climate change. It provides further insights as to the complementary nature of climate policy and resilience while galvanizing New Orleans against future extreme events. Abadie (2018) reported on an application of probabilistic weighting of IPCC scenarios to reduce sea level damage risk for New Orleans.

3.4 DISCUSSION

3.4.1 Key findings and patterns

In the introduction of the paper, four transition periods were introduced which are confirmed by our historical inquiry. Another transition period (early 1800 – 1890s) was identified, which can be seen as the initial phase of the single purpose era as watershed management was essentially absent.

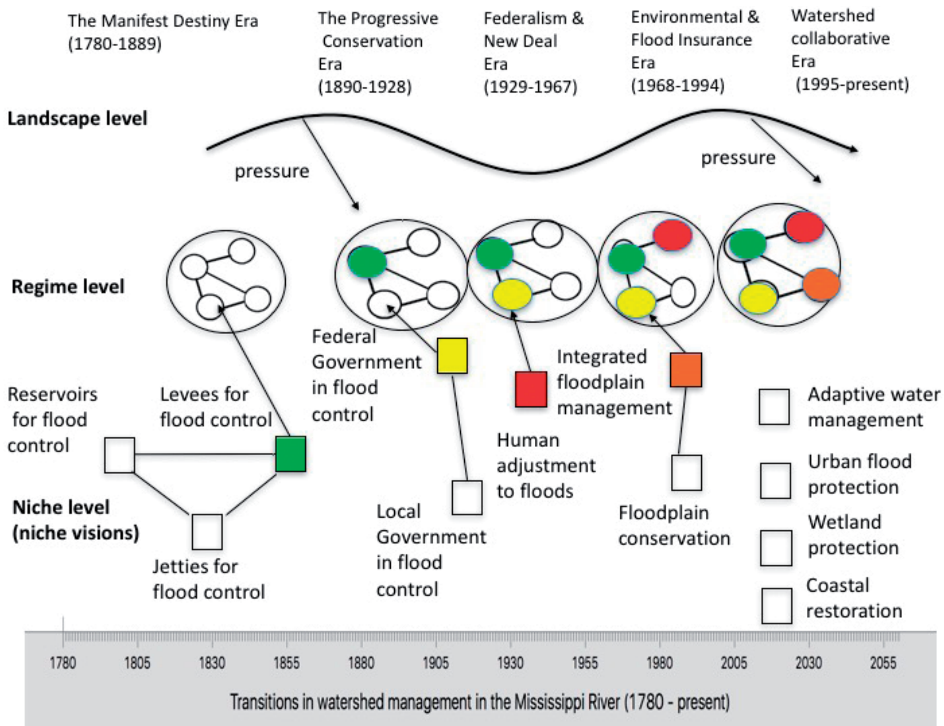

Figure 3.2 A chronological overview of transitions in watershed management in the Mississippi River.

The inquiry shows that in the lower Mississippi five different periods can be identified in watershed management, which can be characterized by different guiding principles and societal functions. Results are summarized in Figure 3.2, Table 3.2 and Table 3.3.

Firstly, a key finding from the case study is that a cumulative pattern can be observed in which the number of societal functions increased with every transition, which led to a more extensive and complex water management regime after every transition. Whereas in the first era four functions were pursued, in the fifth era this had grown to nine functions. The water management regimes in the first two eras were single-purpose, succeeded by several multi-purpose water management regimes. Since the fifth era, the water management regime has become more integrated to strike a balance between economic and environmental objectives. At present, a transition is unfolding towards more adaptive water management regimes to better account for the complexity of SES and the related uncertainties in water management in the face of climate change. This may point to a difference to socio-technical transition research e.g. (Geels, 2002; Geels, 2005b), in which the focus is on emerging technologies that provide new functions (e.g. smart phones) or provide an existing function in a more efficient or sophisticated way. By contrast, water management transitions are not driven by technological improvement, but rather mission driven. Since the 20th century, water management regimes have not only become more extensive, but also more integrated enabling managing and combining multiple and potentially conflicting societal functions. Possibly due to its public or government nature, there is also a larger discussion at play on which (public) tasks should be provided and the opportunities of new technologies is only one of the factors in a broader societal debate and political decision making see e.g., (Bos et al., 2015; de Haan et al., 2015; Rogers et al., 2015).

Secondly, external factors like landscape factors have also a major influence on the rise of a new niche vision, as they emerged as environmental, economic, social and political pressures on the regime and created windows of opportunity for change. A similar pattern can be found in historical transitions in European land management see e.g., (Jepsen et al., 2015). With regard to landscape factors, a distinction can be made between disruptive events and gradual developments. Disruptive events like flood disasters have been one of the major drivers for change. Flood disasters created windows of opportunities for new institutional developments (e.g., the development and enactment of Flood Acts), because these disasters revealed the shortcomings of dominant water management practices and the necessity for new water management solutions see e.g., (Wiering, 2006; Xia and Pahl-Wostl, 2012). Gradual developments that triggered change were technological, scientific, economic and societal developments. For instance, the shift to levee-based flood control was based on new hydrological theories on river flows. The Great Depression and the subsequent New Deal program favored a shift to multi-purpose water resources management, which was possible through technological developments, such as concrete dam building design, and the willingness to invest in public infrastructures to mitigate the socio-economic decline due to the great depression. An example of a societal factor, is the regime response to increased environmental awareness that provoked a shift towards more environmentally sound water resources management. However, there is no single factor decisive in niche-driven change, but it is rather the interplay of various factors triggering change (Geels and Kemp, 2007; Geels and Schot, 2007).

Thirdly, niches and niche visions seem to play an important role in revealing the shortcomings of the prevailing guiding principle for water management. For transitions to occur, emerging visions need to trigger disruptive changes in the dominant guiding principle for water management and the development and testing of a credible, alternative guiding principle to replace the old one, both of which have been the case in all transition periods. It is unlikely that incremental changes lead to a transition, but rather to a refinement of current practices see e.g. (Pahl-Wostl, 2011).

Fourthly, if there were several niche visions present, only one vision led to a transition. No evidence for hybridization or integration of multiple niche visions was found, though there was clearly a struggle between competing visions and their supporting networks. This may suggest that the niche visions provided competing solutions that are complementary to the regime. The analysis does not give evidence whether it was especially due to the content of the vision, or due to agency, or both. In the first era, there was a scientific base for the emerging vision, whereas the niche vision in the second era was backed by emerging technologies for water engineering. During the third era, there were no competing niche dynamics, but the vision offered a real alternative to existing flood control practices. In the fourth transition period, increased environmental awareness, which is a landscape factor, enabled the uptake of the vision. This may suggest that new developments were not decisive for the uptake of vision but rather new knowledge developments from which new guiding principles for water management emerged. These principles led to new societal functions or refurbishment of existing ones.

Moreover, all visions provided guidance and image, but the level of guidance was determined in the way agency was provided by actors. The case shows that agency is key to the further diffusion of visions and niches. The case also shows that each niche vision can be related to key actors that can be seen as vision champions, who showed rule-breaking behavior and leadership that inspired and mobilized others. Vision champions can provide agency and were found both outside and inside the watershed management regime. For instance, both White and Kusler acted initially from outside the regime (i.e. research niche), in which they were able to develop, freely express and further mature the novel vision. For instance, both Humphreys and Hoover first became leading in the water management regime from which they facilitated change as well as the diffusion of a new vision. The concept of vision champion has been useful for our analysis. The presence of a vision champion does not necessarily guarantee a successful adoption of an emerging vision. The case shows that some vision champions were more successful than their counterparts because they were successfully mobilizing and creating networks leading to agency. Therefore, vision champions should be seen as embedded in larger networks, in which the type of membership, role, connections and power of actors may influence successful adoption of a vision see e.g., (Huitema and Meijerink, 2010; Huitema et al., 2011).

3.4.2 Limitations of the study

Overall, the relevance of our findings may be constrained by some limitations. Our causal narratives draw on secondary sources, which are second hand interpretations of the events under study. These sources are one or more steps removed from these events and may be biased. The use of secondary sources in the study of historical transitions has been criticized (Ertsen, 2014; Genus and Coles, 2008), but we argue that it is still useful and allows for conclusions, though it should be noted that more detailed research into each transition using primary resources would be recommended for substantiating and validating our findings. This may lead to refining the starting and ending points of our transition periods, in which we described the landscape and regime factors that resulted in nonlinear changes in the water management regime. As causal narratives are by definition limited and narrowly defined, we are aware that other landscape and regime factors (e.g., indigenous knowledge or uses of rivers or the American history of slavery) may have intersected with emerging and ways of thinking in water management.

From a methodological perspective, one could question the relevance of our findings to current transitions towards adaptive water management. Extrapolation of historical transitions into the future suggests that the future is a continuation of the past. Transitions are, in fact, heterogeneous, long-term effects of socio-technical and socio-ecological change and contingent on factors such as time scale, place, and social, environmental political and economic context. Extrapolation may simplify history to a linear, causal process, which project a narrowed view on the complex and dynamic nature of water management regimes that is driven by innovation to continue its existence. This complex reductionist view neglects the role of human agency that manifests itself around short-term socio-environmental dynamics as agents, visions and niches continuously interact in transitions. We therefore reject the idea of linear history but rather argue for adequate historical analysis, which describes the past not just as it was meant to be logic based on ex-post insights see e.g., Ertsen (2014). Our framework can be used as a heuristic device or the basis for analyzing niche-driven change in water management regimes and identifying recurrent patterns in water management transitions.

Another limitation is our focus on the interaction of visions and actors in niches and less on learning processes and knowledge development, which are key to vision development and niche formation. An evaluation of learning processes could provide other explanations on why some emerging visions were more promising than others and why some actors were more successful in building a supporting network for the vision. We argue that these aspects need to be investigated in light of landscape and regime factors. In doing so, we acknowledge the potential relevance of other explanations, theories of change and realities of the complex and diverse lived experience. Molle (2009), for example, described the evolution of the concept of river basin and how it has been associated with various strands of thinking and sometimes co-opted or mobilized social groups or organizations to strengthen the legitimacy of their agendas. This study provides an alternative explanation on how interconnected and nested waterscapes have been managed by discontinuous nested political, administrative and social levels in the US and western Europe. The relevance of this study lies in its focus on realignments of power structures between the local, regional and national levels, which have not been included in our study. We argue that power structures could enrich our historical analysis, providing further insight into the way actors provided agency e.g., what strategies did actors adopt to shape transitions, what resources did they mobilize and deploy in realizing these strategies, the role actors played in transitions and how they aligned their strategies and resources to achieve common goals. Furthermore, a complementary view on power structures is provided by Swyngedouw (2009), who confirmed multidimensional relationships between the socio-technical organization of the hydro-social cycle, the associated power geometries that regulate access to and exclusion from water, as well as the uneven political power relations that affect the flows of water.

3.5 CONCLUSIONS AND RECOMMENDATIONS

In this paper, we have developed a conceptual framework for studying the interplay of visions and actors in niche-based change in water management regimes. The framework also emphasizes the importance of agency not only in advocating and developing emerging visions and niches, but also in keeping the status quo. Vision champions and niche networks are important in initiating changes that depart from an existing water management regime, which eventually may lead to its transition, as well as advocating and substantiating emerging visions. Vision champions can be found outside and inside the existing water management regime.

Overall, we conclude that water management regimes change over time through transitions. They are preceded by niche developments, in which new visions emerge and mature. The study shows that only one of these visions becomes successful in guiding transitions, in which there is no single factor or development decisive. A transition is rather the result of the interplay of a range of factors at the landscape, regime and niche level. From our historical inquiry, we conclude the following: (i) emerging visions play an important role in guiding transitions; (ii) agency enables the further diffusion of visions and niches; (iii) vision champions play an important role in transitions, but are not decisive; (iv) each transition has led to an extension of the number of societal functions provided, which has led to more complex water management regimes in which functions are combined and integrated; and (v) external landscape factors are important, as they can lead to awareness and urgency in important decision making processes.

We consider our findings relevant to water management policy and transition studies. Our study provides a longitudinal study on water management transitions. It reveals the complexity of water management transitions, which are contingent on social, environmental, political and economic factors. It enables water managers and policy makers to critically reflect upon the viability of past and current water management practices in light of vision development and experiments for adaptive water management in niches to acquire knowledge and experiences about new management practices and schemes for adaptive water management. Such niche developments need to be facilitated by water managers and policy makers to enable knowledge development and learning processes for crafting transition pathways to adaptive water management. From a research perspective, our study has relevance to transition studies, as it contributes to a better understanding of the role of visions, actors and niches in water management transitions, which have been hitherto undertheorized in the transition literature. It demonstrates that water management transitions are unidirectional developments, but rather path-dependent processes that may be affected by various drivers, including sudden events e.g. (Jepsen et al., 2015).

Regarding research recommendations, we identify the following future research avenues for transition research. Although our contribution is on the overall picture and patterns over a much longer period of time based on secondary sources, we would recommend follow-up research into primary sources for specific transitions that could shed more light on how networks emerged and the role of key persons, who can become key just because they are within a network of other actors and persons contributing in their way to the further development of the network.

In-depth research on specific transitions in the Lower Mississippi River is needed to substantiate and validate landscape and regime factors, as well as the starting and ending points of transition periods. Using primary sources can lead to more insight into other landscape and regime factors and their intersections that have been overlooked in this study. We recommend extending the research focus on evaluating learning processes and knowledge development in historical transitions and validating findings against alternative explanations and theories of change. Finally, since transitions are contingent on many factors, whether or not a transition has taken place is not a transparent matter. Neither are transitions comparable. A comparative, longitudinal analysis of other transitions cases is recommended to identify general patterns and context specific factors within different institutional contexts. A longitudinal research design is inevitable if one wants to identify whether a transition process took or is taking place, but also under which circumstances this happens. Longitudinal case studies have become a standard approach to the study of socio-technical transitions, where variables change qualitatively as well as quantitatively and where the aim is to trace processes of transformation. This methodology allows contingencies to be set against more systemic forces, and bringing to the fore the concrete, context-dependent knowledge in, which different types of actors try to make sense of and participate in complex processes of change. Comprehensive transition analysis and country-comparative research on longitudinal case studies addressing multiple transitions in water management are yet limited, but warrants further investigation.

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CHAPTER 4

COMBINING BACKCASTING AND ADAPTIVE MANAGEMENT FOR CLIMATE ADAPTATION IN COASTAL REGIONS: A METHODOLOGY AND A SOUTH AFRICAN CASE STUDY

Developing adaptation strategies for deltaic and coastal regions is a major challenge, due to future uncertainties of climate change and complexity of the social-ecological systems to be managed. This paper investigates how desirable futures or normative scenarios approaches, in particular backcasting, can be used to develop more robust climate strategies in coastal regions. The paper develops a methodology in which participatory backcasting and Adaptive Management are combined, and its applicability is demonstrated for the Breede-Overberg coastal region in South Africa where a catchment management strategy has been developed. It is concluded that the methodology offers an adequate framework for developing and implementing long-term climate adaptation strategies and policies, including a transition management scheme for intermediate assessments.

Keywords: adaptation, scenarios, backcasting, visions, adaptive management;

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Van der Voorn, T., et al. (2012). "Combining backcasting and adaptive management for climate adaptation in coastal regions: A methodology and a South African case study." Journal of Futures **44**(4): 346-364.
DOI: https://doi.org/10.1016/j.futures.2011.11.003

4.1 FUTURE CHALLENGES OF CLIMATE ADAPTATION

Developing adaptation strategies for deltaic and coastal regions is a major challenge, calling for the development and use of sophisticated futures approaches. The impacts of global climate change will continue to manifest themselves locally, albeit at a varying rate and magnitude. The impacts of floods and droughts on social-ecological systems (SES) impose major challenges. In particular, flood prone deltaic and drought prone coastal regions with high concentrations of population and economic activity in major cities located in floodplains and along the coastline are seriously threatened (Adger, 2000; Adger et al., 2005b). Climate change adaptation and future planning have therefore become mandatory for environmental and climate policymakers (Alcamo and Henrichs, 2008). As a consequence, futures and scenario studies are increasingly used in long-term climate policy and decision making and related methodology development is increasing.

The term SES is used to emphasize interconnectedness of social and ecological systems through human and natural elements that are closely interacting and mutually constituting (Folke et al., 2005b), which is also strongly the case in today's rapidly changing and densely populated deltaic and coastal regions (Berkes and Folke, 1998). This integrated concept of humans in nature complicates assessing and predicting future exposure of societies to climate change (Berkes, 2003). Model-based climate impact assessment studies may improve our understanding of complex changes in SES that may be attributed to anthropogenically caused changes in the climate. Unfortunately, their explanatory capacity is rather limited for various reasons, as for instance argued by Berkhout et al. (2002). Firstly, they often generate simplified projections of future climate change. Aiming at complexity reduction, simulation models designed for forecasting future developments typically focus on a restricted subset of potential future conditions. This compromises the number of exposure units and climate change scenarios under study. Secondly, to make analyses of tractable impacts, these studies often envision SES to develop linearly over time (Harrison et al., 1995). SES, however, are self-organizing complex adaptive systems characterized by nonlinear dynamics, threshold effects, cascades and surprises (Folke et al., 2005b). This limits the ability to predict future key drivers influencing ecosystem functioning, including system behavior and responses to human intervention (Scheffer and Carpenter, 2003b). Limited predictability of system behavior increases uncertainty in our understanding of the system itself, its historical trends and the system elements and interactions, including nonlinearities, feedback loops, and delays, all of which give rise to those trends (Pahl-Wostl et al., 2007a). Thirdly, large and poorly reducible model uncertainties are intrinsically interwoven in impact assessment studies, despite considerable methodological progress that has been made over the last years.

In modelling complex interactions of climate and society, analogies are often used to connect space and time. That is done by using comparison between comparable cases in different climatic zones in the present and/or comparison with cases of adaptation through history (Glantz, 1988). Generalizations are difficult to derive from these comparisons because of many intervening case-specific factors involved (Berkhout et al., 2002) and a lack of knowledge due to limited availability and variability of data. Narrower impact studies yield more detailed quantitative results, yet their accuracy may shade deeper underlying uncertainties rather than to overcome them (Reilly and Schimmelpfennig, 1999). These uncertainties and knowledge gaps renders developing any kind of adaptation strategies highly challenging (van der Sluijs, 2007).

Meanwhile, today's key challenges of environmental science and policy often reflect the nature and rate of and responses to climate change and the concomitant impacts on the future state of the SES concerned (Dessai et al., 2005; Dessai et al., 2007; van der Sluijs et al., 2010). Impact assessments of future climate change projections derive their meaning from assumptions about interconnected though not yet evident socioeconomic and ecological changes over the long-term(Lewis and Conaty, 2009)[3]. Given the limited predictability and controllability of SES dynamics, the future is surrounded by irreducible uncertainty, which is an issue insufficiently addressed in many SES studies, in particular how this could or should be combined with adaptive long-term goal-oriented policy-making.

This paper addresses the question how climate adaptation strategies and policies can be developed under uncertainty without compromising the ability to adapt to and shape change and to learn how to cope with uncertainty without losing future options for future adaptability. In various critical reviews of different strands and approaches in the field of futures studies (Sondeijker et al., 2006; van Notten et al., 2003), scenario planning and forecasting are referred to as the most widely applied approaches to exploring likely projections of the future. However, for dealing with the above sketched dilemma of combining robust long-term climate policies with taking into account uncertainty, it is investigated in this paper whether the normative approach to foresight and scenarios, in particular backcasting, can be combined with adaptive management, a well-known approach in dealing with SES.

Backcasting is well-known as a normative approach focusing on desirable futures, but nevertheless least widely applied compared with regular forecasting and scenario approaches. From the early 1990s onwards, it has become increasingly popular in addressing future sustainability challenges and involving stakeholders (Quist, 2007;

3. To account for interconnected social, economic and ecological changes, one could speak of socioeconomic-ecological systems (SEES).

Vergragt and Quist, 2011). It has also been proposed as an appropriate approach for developing low-carbon pathways and dealing with climate change (Giddens, 2009). As the explanatory capacity of large-scale and discontinuous climate change impacts exposes a considerable gap in the futures literature (IPCC, 2007; List, 2004)[4,5], we denote backcasting the least extensively described and evaluated approach in the field of adaptive management (AM). At the same time, attempts to compare and contrast both approaches to developing climate adaptation strategies under uncertainty are limited. Our aim is to demonstrate backcasting as a complementary approach to AM, by integrating the key challenges that the two approaches consider in complementary ways into a combined methodology for developing climate adaptation strategies and policies (Pahl-Wostl, 2008a, b; Pahl-Wostl et al., 2007a; Pahl-Wostl et al., 2009; Pahl-Wostl et al., 2007b; Quist, 2007; Quist et al., 2001; Quist et al., 2011).

For that purpose, Section 4.2 will distinguish backcasting from other approaches to explore the future and investigate the relevance of backcasting to field of climate adaptation. In Section 4.3, we will develop a framework to demonstrate backcasting as a complementary approach to adaptive management by highlighting methodological congruence in the methodological purposiveness of backcasting. As a point for departure for further refinement of our framework, Section 4.4 will evaluate its applicability in the case of the development process of a catchment management strategy for the South African Breede-Overberg Water Management Area. Finally, Section 4.5 will reflect upon what conclusions can be drawn from this evaluation and offer points of departure for further methodological refinement.

4.2 EXPLORING THE FUTURE

4.2.1 Foresight, forecasting and scenario analysis

The field of futures studies is characterized by heterogeneous strands and traditions, including scenario planning, "La prospective' (Godet, 1987) and strategic foresight. Scenario thinking is as old as prospective storytelling but its application for future thinking dates back to the 1950s (Sondeijker et al., 2006). Both scenarios and fore-

4. Although backcasting is advocated as a promising tool for anticipating discontinuity. List (2004) points out the uncertainty about it. He argues that it may not be readily scalable, because discontinuities can very greatly in scale and in consequences.
5. The IPCC (2007) reports that investigations into climate change and its potential consequences have begun to recognise the importance of strongly nonlinear, complex, and discontinuous responses. These types of responses, called singularities, can occur at all temporal and spatial scales of systems influenced by climate change (high confidence can be given to the likelihood that some such singularities will occur, but low confidence usually is assigned to any specific example of a possible abrupt event.

sight are occasionally treated synonymously, as the distinction is not always evident. And yet, the former is neither a proxy nor a requisite part of the latter.

For the sake of clarity, Durance and Godet (2010) suggest the following distinction: *"A scenario does not resemble a future reality but rather a means to represent it with the aim of clarifying present action in light of likely or desirable futures. Foresight, on the contrary, must master the constraints of the present"*.

Although foresight has become a convenient shorthand for the wide range of forecasting approaches, further scrutiny of vocabulary used by futurists reveals the difference between the two (Martin, 2010; van 't Klooster and van Asselt, 2011). As Martin (Martin, 2010) advocates: *"Foresight is mainly concerned with creating an improved understanding of possible developments and the forces likely to shape them. Forecasting is about making a probabilistic statement, on a relatively high confidence level, about the future, where accuracy and reliability is of key importance"*.

Forecasting approaches are by definition projective, as they rely on trend extrapolation and both qualitative and quantitative historical data (Quist, 2007). This historic deterministic view involves predicting future developments on the basis of historically empirical verifiable inquiries (Griffin and Isaac, 1992; Mahoney, 2003a; Pierson, 2003). Treating the future as something similar as the past renders a 'surprise free' future that is connected to the present in a straightforward way (Sardar, 1999). Apparently, most people find themselves mentally anchored in the past from which they do not easily deviate in regards to the future. The past, however, may manifest itself as an obstacle in constructing the future, distorting and narrowing our vision on the future (Bell, 2002). Hence, this historic deterministic perspective has been criticised for treating the future as a continuation of the past and for its ignorance to the past as a potentially misleading guide to the future. Another drawback of this perspective is its limited reliability. That is, reliability is only secured in the short-term and in cases of well-defined and relatively stable systems like, for example, existing markets (de Laat, 1996). As forecasting relies on dominant trends[6], it is considered unlikely to generate solutions to breaking trends that would have strong implications for many sectors (Dreborg, 1996).

In exploring plausible but not yet evident pathways into the future, alternative approaches are needed to explore what such a plausible pathway could be. Scenario analysis is such an alternative to capture irreducible uncertainties involved in the

6. Like, for example, the phenomenon of "peak oil"

future development of a system (Pahl-Wostl, 2008a; Robinson, 1990). Given that we know so little about the future, it needs to be conceptualised as being emergent and only partially knowable. Further insight into complex interrelationships among trends and key uncertainties in foresight are likely to emerge from a participatory, iterative learning-by-doing and doing-by learning endeavour (Sondeijker et al., 2006).

Scenario analysis adopts a futuristic approach of postulating the future rather flexibly (Kahn and Weiner, 1967). To think about our future is to think the unthinkable, by breaking with or even forgetting our past and present (Koriat et al., 1980). This requires creative thinking about the unknown future in an a priori manner independently of past-based empirically verifiable explanations of the past (Ringland, 2002). And yet, arguments for treating the past as a misleading guide to the future emerge from social learning processes that often occur in the aftermath of major discontinuities (Diamond, 2005; Gilovich, 1981; Ponting, 1991)[7]. What does happen in the future depends on what has happened in the past, which may trigger discontinuous changes (Brooks, 1986).

Discontinuous futures cannot be reliably forecasted, yet they can be generated through for instance context scenarios or envisioned and 'lived as normative scenarios and learnt from it (Quist, 2007; Sondeijker et al., 2006; van der Heijden, 1996). Hence, backcasting is about learning how desirable futures can be attained as much as how undesirable futures, including externalities of actions yet to be taken, can be avoided or anticipated (Robinson, 1988). In the remainder of this paper, we will demonstrate such a learning based approach for dealing with rapid change and achieving management goals where uncertainty exists about how to get there to be complementary to adaptive management.

4.2.2 Normative and exploratory scenario approaches

In scenario development, three major kinds of scenarios can be discerned (Quist, 2007; Vergragt and Quist, 2011): *trend extrapolation*, *exploratory* and *normative*. Exploratory scenario approaches aim to postulate a range of underlying conditions and generate alternative futures as a means of demarcating a 'possibility space' through which societies move and navigate themselves (Berkhout and Hertin, 2002). These approaches have proved useful for exploring and anticipating the future in varying research contexts e.g. transition research (Kemp and Rotmans, 2001; Sondeijker et al., 2006).

7. The historical consequences of deforestation on Easter Island provide an eloquent example of how continuing the past poses inevitable changes in the future.

In the context of climate change, the IPCC's emissions scenarios provide the basis for the majority of long-term climate change projections, including those of the Fourth Assessment Report (Girod et al., 2009). As stated in the Special Report on Emissions Scenarios, these scenarios serve a twofold objective: "*to advance IPCC's future assessments of climate change and its impacts, and adaptation and mitigation options; to provide the basis for analysis by the wider research and policy community of climate change and other environmental issues*" (IPCC, 2000). In light of these intentions, the emissions scenarios have provided the basis for many scientific studies and a reference point for the political and societal discourse on climate change.

Unlike early series of IPCC projections (i.e. the SA-90 and IS92-Scenarios), the SRES scenarios contain more recent driving force data for emissions and were developed in a fundamentally different way (Arnell et al., 2004)[8]. The IPCC authors of the SRES series, as stipulated by Girod et al. (2009), refused to assign probabilities to the scenarios and instead adopted the term 'projections. Each projection was backboned by a narrative storyline, describing how the world population, economies and political structures would evolve over the next decades. Whilst providing input drivers to climate models, these storylines represent a wide range of different development pathways for the world that provide a meaningful basis for impact studies.

As possible surprises and discontinuities have not been considered in the SRES projections (Girod et al., 2009), the future appears to be an incremental continuation of the past and present. When dealing with multiple and changeable drivers of change, extrapolating the future from data and analogies of the past is not plausible anymore (Berkhout and Hertin, 2000). To adequately address these sources of uncertainty and unpredictability, alternative methods and approaches are needed to support the development of climate adaptation strategies under short- and long-term uncertainty.

4.2.3 Implications for developing our methodology

Normative scenario approaches such as backcasting are considered better suited to account for problems of discontinuity as a source of uncertainty (van Notten et al., 2005; Vergragt and Quist, 2011). A distinct feature of backcasting is its normative nature. More specifically, it generates images of the future assessed in terms of desirability and attainability, including their consequences, and explores pathways to often

8. The emissions scenarios of the Intergovernmental Panel on Climate Change (IPCC) quantifying global greenhouse gas emissions up to the year 2100 have significantly changed during their evolution from the First (1990, SA90), through the Second (1995, IS92), to the Third Assessment Report on Climate Change. The SA90-scenarios relate to storyline axes on energy supply and efficiency, whereas the IS92-scenarios refer to storyline axes on population, income growth and fossil fuel resources. The term storylines refers to the key variables used in the scenario description that could be used as storyline axes.

radical change and decisions that may bring about or avoid this future in an incremental fashion. Backcasting derives its problem solving potential from its ability to generate solutions on unexpected trend breaks in persistent dynamics. It does so, by recognizing the irreducibility of uncertainties about future developments (i.e. uncertainty associated with climate and societal change) and externalities of actions yet to be taken but also the need to account for these uncertainties by assessing the risks of undertaking (precautionary) action.

4.3 COMBINING BACKCASTING AND ADAPTIVE MANAGEMENT

4.3.1 Adaptive Management (AM)

Climate policies are being developed and implemented and need to be regularly appraised in the light of shifting social, economic, environmental, political and scientific developments (Klein et al., 2005b; Maxim and van der Sluijs, 2011). This is best achieved through a reflexive policy appraisal process (Huitema et al., 2009; Voß et al., 2006; Voß and Kemp, 2005)[9]. Adaptive management (AM) provides an overarching concept to do so (Pahl-Wostl et al., 2007b) (Pahl-Wostl et al., 2007b, cf. Jacobson, 2009) (cf. (Jacobson, 2009)).

AM has been advocated as a concept in ecosystem management for quite some time (Holling, 1978; Lee, 1999; Pahl-Wostl, 2007b; Walters, 1986). This management approach assumes that ecological systems are self-organising complex adaptive systems, and that management must be able to readjust to change or surprise in ecological systems (Gunderson and Holling, 2002). However, the concept of AM used here puts strong emphasis on the human dimension, due to high interdependency of social and ecological systems (Pahl-Wostl et al., 2007a).

Moreover, AM is here characterised as a systematic approach for improving management policies and practices by learning from the outcomes of implemented management strategies. AM distinguishes itself from other management approaches in that it aims at capacity building to improve the management of SES by putting in place both learning processes and the conditions needed for learning processes to take place.

9. Reflexive suggests the policy appraisal process understands itself to be part of the dynamics that are to be governed. Policy processes then becomes the object of shaping adaptation strategies. Reflexive also implies that such processes are entangled in feedback loops and are partly shaped by the (side-) effects of its own working upon which need to reflected.

Another distinct feature of AM is its explicit recognition of an intrinsically limited ability to predict future key drivers influencing the functioning of a socio-ecological system, including system behavior and responses (Pahl-Wostl et al., 2007b). Limited predictability of system behavior increases uncertainty in our understanding of the system itself, its historical trends and the system elements and interactions, including nonlinearities, feedback loops, and delays, all of which give rise to those trends (Scheffer and Carpenter, 2003a). Another type of uncertainty is a lack of knowledge due to limited availability and variability of data. AM accounts for these instances of uncertainty, by assuming a persistent lack of knowledge on how the different parts of the system interact, how the system works and how it will change in the course of time (Borowski and Pahl-Wostl, 2008).

To account for these different types of uncertainties and to sustain the capacity for change, the whole process of policy development and implementation requires being iterative and cyclic. The AM process is constituted around a structured, learning cycle of four sequencing phases (Pahl-Wostl et al., 2007b): (1) starting from assessment (agenda setting and problem identification), (2) through policy formulation to (3) implementation, and (4) monitoring used as an input for the assessment phase in the next cycle. Social learning refers to learning of the social entity as a whole and the emergence of properties of the actors' collective. That is to say, it is constituted around processes of multi-party interactions, embedded in a specific societal and environmental structural context and leading to specific outcomes (Pahl-Wostl, 2009)[10].

Integrating social learning with changes in policy is most likely to occur, if previously implemented policies allow changes. Social learning refers to learning by all stakeholders to manage the issues in which they have a stake (Isendahl et al., 2009; Isendahl et al., 2010; Pahl-Wostl et al., 2007a). For policy changes to occur, the conditions for social learning need to be put in place. Stakeholder participation is considered crucial to facilitate processes of social learning and negotiations to achieve consensus despite different perspectives and stakes and the aforementioned types of uncertainty that need to be taken into account when addressing a management problem (van der Heijden, 1996). Knowledge about system behaviour is thereby accumulated during the management process and capacity has to be developed to respond to unexpected developments.

10. Social learning is here defined in light of social learning in river basin management has been developed in the context of the European project HarmoniCOP (Harmonising COllaborative Planning): www.harmonicop.info). According to Pahl-Wostl (2009) the focus of the conceptual approach chosen is on learning of the social entity as a whole and the emergence of properties of the actors' collective. This approach is characterised by a broad understanding of social learning that is rooted in the more interpretative strands of the social sciences.

Building adaptive capacity

In the field of climate adaptation, considerable research effort has been invested in conceptualizing the determinants of climate adaptation (e.g., 'adaptive capacity' (Cumming et al., 2006; Dobzhansky, 1968; Intergovernmental Panel on Climate Change, 2001; Smit and Wandel, 2006), 'exposure' (Wilches Chaux, 1993; Wisner, 2005), 'resilience' (Adger et al., 2005b; Folke, 2006; Holling, 1973; Holling, 1978; Holling, 1985; Holling, 1986), 'vulnerability' (Bohle, 2007; Gallopin, 2006; Wilches Chaux, 1993; Wisner, 2005)), including their interconnectedness, over the past decades, in order to differentiate between systems according to their need for adaptation (Smit et al., 1999; Smit et al., 2000; Smithers and Smit, 1997).

We here apply a more generic concept of adaptive capacity to scrutinize the process of adapting to and shaping change in SESs without compromising options for future adaptability (Gallopin, 2006)[11]. This requires a delineation of the SESs to be managed, expressed in terms of the human causes of potential changes in natural processes underlying those systems. To indicate the short- and long-term policy implications of such complex dynamics, we introduce the concept of management regime. A management regime is here referred to as the overall management system of technologies, institutions, environmental factors, and paradigms that are highly interconnected and essential to the functioning of the system that is targeted to fulfil a societal function such as water supply or flood control (Pahl-Wostl et al., 2007b). The resource system is the 'supersystem' comprising all environmental and human components, including the regime.

To understand how social interactions influence a regime's capacity to be adaptive, we consider them embedded in a structured social interaction context or so-called 'Action Situation' (AS)[12]. AS relates to a key concept integrated by the Management and Transition Framework (MTF) for developing a more coherent understanding of the complexity of regimes (Knüppe and Pahl-Wostl, 2011; Pahl-Wostl et al., 2010)[13]. An AS thereby represents processes where 'actors' take certain 'roles' and perform certain 'actions', leading to a specific outcome. Multi-level interactions can be represented as

11. This generic concept of adaptive capacity includes two different components, namely: (1) the capacity of the SES to cope with environmental contingencies (to be able to maintain or even improve its condition in the face of changes in its environment(s)) and (2) the capacity
12. There is conceptual congruence with the concept of transition arenas used by Sondeijker et al. (2006)Actors within a transition arena take part in a cyclical process, also called TM-cycle, within which problems are structured, visions, transition scenarios and transition pathways are developed, networks are mobilised, experiments are carried out, results are monitored and learning points are reflected on.
13. The MTF, originally developed within the context of the NeWater project, can be deployed as a tool for multi-level analysis of processes of social learning and societal change leading to sustainable and thus integrated and adaptive water management.

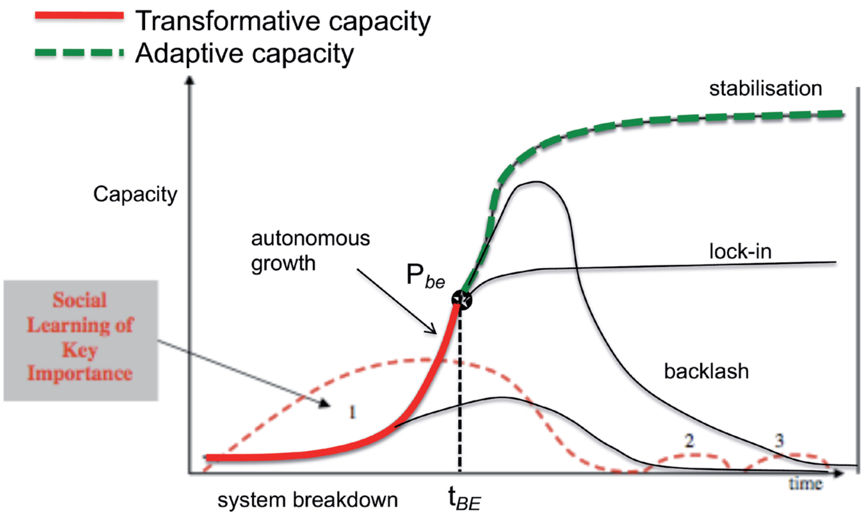

Figure 4.1 Schematic and simplified representation of qualitative features of the change in adaptive capacity and the mismatch between expected goals and achieved management goals (adapted from Pahl-Wostl (2005a)).

a sequence (or network) of ASs which are hierarchically structured according to different administrative units. These are the traditional boundaries of traditional units of administration (i.e., national, provincial, local) and those defined by the hydrological principle (i.e., river catchment, tributary and sub-tributary). In developing climate change adaptation strategies within a catchment these levels are not mutually excluding but rather complementary (Borowski et al., 2008). Capacity building for climate change can then be represented as sequences of interconnected AS.

The regime concept also allows us to demonstrate the important role of social learning in increasing the adaptive capacity of a regime. Pahl-Wostl (2005a) have developed a schematic, but simplified representation of qualitative features of the change in adaptive capacity and the mismatch between expected and achieved management goals. Figure 4.1 shows that if mismatches between regime properties and the management goals become too large they trigger a change (1). A regime is assumed to be in its breakdown phase and faces a considerable lack of transformative capacity to respond effectively to this breakdown. This increases the mismatch and the need for building capacity through social learning, both of which are assumed to trigger regime change. When regime transition has reached the stabilisation phase, transformation dynamics turn into optimization processes (2,3).

Rather new is the concept of a break-even point that exists along this S-curve (i.e., logistic function) at which the focus shifts from building transformative capacity to adaptive capacity[14]. At the starting point of the S-curve in Figure 4.1, the regime is supposed to be in its breakdown phase. At the same time, the regime is unable to adopt adaptive management schemes, unless its structure undergoes a transformation. To this end, the system has to build transformative capacity first. That is to say, the ability of the system to shift to new or different configurations or create new stability domains; to re-define itself through acquisition of new variables or allowing them to emerge e.g., Folke et al., (2005b). Once the key regime elements have sufficiently been re-organized into new or different dynamically stable configurations, further optimization of the regime is needed to sustain the adaptive capacity for change by improving the whole process of policy development. It is the break-even point- that is to say, the tangent point $P_{BE}(t_{BE})$ on the S-curve - at which building transformative capacity turns into adaptive capacity.

At this point, a sufficient degree of stability of the regime is assumed. By comparison, it would be far too early to assume such a degree of stability prior to the tangent point, though it is a critical phase in regime development. If the regime lacks sufficient capacity to transform, its development could still be impeded by 'lock-in' (Pahl-Wostl, 2005a, 2006) or 'backlash' (Biber, 2009) or a 'system breakdown' (Brugge and Rotmans, 2007; van der Brugge et al., 2005). Lock-in indicates strong interdependence of regime elements. These elements co-evolved over a long period of time, stabilizing regimes but also blocking changes (Huntjens et al., 2010). Backlash is a common phenomenon in environmental law, as environmental harm usually manifests itself after the human or natural induced event that causes it (Biber, 2009). Regulatory action may take an extended period of time to succeed in undoing the harm that has accumulated from prior human activity. If the effectiveness of the action remains uncertain, a gap between regulatory action and environmental performance may arise. System breakdown is indicative of the regime's instability. If the regime faces a persistent lack of transformative capacity, it undergoes continued instability. Such a regime may be found in developing countries, where corruption and the absence of civil society, a lack of efficiency and effectiveness of existing governance structures pose problems for any kind of development—not only for resource governance (Pahl-Wostl, 2009). Limited transformative capacity indicates strong interdependence of regime elements, stabilizing regimes but also blocking changes. For the regime to overcome these instances of inertia, it requires take off through 'momentum' cf. Hughes, (1983, 1987).

14. In innovation studies, it is argued that the emergence of a technological innovation can be described by a Kondratieff long wave cycle (K-wave) that is originally used to explain long wave economic cycles. Its originator Nickolai Kondratieff was a Russian economist (1892-1938) in Stalin's Agricultural Academy and Business Research Institute ("Long Waves in Economic Life" - originally published in German in 1926). Kondratieff's major premise was that capitalist economies displayed long wave cycles of boom and bust ranging between 50-60 years in duration.

4.3.2 Backcasting

Backcasting was developed in the 1970s in energy studies (e.g. (Lovins, 1976; Lovins, 1977; Robinson, 1982) and later also applied to sustainability e.g., (Höjer and Mattsson, 2000; Robinson, 1990). From the early 1990s onwards, it has developed into a participatory approach, especially in Canada (Robinson, 1988; Robinson, 1990), Sweden (Carlsson-Kanyama et al., 2008; Dreborg, 1996), the Netherlands (Quist and Vergragt, 2006; Quist, 2007). It has been applied to various domains including climate adaptation, water, food, cities and regions and the scale varies from the local to regional, national and international.

Backcasting can be described as developing and assessing the relative feasibility of alternative futures (Robinson, 1990) or as generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved (Quist, 2007). Key to participatory backcasting are stakeholder participation, learning by those stakeholders and development of visions (Quist, 2007; Quist et al., 2011), as well as the methodological aspects including tools and methods. Participatory backcasting has also similarities with transition management (Loorbach, 2006b; Rotmans, 2001), which is another normative foresight approach.

In participatory backcasting stakeholders interact and are involved in developing, assessing, discussing and adjusting future visions. This all stimulates first and higher order learning among the stakeholders involved, which may also lead to spin-off and follow-up, as was shown for several backcasting studies in the Netherlands (Quist et al., 2011).

A considerable variety in backcasting can be observed though, but based on a literature review, Quist and Vergragt (2006), Quist (2007), Quist et al (2011) have developed a comprehensive methodological framework for participatory backasting. The framework consists of five steps and the outline of a toolkit containing four groups of methods and tools. The fives steps consist of (1) strategic problem orientation; (2) Vision development; (3) Backcasting analysis; (4) Elaboration, assessment & agenda development, and; (5) embedding of results. The steps should not be seen as linear, as iteration and moving forward and backward between these steps is possible and in fact likely to take place. The four groups or methods include: (i) participatory tools, (ii) design tools, (iii) analytical tools and (i) management, coordination and communication tools. The underlying backcasting approach of the framework is both inter-disciplinary (combining and integrating tools, methods and results from different disciplines) and trans-disciplinary in nature, as it involves stakeholders, stakeholder knowledge and stakeholder values.

The framework also discerns three types of demands: (i) normative demands, (ii) process demands, and (iii) knowledge demands. Normative demands reflect the goal-related requirements for the future vision. Process demands resemble the requirements regarding stakeholder involvement and their level of influence in the way issues, problems and potential solutions are framed and resolved in the backcasting study. Knowledge demands are needed set requirements to the scientific and non-scientific knowledge strived for and how these are valued one to another.

In backcasting studies various goals can be pursued, which can refer to process-related or content-related aspects, or to a range of other aspects such as knowledge and methodology development. Generally speaking, stakeholder engagement is typically heterogeneous because of the involvement of stakeholders from different societal domains like business, research, government and the public and public interest groups, with the latter including both the wider public and public interest groups.

Visions: trenscending the existing

Vision development is key to backcasting, but visions are more widely present, ever since mankind has developed a curiosity for the notion of knowing what will happen in the future (Godet, 1987). The method of visioning has become a popular approach for making statements about and for the future, also labelled future visions (van der Helm, 2009). These visions appear in various contexts, albeit in different shapes (e.g., business, political, religious and personal) and at varying levels of content detail. In their appearance though, future visions often lack any substantial scrutiny. But, what makes visions relevant to future studies?

To develop a better understanding of the meaning and functions of a vision, three key aspects can be distinguished (van der Helm, 2009): the future, the ideal and the desire for deliberate change (cf. the 'Leitbilder' concept (Dierkes, 1992; Dierkes et al., 1996)). Firstly, visions of the future act as mental images or creative flashes of insight into an attainable future triggering new policy developments (Mambrey, 2000; Mambrey et al., 1992). Secondly, the envisioned future is considered the ideal, as opposed to contextual and historical contingencies. Whether this is best or not remains a much-debated subject though. Visions are therefore often associated with desirable or undesirable futures as opposed to possible futures or likely futures (Robinson, 1990). Thirdly, a vision concerns transformational change to replace or targeted at replacing old structures by new ones. Any expression of a future without clear reference to a need for change should not qualify for a vision. The term vision is then applied to what is actually labelled 'view' (e.g., worldview) or perspective (e.g., point of view). This inconsistency in vocabulary is largely unavoidable given that a vision always consists of elements underlying one's worldview or point of view. In sum, a vision can be quali-

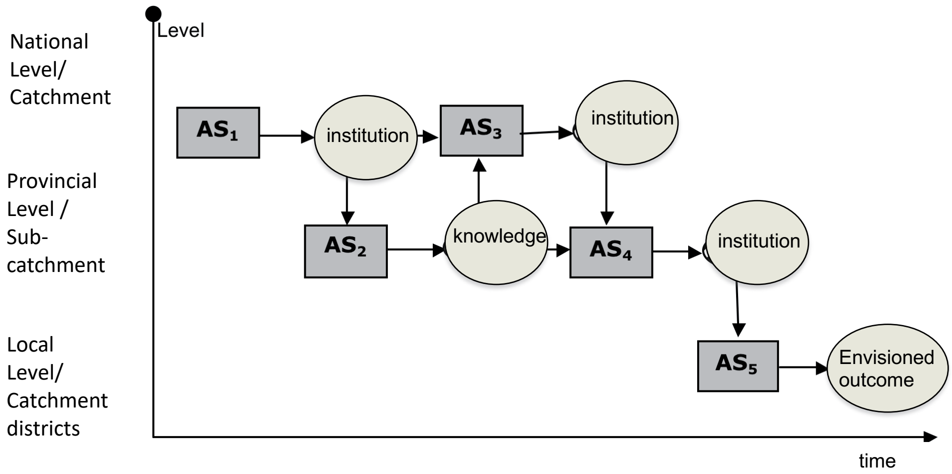

Figure 4.2 Vertical integration of action situations that is assumed essential for realising an envisioned outcome at local level (type of representation adapted from Pahl-Wostl (Pahl-Wostl, 2005a).

fied as a more or less explicit claim or expression of a (un)desired future that mobilizes present potential to bring about that future.

A vision is a contextual concept, deriving its meaning from a given context where it can potentially guide actor behavior, particularly if shared by actors and generated in a participatory learning mode (Grin, 2000). Context may here be denoted both geographically (e.g., regional or national regulatory framework) and socio-cognitively (e.g., mental models). A vision, for example, usually emerges from creative thinking that may challenge the dominant regulatory perspective or worldview codified in regional or national regulatory frameworks (Berg, 2000). A vision and the context from which it emerges are mutually reinforcing, albeit limiting the opportunities for critical assessment and reconstruction of a vision. Actors, however, will not easily change their basic values (Beck, 1977) particularly when alternative values and visions are considered socio-cognitively and/or regulatory contradictory.

The 'transformational change' aspect of a vision forms a medium for establishing 'structural couplings' between different and largely social systems. By analogy with Parsons Parsons (1934), Luhmann (1995) labelled them symbolically generalized communication media. This suggests that structural couplings of AS across different regime levels result from actor visions and expectations communicated across these levels. Figure 4.2 illustrates an ideal example of vertical integration of AS within a catchment area. An institution is produced by AS1 at the top-level influencing AS2 at the next lower level. AS2 produces knowledge that in turn provides input for process (AS3) at the higher level but as well into a continuation of the process at the same level. AS4 is influenced by institutions from the next higher level produced by AS3 but as well by the knowledge produced at the same level by AS2. The institution produced by AS4 influences AS5 one level below that is producing the envisioned outcome.

After Pahl-Wostl, vertical integration of AS may lead to a structural change of the whole regime, if 'new' actors or actor coalitions come into play, new regulatory frameworks are introduced, and power structures are changed. Arguably, a regime characterized by low adaptive capacity is assumed to fail to vertically integrate the key elements of capacity building. After Cumming et al. (2006), the regime lacks the capacity to adapt the level of management to the level of the environmental problems. Consequently, flows of knowledge and information, existing formal and informal institutions and actors are not properly aligned to fulfil the management goals envisioned for the future. For management to fulfil its goals, the following key elements need to be vertically integrated:

- Formal and informal institutions
- Knowledge and information
- Management goals and activities envisioned for the future
- Actors interacting within and across action situations

However, structural coupling is most likely to emerge from strong visions. As van der Helm (Van der Helm, 2009) claims, the strength of these visions depends on the explicitness and authority of the vision statements to advance actors into a desired direction. Structural coupling calls for a different appreciation of the notion of vision and the method of visioning. Opposed to visioning used as part of backcasting, structural coupling does not require the co-development of new worldviews or paradigms in a participatory setting. Neither is a shared vision considered prerequisite e.g. (Dierkes, 1992; Dierkes et al., 1996) which could be at the expense of a systems perspective on change though cf. (Weaver et al., 2000). A strong vision derives its strength from being pursued by authoritative leader, guiding actors into the desired direction. What emerges from visioning though may not be as enduring, authoritative and explicit as the strong vision that enables structural couplings.

Combining Backcasting and AM: towards a new methodology

Our next step is to combine backcasting and Adaptive Management in a new methodology that can be applied to climate adaptation in coastal regions. It should combine the steps and concepts from adaptive management as proposed by Pahl-wostl et al. (2007) with the framework and concepts developed by Quist and Vergragt (2006), Quist (2007), Quist et al. (2011) , without neglecting the uncertainty surrounding climate futures.

For backcasting to be postulated as a complementary approach to AM, it compels us to seek for methodological congruence between backcasting and AM. Complementary, as backcasting provides AM a long time frame for the fulfilment of short and mid term management goals, whereas AM aims to secure adaptiveness and reflexivity within this timeframe. Congruence is to reside in the methodological purposiveness of the backcasting steps to make the whole process of policy development more adaptive and reflexive. The stage of assessment (AM step 1) integrates the process of strategic problem orientation where the full complexity of the systems to be managed needs to be taken into account. This requires system specification, integrating different knowledge bases in the natural and social sciences (Döll et al., 2008; Leemans, 2009). As part of this process, scenario development allows us to make different projections of future development of the systems concerned, also known as context scenarios.

Next, policy formulation (AM step 2) has to account for the different normative assumptions, goals and worldviews of stakeholders. A common vision that accommodates all these basic elements is key to holistic problem solving. This vision has the potential to converge stakeholders on a commonly agreed upon problem articulation and goals, including plausible directions for goal fulfilment (Grin, 2000). In this endeavor, the key challenge for stakeholders is to agree on two most essential driving forces as a backbone for the context scenarios. These forces that serve as scenario axes are those developments surrounded by uncertainty because they are sensitive to trend breaks and can develop into different directions (van 't Klooster and van Asselt, 2006).

In the backcasting analysis, possible trajectories are envisioned for policy implementation (AM step 3) that perform well under different possible, but initially uncertain, future developments. In view of climate adaptation, the aim is not to identify the 'best' strategy anticipating very specific climatic conditions because that strategy may not perform well if those conditions are not met. The focus is rather on a robust strategy that performs well under a variety of conditions. This requires continuous monitoring and assessment on strategy performance (AM step 4), revealing the potential need for minor adjustments or major course corrections (as input for the assessment phase in the next cycle).

For our research purpose, we have developed a new methodological framework from a wide variety of backcasting studies and methodologies, indicating a diversity of the methods and concepts applied, the different methodological steps and the degree of stakeholder involvement (Quist et al., 2011; Quist and Vergragt, 2006)[15]. The back-

15. Vergragt and Quist have recognized a large variety and diversity in backcasting studies and backcasting methodologies, both of which reflect that different backcasting strands, traditions and practices have evolved in different parts of the world.

casting framework here proposed consists of five iterative steps cf. Quist, (2007a):
Strategic problem orientation

1. Visioning
2. Goal setting
3. Backcasting analysis
4. Evaluation and monitoring

Strategic problem orientation

Climate adaptation strategies are attuned to the nature and rate of and responses to climate change and the concomitant impacts on the future state of the SES concerned (Adger et al., 2005a; Klein et al., 2005b). Impact assessments of future climate change projections generate results that reflect our assumptions about interconnected though not yet evident socioeconomic and ecological changes over the long-term (M. Lewis, 2009). Given uncertainties in the data employed by such assessments, more than one legitimate assumption may be compatible with the available body of knowledge (Gallopín, 2006; Pahl-Wostl et al., 2007a; Voss and Kemp, 2005). In addition, new knowledge about SES behavior or changes in environmental and/or socioeconomic conditions may merit changes in early made projections.

At the same time, knowledge relevant for this assessment cannot be limited to objective facts devoid of context (Pahl-Wostl et al., 2007b). Relevance is also dependent on subjective interpretations, as stakeholders may have different understanding of the phenomenon observed and its possible cause(s). This understanding remains ambiguous because of the simultaneous presence of multiple cognitive frames (Dewulf, 2005). Hence, these considerations demands requirements to the scientific and non-scientific knowledge strived for and how these are valued one to another.

Scenario development offers a useful approach for the development of joint interpretations relevant to constructing future projections of SES dynamics and the implementation of collective action. One or more context scenarios may be required to model these trends. The desired number of context scenarios to be developed depends on many factors (e.g., available resources and knowledge (Alcamo and Henrichs, 2008) yet they may differ in content to which they are addressed. The scenario content is dependent on the different assumptions made about how current trends may develop (Figure 4.1), how critical uncertainties will play out, and what new factors will come into being (Alcamo, 2008; Rothman, 2008). The scenario-axes technique is a common method to summarize those driving forces and critical uncertainties of principal interest in two axes. The 'extremes' of each axis represents one end of the assumptions, rendering four different context scenarios.

Visioning

Visioning is about making normative claims about and for the future by thinking about the kind of future we wish or do not wish for ourselves relative to contextual and historical contingencies (Grin, 2000; van der Helm, 2009). The aim is to articulate a shared future reflecting the need for change as a necessary requirement to transcend these contingencies. There lies the challenge of reaching consensus among stakeholders on what such a future that would be as much as ensuring the long-term commitment of stakeholders to converge in their actions towards that future. Visioning requires process management and design, both of which regulate stakeholder involvement to create a safe environment where stakeholders are aware of their level of influence in the way issues, problems and potential solutions are framed and resolved in the visioning process (Vergragt and Quist, 2011).

The future vision resulting from a visioning exercise often lacks any substantial underpinning allowing further verbal and cognitive scrutiny (van der Helm, 2009). The vision's potential to mobilize resources and stakeholder commitment required for reaching out to the future resides in those parts of the vision that can be made explicit, communicated and shared. Guiding images of the future and explicit vision statements, for instance, can articulate the present-future gap between yet to be bridged and provide guidance on closing this gap by setting goal-related requirements for the future vision.

Goal setting

In the face of climate change, adaptiveness suggests a diversity of means available to address a challenge without compromising adaptiveness over the long run (Pahl-Wostl et al., 2007b). This requires reframing different actor perspectives and worldviews in order to converge to a commonly agreed upon problem definition, but allowing at the same time a wide range of methods for goal fulfilment.

A vision has the potential to converge stakeholders on a commonly agreed upon problem articulation and goals, including plausible directions for goal fulfilment (van der Helm, 2009). Seemingly interconnected, visions should not be used as a synonym for goals (cf. (Shapiro, 1996))[16]. A strong vision derives its guiding potential from the apparent gap between the 'what is' and 'what ought to be', whereas goals outline rationalised pathways for making the vision become reality (van der Helm, 2009).

Such a vision may support process leadership is of importance in multi-actor collaboration (Dewulf et al., 2005; Loorbach and Rotmans, 2006). Process leadership is

16. Shapiro (1996) refers to term goals in a broad sense, as something closely related to what we prefer to denote futures.

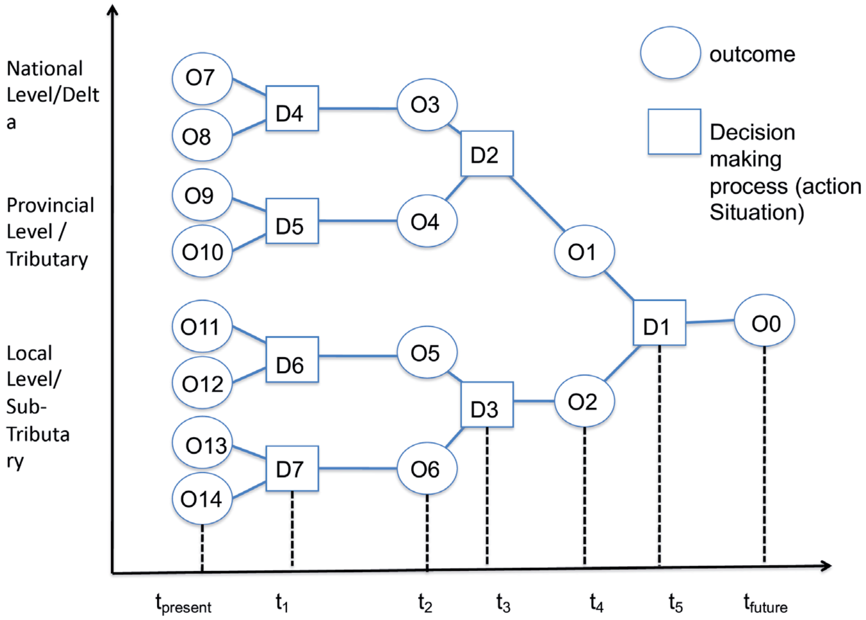

Figure 4.3 Schematic presentation of the backcasting analysis.

required to create the conditions needed to get the most out of the diversity of perspectives, competencies, and resources, while ensuring that each actor can meet his own objectives (Vansina, 1999). After Pahl-Wostl et al. (2007b), in this initial phase of the backcasting exercise, social learning is of critical importance to build trust and achieve consensus on the innovative solutions to current and anticipated future problems.

Backcasting analysis

The point of departure for the backcasting analysis is to build bridges from the present to a desired future in a retrospective way, while identifying the policy actions that bring about that future. This requires the path to achieve the vision to be translated into strategic actions first. As demonstrated in Figure 4.3, the expected outcomes of these actions need to be scheduled in a time-sequential order starting from the future until the present and assigned to a certain regime level.

Numerous and varying definitions of scenarios exist, yet there is agreement on the idea that scenarios consist of a series of specific and explicit 'if-then' propositions exploring the consequences of a range of driving force assumptions (Alcamo, 2008; Alcamo and Henrichs, 2008; van't Klooster and van Asselt, 2006). Each scenario seems to connect those assumptions either in a normative or descriptive way. We here refer to a backcasting scenario as a description of how a desirable future may unfold based on a chain of 'if-then' propositions (Schoemaker, 1993). It is important to distinguish backcasting scenarios from exploratory context scenarios. The latter type of scenarios typically contains a description of key driving forces for change that affect the pathways in the backcasting scenarios.

As demonstrated in Figure 4.1, transition dynamics can develop into pathological path dependence or so-called "lock-in". Such dynamics may influence the pathways envisioned in the backcasting scenarios in different ways. The seeming aim is to span the gap between the projected trends in the context scenarios and the pathways in the backcasting scenarios, highlighting those intermediate events that bring about a desirable future (Dortmans, 2005). In view of climate change adaptation, a robust adaptation strategy is considered to fulfil this need for all scenarios (van't Klooster and van Asselt 2006).

Evaluation and monitoring

In some backcasting studies (e.g., (Holmberg, 1998a; Quist et al., 2001)), it appeared difficult to combine implementing and monitoring of outcomes and realising follow-up activities. Both steps were in fact singled out in the methodology. There is, however, a three-fold reason to embed them as separate steps in the backcasting methodology. Firstly, they can support the alignment of requirements of policymakers and other stakeholders needed to onset the envisioned transition. Secondly, they can further advance the fulfilment of the vision. Thirdly, they facilitate social learning about structural changes in the systems concerned in regards to the impact of previously implemented policy actions. The outcomes of learning processes may trigger a new policy cycle for re(de)fining the system and the current and anticipated future problems, and re-evaluate early-chosen strategies for solving these problems.

Monitoring thus supports the whole process of policy development to remain reflexive. That is, to be prepared to question and continuously update policy goals - policy appraisal process (Borowski and Pahl-Wostl, 2008; Holmberg, 1998b; Pahl-Wostl et al., 2007a) cf. (Huitema et al., 2009; Voß et al., 2006; Voß and Kemp, 2005) have developed the following set of criteria against which the degree of reflexive management can be assessed[17]:

- The degree of integrated knowledge production and diffusion
- The diffusion of newly produced knowledge into policy making
- The degree of transparency, openness and flexibility of policy making
- The degree of multi-level stakeholder participation
- The degree of participatory goal formulation, fulfilment and assessment
- The degree of multi-level approach to policy analysis and development

17. Voß et. al. originally coined the term reflexivity in light of governance.

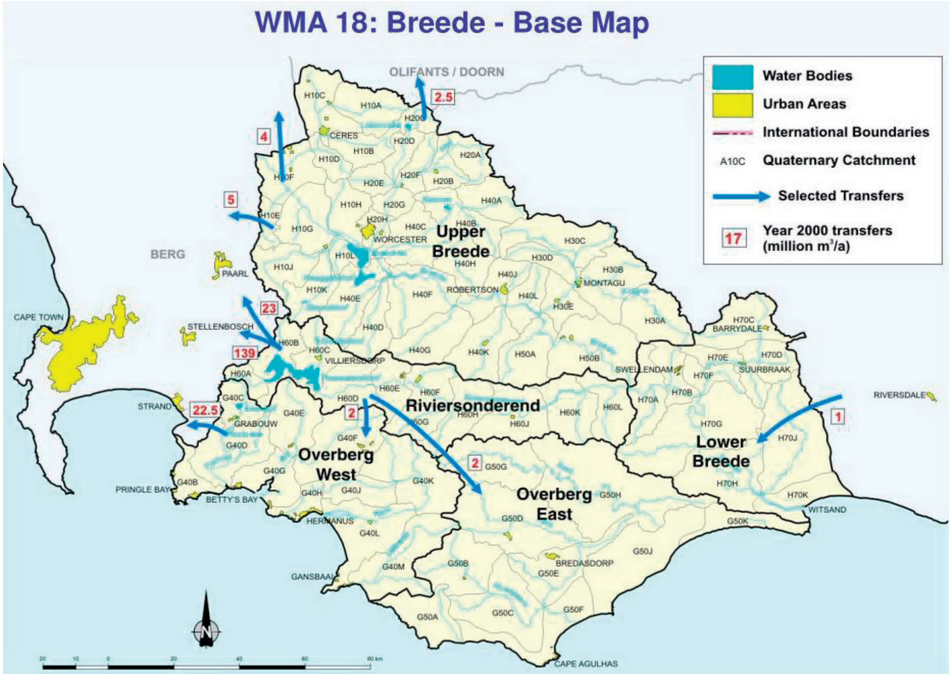

Figure 4.4 Catchments and local municipalities in the BOWMA (Breede-Overberg Management Agency, 2010).

4.4 CASE STUDY: THE BREEDE-OVERBERG CATCHMENT MANAGEMENT STRATEGY

In this Section, we will evaluate the applicability of the developed backcasting framework to the case of the Breede-Overberg coastal region in South Africa near Cape Town where a Catchment Management Strategy was developed in 2010 through a participatory process. Our objective herein is to gain insight as to how the CMS development process chosen deviates from the normative 5-step model developed in the previous sections and what conclusions can we draw from this inquiry with respect to the normative model and its various steps, as distant observers of the CMS development process.

4.4.1 Background

In July 2005, the Minister of Water Affairs established the Breede-Overberg Catchment Management Agency (BOCMA) to secure compliance with the 1998 National Water Act (NWA). The Governing Board was appointed in October 2007 and the CMA became operational with the appointment of the CEO and staff over the past

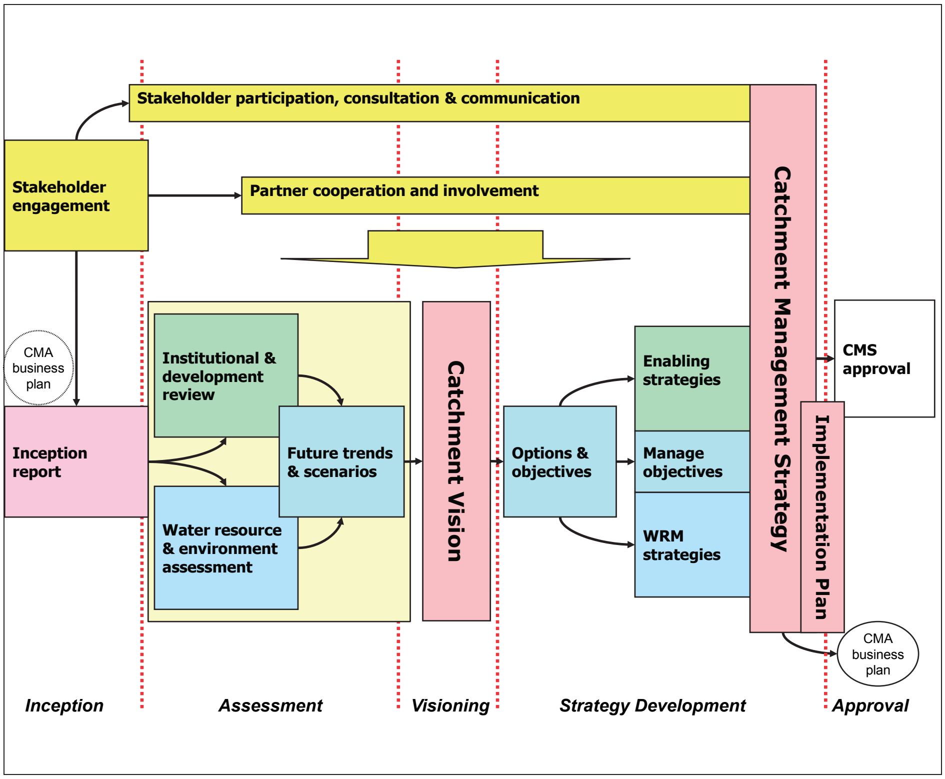

Figure 4.5 The CMS Development process (Breede-Overberg Management Agency, 2010).

two years. Under the auspices of the NWA (1998), BOCMA is the lead agent for water resource management (WRM) within the Breede WMA, BOCMA is to play a key role in protecting, using, developing, conserving, managing and controlling water resources and in understanding the interconnectedness and importance of water to most aspects of the social economy.

For securing compliance with the NWA, in 2010, BOCMA has initiated the development of a Catchment Management Strategy (CMS) for managing the Breede-Overberg WMA situated in the southwest corner of the Republic of South Africa (Figure 4.4). While, it derives its name from the largest river within its boundaries, namely the Breede River, a significant portion of the WMA consists of the rivers of the Overberg. The BOWMA (BOWMA) falls entirely within the Western Cape Province and is characterized by mountain ranges in the north and west, the wide Breede River valley, and the rolling hills of the Overberg in the south.

There is a clear policy and legal requirement for the development of a CMS in the BOWMA as outlined above. There are also compelling social, economic, environ-

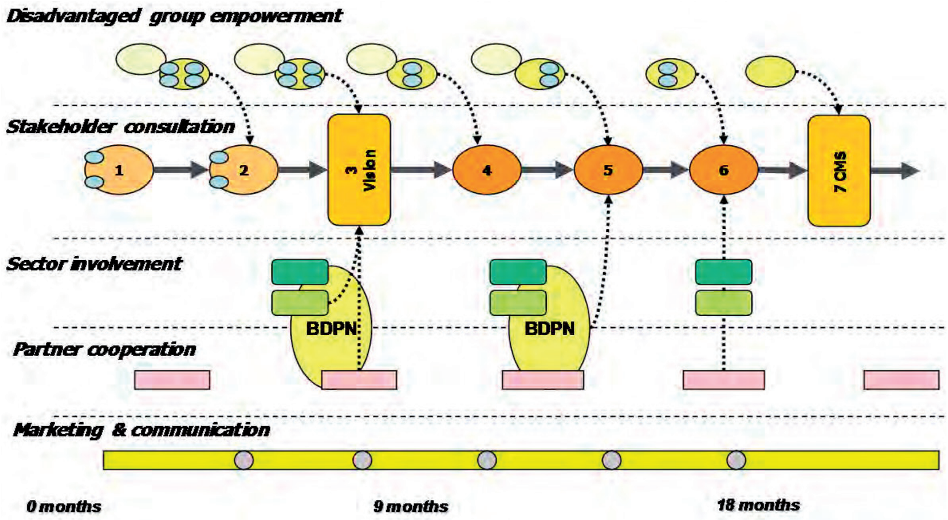

Figure 4.6 CMS Stakeholder Engagement Process (Breede-Overberg Management Agency, 2010).

mental and water resources considerations for a CMS in the BOWMA, given the convergence of historical developments, future uncertainties and the changing environment for WRM in this area. The CMS development process is to support local, provincial and national development objectives and has the broad support of all stakeholders in realizing the Breede-Overberg Vision of "Quality Water for All Forever" in 2030. Although the local execution of the CMS is delegated to local organizations such as Water User Associations, the financial and administrative responsibilities for setting and collecting water user charges reside with BOCMA. The agreed objective of the CMS process is to bring together social, technical water, economic, environmental and political-institutional aspects and issues, in order to set the direction for management decision-making and strategy development over the next 20 years. The CMS only provides management objectives and actions for the next 5 years until the legally required review. As illustrated in Figure 4.5, BOCMA proposed five chronological steps to guide the CMS development process over the next 5 years before it is reviewed and revised in its second edition: inception, assessment, visioning, strategy development and approval. This will include the incorporation and resourcing of relevant CMS actions into the BOCMA business plan.

As illustrated in Figure 4.6, the CMS development process was initiated through a broad stakeholder consultation process (Steps 1 & 2) that firstly mobilized stakeholders (i.e., historically disadvantaged individuals and water users and managers), but then secondly enabled them to analyze the current situation and identify the issues and challenges that require redress. Moreover, stakeholder engagement was aligned with other support streams such as sector involvement (i.e., agricultural and environmental groups) and partner cooperation (i.e., provincial and local government) providing an important robustness to the engagement process. Support was provided to stakeholders in assisting them to prepare for meetings by explaining technical concepts, the objectives for meetings and reinforcing stakeholder roles and responsibilities. This was aimed at disadvantaged groups but was not exclusive to them. These steps provided the technical backdrop for stakeholders to develop a vision (Step 3) for the BOWMA.

As stakeholder consultation hereafter became quite technical in nature, the development of options (Step 4), the sub-strategies (Step 5) and the complete CMS (Step 6) were done in consultation with a Reference Group of external consultants. The larger group of stakeholders nominated this Group. The final strategy was then taken back to the broader stakeholder group at a "launch" workshop (Step 7) prior to the CMS being published for public comment.

4.4.2 Strategic problem orientation

For many years, it has been generally assumed that there is adequate water of acceptable quality to meet the farming, tourism, urban and industrial water demands of the BOWMA and Cape Town, without adversely impacting upon important wetland, river and estuary ecosystems. This perception was based on outdated water use information but more recent evidence indicates that the catchment water resources are stressed and the aquatic ecosystem health in many parts of the system is deteriorating.

Over the past decade there has been a decline in ecosystem health in many parts of the Breede and Overberg Rivers, indicated by comparative river health surveys conducted in 1999 and 2010. Increased salinity concentrations during summer low flows also pose challenges and have had to be carefully managed in the middle Breede River over the past couple of decades. This is not possible in the lower Breede River, where natural geological and tidal impacts make summer flows unfit for irrigation. In each of the three years prior to 2010, major (estimated 1-in-100 year) floods occurred in the coastal areas of the Breede and Overberg. These floods caused significant infrastructure damage and had profound impacts on the morphology of these river and estuary systems. It is unclear whether this reflects an unlikely confluence of events or the beginning of increased climate variability.

From a social-economic perspective, the variation in natural and water resource availability is reflected in the unevenness of economic production between areas. The relatively water abundant upper and central Breede valley dominates economic production, whereas the water constrained lower Breede and Overberg East are relatively insignificant. As with the economic production, employment is closely linked to water resources through agriculture and tourism. Given that significant inequalities between households also exist, and are linked to differences in employment and historical inequities, WRM has a direct impact on the level and distribution of social and economic development in the BOWMA.

These water management challenges altogether are difficult enough by themselves but also exacerbated by outdated and uneven information in the BOWMA. Hydrological modelling in much of the Breede has not included the past 20 years monitoring and has not been done for much of the Overberg. Water use information is 10 years out of date during which there has been significant expansion of irrigation, while verification of the legality of water use has not been conducted. Sound WRM requires reliable information, particularly in a system that is as stressed as the Breede-Overberg. BOCMA (Breede-Overberg Management Agency, 2010) will use the requisite datasets generated by information and monitoring systems as a basis to understand the latest status of the resource and, from a historical and systems perspective, to predict future impacts. These systems together with an institutional setting that would formalize data processing and management are yet to be in place in conjunction with a newly adopted three-tier administration model for the BOWMA[18]. This poses a major challenge for management to account for knowledge asymmetries.

In dealing with the challenges outlined above, BOCMA (Breede-Overberg Management Agency, 2010) rejects traditional ways of planning based on projecting future trends to identify the best management actions. Alternatively, BOCMA has adopted a scenario planning approach to identifying actions that are robust under different probable futures of the BOWMA instead, reflecting the need to monitor and refine these actions when future conditions change. This is particularly appropriate for areas undergoing rapid change as much as for achieving management goals in the BOWMA where gradually shifting economic conditions and climate variability make goal fulfilment uncertain. Based on an uncertainty assessment, BOCMA arrived at three context scenarios narratives describing possible futures for the Breede-Overberg as presented in Table 4.1.

18. For the management of water resources, the NWA introduced a new three-tier administration model: the Minister of the Department of Water Affairs at the national level, catchment management agencies (CMAs) at the catchment level, and water user associations (WUAs) at a more localised level.

Table 4.1 Future projections for the BOWMA (Breede-Overberg Management Agency, 2010).

"All in it together" scenario	**"Race to the bottom" scenario**	**"Things fall apart" scenario**
This scenario reflects a cooperative future, supported by sustained development, growth and institutional strengthening. This provides the most favorable environment for balanced and effective water resources protection, development, sharing and use. It is also characterized by the highest demands for water associated with economic development and urban population growth, together with the needs establishment of viable commercial farms by black farmers supported by existing commercial farmers. However, the importance of environmental functioning to support ecosystems, tourism and residential areas ensures a balance with environmental requirements and strongly drives efficiency in water use. Regulatory initiatives are supported by the cooperative outlook, self/peer regulation and institutional resources	Whilst maintaining some growth, this scenario is characterized by on-going inequality, limited cooperation. Inadequate institutional capacity results in limited regulation of water use or waste discharge that is exacerbated by the limited cooperation. The dominance of established individual interests tends to trump the common interest and those of the more marginal voices. The management environment prioritizes growth and focuses on providing the necessary inputs to this growth (such as water), whilst neglecting environmental and social requirements. Demand for commercial and municipal use of water increases with the growing production and population, but with deterioration of environmental resources and limited reallocation of water to emerging farmers	This scenario is characterized by social disintegration and stagnant economic growth, together with limited institutional capacity and ineffective policy. Limited growth and investment implies little significant increase in water demand from agricultural or urban users, although the existing use may become less efficient. Some redistribution of water may take place, but with limited support to ensure its long term viability. Environmental quality is not prioritized and regulatory control cannot be maintained, but potentially less pressure on the water resources may indicate a lower level of degradation that may otherwise be expected

These narratives demand a slightly different though complementary focus for the CMS: (i) 'participatory-cooperative management' as a priority for the first, (ii) 'control-regulatory management' as a priority for the second, and (iii) 'empowering-supportive management' as a priority for the third. These priorities combined reflect the spirit of BOCMA's paradigm for adaptive WRM and provide the cornerstones for a robust CMS. Priority has been given to the first scenario, as it would support the implementation of an adaptive water management paradigm in the BOWMA. Here, scenario development has served the aim to explore enabling conditions for the implementation of this paradigm, given future projections of social-economic and environmental developments.

4.4.3 Visioning and goal setting

The purpose of the Breede-Overberg catchment vision (hereafter referred to as the vision) is to provide a collective medium-to-long term perspective of the desired state for the BOWMA. This will guide the definition of management objectives and the development of water related strategies and actions, in order to generate a sense of cohesion and common purpose between the diverse stakeholders in the area. The vision emerged from a series of work sessions with a broad and diverse range of stake-

Table 4.2 Sub-visions of the catchment vision ((Breede-Overberg Management Agency, 2010)).

Zone	Sub-vision
Upper Breede	Healthy and flowing source rivers and wetlands providing water for equitable and efficient agriculture, including downstream in the Breede River
Central Breede	Healthy rivers and groundwater used efficiently and equitably in the agricultural and economic heartland of the Breede region
Riviersonderend	Healthy alien invasive-free rivers and dams used to support regional economic development, agriculture and equity
Lower Breede	Healthy functioning estuary to sustain local development through responsible use and protection of water resources within the entire Breede catchment area
Overberg East	Healthy wetlands and estuaries dependent upon flowing and functioning rivers and aquifers under changing climate and shifting economic conditions
Overberg West	Healthy estuaries, rivers and aquifers that are sustainably used to balance the needs of job creation, residents, agriculture, tourism and conservation

holders. The process entailed the identification of key issues and priorities, translation of these into core elements of the vision for each of the six management zones, and then synthesis of these into a coherent vision for the entire WMA. The vision was thus articulated in the context of a broader development vision for the region, reflecting government development planning imperatives and intent at provincial and local levels.

Furthermore, the vision concerns a balance between environmental protection and agricultural, tourism and urban development with a focus on the needs and aspirations of the catchment's residents. As highlighted in Table 4.2, the vision has been reinterpreted through the sub-visions for each of the six management zones that recognize the inherent differences between the zones and reflect the priority WRM challenges. The vision also highlights the need for adaptation and the possibilities of diversifying the economy through innovative energy and information technologies. This was embedded in a water-related catchment vision for the BOCMA, labelled: "Quality water for all forever". Stakeholders were able to translate the vision into three vision statements, explicit enough to set goals guiding joint action for achieving the balance between protection and development (Table 4.3).

Table 4.3 Shared vision statements ((Breede-Overberg Management Agency, 2010)).

Vision statement 1: Protecting our rivers, groundwater, wetlands and estuaries in a healthy and functioning state for nature, people and the economy	
Goals	• The majority of the Breede and Overberg estuaries and wetland systems are protected in a slightly modified state
	• Riverine water quality is maintained at an acceptable level for the irrigation of fruit and vegetables, as well as contact recreation

Vision statement 2: Sharing our available water equitably and efficiently to maintain existing activities, support new development and ensure redress, whilst adapting to a changing climate and world	
Goals	• Adequate water of good quality is allocated to meet the social objectives of service delivery and equity/redress
	• Economic returns from water used in productive activities are continually improved, together with the efficiency of municipal water use

Vision statement 3: Cooperating to jointly nurture, take responsibility and comply, so that our water resources are well managed, under the leadership of a strong Breede–Overberg CMA	
Goals	• Compliance with water use authorization conditions is improved every year
	• Full implementation of the Breede–Overberg catchment management strategy by those responsible

Table 4.4 Paradigms for the realization of the vision (Breede-Overberg Management Agency, 2010).

Paradigm	**Assumptions and principles**
Business as usual	"A developed landscape" follows a traditional technical planning approach to water management, using existing information (as the best available) to plan water use development projects (regionally and locally), while ecological and water quality impacts are mitigated through local management plans.
Middle ground	"A balanced environment" follows a more precautionary economic developmental approach, acknowledging that current information may be outdated and our understanding of the system is limited, with sustainable water resource protection, development and use being balanced to meet local and national imperatives.
Ecorestoration	"A greener pasture" prioritizes the improvement of riverine and estuary functioning, with sustainable local development where possible, acknowledging that current information and understanding is likely to be outdated and detailed monitoring will be required.

Table 4.5 Strategic areas envisioned for the CMS (Breede-Overberg Management Agency, 2010).

Strategic areas	**Focus**
Protecting for people and nature	This primarily focuses on the management of streamflow, water quality, habitat and riparian zones related to riverine, wetland, estuarine and groundwater resources, to maintain important ecosystem goods and services and biodiversity
Sharing for equity and development	This primarily focuses on the management of water use from surface and groundwater resources through the operation of infrastructure, in order to provide water for productive and social purposes within and outside of the WMA
Cooperating for compliance and resilience	This primarily focuses on the management of institutional aspects to enable and facilitate the protection and sharing of water, including the more cooperative stakeholder, partnership,information, disaster risk and adaptation elements of the strategy

BOCMA considers the catchment vision and vision statements as intentionally aspirational. Notwithstanding possible trade-offs, the goals that reflect the vision indicate the desired state for which the BOWMA should be managed (Table 4.3). Additionally, three distinct management paradigms were formulated that reflect different WRM assumptions and principles and specify how this state should be accomplished (Table 4.4).

Different sessions of stakeholder consultation have been organized to critically assess these paradigms and the underlying philosophy, in terms of the implications for the balance between environmental protection and water resource development-use to be achieved by the CMS. Based on these stakeholder sessions, the middle ground paradigm was claimed to be the most suitable for goal fulfilment and dealing with trade-offs between 'business as usual' and 'ecorestoration'. This claim may hold, unless new information about goal fulfilment proves otherwise.

4.4.4 Backcasting analysis

The vision statements and in particular the goals of protecting, sharing and cooperating, provide the unifying framework for the CMS. The Strategic Areas presented in Table 5 provide the contexts for which management goals are to be translated into Strategic Measures and Actions. BOCMA considers these areas consistent with the resource protection, regulation of water use and facilitating /cooperating strategies proposed by the national Department of Water Affairs guidelines for catchment.

For the backcasting analysis, the aforementioned "middle ground" paradigm has been used to construct pathways to fulfil the long-term goals described in Table 4.4. As illustrated in Figure 4.7, these pathways are meant to represent the intent of the vision statement (rather than comprehensive) and thus to guide the development and implementation of the CMS in each of the strategic areas.

Some overlap between these strategic areas is expected to arise, so linkages have been highlighted where relevant (i.e., the thick arrows in between the strategic areas). This overlap represents contributions of strategic actions to multiple objectives that have been cross-referenced in the implementation of the CMS. A priority-based implementation scheme for these actions has been developed to maximize the benefits of concerted action and to strike a balance between multiple and competing priority issues of stakeholders.

Although beyond the scope of the CMS development, further detailed analysis of critical junctures allows a critical path to surface in the implementation scheme. Critical path analysis defies the idea of goal fulfilment to be a straightforward and certain.

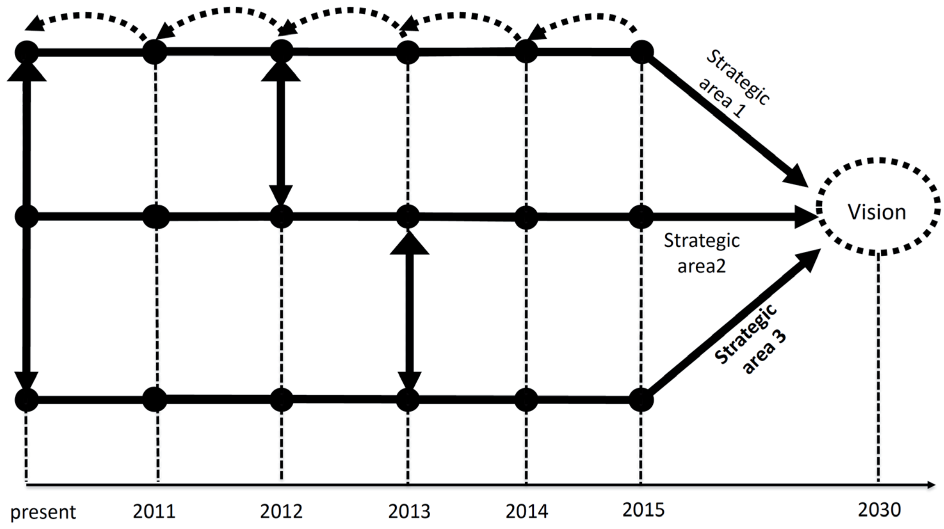

Figure 4.7 A critical path analysis of the CMS implementation scheme.

This could be true under fixed conditions, yet the future is not 'surprise free'. In the latter case, BOCMA's implementation scheme offers limited flexibility to anticipate the impacts of unforeseeable developments like, for instance, delayed effectiveness of actions and/or discontinuities in climate change trends ((Biber, 2009)).

For a robust CMS, goal fulfilment must be secured under varying climatic conditions. This requires a degree of flexibility to reprioritize actions relative to these conditions. Flexibility implies 'slack time' for each priority action, as the time between its earliest and latest starting time without delaying the subsequent or preceding action. This time slot demarcates a window of opportunity to absorb the impacts of unpredicted developments and to mobilize and secure a diversity of means to adapt to those.

4.4.5 Evaluation and monitoring

There are no implementation results of the CMS yet available since the recently drafted CMS awaits endorsement of the Minister. BOCMA will take lead responsibility in monitoring the implementation of the CMS, evaluate the progress made on an annual basis, and take appropriate responses when necessary. Continuous monitoring effort is key to management to remain reflexive. Reflexivity suggests the ability to incorporate minor adjustments or major course corrections in the implementation of the CMS in the face of shifting social, economic, environmental, political and scientific developments. For the CMS to be robust, it should perform well under a wide variety of variable conditions. Although not explicitly stated by BOCMA, robustness implies a continuous quest for the best available information on national and global shifts as well as emerging challenges in the BOWMA. In this line of reasoning, adaptiveness can be explained in terms of reflexivity and robustness. That is, while securing a diversity of means available to address a challenge without compromising adaptiveness over the long run, goal fulfilment needs to be reflexive in order to sustain and/or improve the robustness of the strategy or policy.

4.5 DISCUSSION AND CONCLUSIONS

In this paper, we have developed a five-step backcasting framework complementary to AM. In developing the framework presented, some relevant conceptual and methodological contributions have been made. Conceptually wise, we have developed a coherent understanding of the notions of adaptiveness, robustness, and reflexivity in view of climate adaptation, which is up to date lacking in the corresponding literature. We argue that adaptiveness can be explained by virtue of reflexivity and robustness. While securing a diversity of means available to address a challenge without compromising adaptiveness over the long run, goal fulfilment needs to be reflexive in order to sustain and/or improve the robustness of the strategy or policy. Secondly, theory development on visioning and visions has been limited and many authors do not go beyond the confirmation that it is important to have or develop a vision, mostly in relation to a specific desire for action. We have pointed out the guiding potential of visioning and visions in climate adaptation effort under uncertainty. Given the long-term nature of this endeavor, we have developed a S-curve transition scheme to assess intermediate achievements in regards to a regime's transformative or adaptive capacity.

Methodologically wise, backcasting can be seen as a complementary approach to AM. The methodological congruence between both approaches resides in the methodological purposiveness of the backcasting steps to make the whole process of policy development more adaptive and reflexive. The stage of assessment (AM step 1) benefits from a strategic problem orientation where the full complexity of the systems to be managed needs to be taken into account and scenario development allows for developing different projections of future development of these systems. Policy formulation (AM step 2) should then accommodate the different normative assumptions, goals and worldviews of stakeholders for which visioning can account. The emerging shared vision has the potential to converge stakeholders on a commonly agreed upon problem articulation, goals and plausible directions for holistic goal fulfilment. Achieving an envisioned future is likely to occur, if accompanied by strong visions that can generate clear images of this future and visionary leadership to mobilize present potential to advance into that future. A backcasting analysis serves the need to envision possible trajectories for policy implementation (AM step 3) that perform well under different possible, but initially uncertain, future developments. There lies the ultimate challenge of closing the apparent uncertainty gap between the projected trends and pathways captured respectively by the context and backcasting scenarios. Finally, AM proves to be a suitable overarching concept for strategy and policy development. Policies and strategies are being developed and implemented and need to be regularly appraised in the light of shifting social, economic, environmental, political and scientific developments. Continuous monitoring and assessment on strategy performance (AM step 4) are needed to assess the potential need for minor adjustments or major course corrections. Our methodology provides a normative and reflexive approach to do so.

In this paper we have demonstrated the applicability of our framework in the case of the development process of a CMS for the BOWMA. Our objective herein is to assess the CMS development process selected against our normative five-step framework and what conclusions can we drawn from this inquiry with respect to the framework and its various steps, as distant observers of the process.

Based on this inquiry, we have identified some points of departure for further refinement of the framework. Firstly, scenario development and backcasting analysis should be seen complementary. There is the apparent aim to span the gap between the projected trends in the context scenarios and the pathways identified in the backcasting analysis, highlighting those intermediate events that bring about a desirable future. Secondly, a strong vision allows visioning and goal setting to be integrated into one step of the CMS development process. The vision has mobilized a diversity of stakeholder perspectives and assumptions about a desirable future, articulating the gap between 'what is' and 'what ought to be'. It also allows stakeholders to make explicit statements and set goals that outline plausible though preferred pathways for making the vision reality. Thirdly, backcasting provides AM a long time frame for the fulfilment of short and mid term management goals, whereas AM aims to secure adaptiveness and reflexivity within this timeframe. As the CMS still awaits ministerial approval for implementation, any claims about BOCMA's ability to establish AM in the BOWMA are somewhat premature. The endorsement of the CMS constitutes a critical step forward, as it would act as a 'terms of reference' that reflects a shared desirable future and an intended common line of action and guiding paradigm for bringing about that future.

Finally, by means of this inquiry, we have offered a manual on how to set up a backcasting process in practice. We therefore argue that our methodology would be of interest to policymakers and practitioners, especially those who are engaged in conducting inquiries about future challenges of climate adaptation. Because of its normative, participatory and iterative nature, including its intrinsic learning-by-doing and doing-by-learning approach, our methodology is considered suitable for action research. It does not search for generalizations but rather for designing a backcasting process for specific cases of climate adaptation under large uncertainty. Within the scope of this argument, we consider our methodology useful to compare several cases to learn from them and/or to support the sharing of insights. We proclaim that more learning effort is required to reconcile the past and future for better understanding and responding to future change. This imposes a moral obligation on societies to appreciate a diversity of perspectives and to act now to ensure a climate proof future.

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CHAPTER 5

ENVISIONING ROBUST CLIMATE CHANGE ADAPTATION FUTURES FOR COASTAL REGIONS: A COMPARATIVE EVALUATION OF CASES IN THREE CONTINENTS

The paper reports on a comparative study of three different cases on vision and strategy development for climate change adaptation planning in: (i) The South African Breede–Overberg Catchment, (ii) The Mississippi Estuary-New Orleans region, and (iii) The Dutch Rhine-Meuse Estuary. The objective of the paper is two-fold: to develop a better understanding of such processes, and to further develop the Backcasting-Adaptive Management (BCAM) methodology. A framework for case evaluation is developed using six dimensions: (i) inputs and resources, (ii) future vision, (iii) stakeholder engagement, (iv) methodological aspects, (v) pathway development, and (vi) impact. Major conclusions based on a cross-case comparison and testing propositions are: (i) participatory vision development is a strong tool for climate change adaptation planning in different governance contexts, and shows considerable diversity in its application in these contexts, (ii) a single, shared future vision is not a prerequisite for vision and pathway development and endorsement, (iii) broad stakeholder engagement enriches strategy development, but the involvement of marginal groups requires additional efforts and capacity building, (iv) multiple pathways and robust elements are useful but require novel expertise, and (v) more institutional embeddedness and support for participatory processes leads to better implementation of the outcomes of these processes.

Keywords: vision development; backcasting; climate adaptation; pathways

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Van der Voorn, T., Quist, J., Pahl-Wostl, C., Haasnoot, M., (2017). "Envisioning robust climate change adaptation futures for coastal regions: A comparative evaluation of cases in three continents." Mitigation and Adaptation Strategies for Global Change **22**(3): 519-546.
DOI: https://doi.org/10.1007/s11027-015-9686-4

5.1 INTRODUCTION

Today's densely populated deltaic and coastal regions are facing significant challenges, due to global climate change (Adger et al., 2005b) or extreme natural events such as extreme floods (Aerts et al., 2014; de Moel et al., 2015), droughts (Black et al., 2013) and sea-level rise (Nicholls, 2004, 2015; Weisse et al., 2014). However, the impacts of global climate change will vary a lot in pace and magnitude across regions and continents (Berkhout and Hertin, 2000; Berkhout et al., 2002; Leemans, 2009). Developing climate change adaptation strategies in urbanised coastal regions is a major challenge, due to the large uncertainties of climate change (Dessai et al., 2005; Dessai et al., 2007; Smith et al., 2005; van der Sluijs, 2007; van der Sluijs et al., 2010) and the complexity and strong interconnectedness of social and ecological systems in these areas (Berkes, 2003; Berkes and Folke, 1998; Folke et al., 2005b; Gunderson and Holling, 2002; Walker, 2004). These systems are complex, self-organising, unpredictable and non-linear in their response to intervention, which further complicates predicting and assessing future exposure to climate change (Berkes and Folke, 1998; Scheffer and Carpenter, 2003b). Making water systems more adaptive and resilient to climate change impacts is an important global climate change adaptation strategy, which needs to be downscaled to the regional level (Shaw et al., 2009b; Sheppard et al., 2011).

The need to integrate climate change adaptation and future planning increasingly resonates in environmental science and policy arenas, particularly in regions that need to accommodate socio-economic growth and are seriously threatened by the impacts of climate change (Adger et al., 2005a; Adger et al., 2005b), such as coastal and delta regions. A major challenge is to develop climate change adaptation strategies (Dessai and Hulme, 2004) and water management policies in face of climate-related uncertainties (Gret-Regamey et al., 2013; Lempert and Groves, 2010; Newig et al., 2005; van der Heijden and Ten Heuvelhof, 2013).

Obviously, adaptation planning under uncertainty is needed and several approaches and methods have been proposed, such as robust decision making (Lempert et al., 1998; Lempert and Groves, 2010), adaptive policy making e.g. (Walker, 2001), adaptation pathways (Haasnoot, 2012; Haasnoot et al., 2013a), and Adaptive Management (AM) (Foxon, 2009; Jacobson, 2009; Pahl-Wostl, 2006, 2007a, b). AM can be described as a systematic approach for improving management practices and policies by learning from the outcomes of implemented management strategies and their uncertainties (Foxon, 2009; Jacobson, 2009; Pahl-Wostl et al., 2007b; Schreiber et al., 2004). Like other approaches in climate change adaptation studies, AM benefits from inputs from scenario and foresight approaches to address long-term aspects in climate change adaptation sufficiently.

However, only forecasting and exploratory scenario approaches have become mainstream in climate change adaptation research (Döll et al., 2008; Girod et al., 2009; Leemans, 2009), but these have limitations too. Forecasting generally results in business-as-usual scenarios, but do not account for uncertainties (Isendahl et al., 2009; Quist, 2007). Exploratory scenarios approaches are well equipped for mapping uncertainties, but do often not account for normative preferences or desirability (Quist, 2007; Van der Voorn et al., 2012b).

By contrast, the potential of normative foresight approaches e.g., (Hoekstra, 1998; Middelkoop, 2004; Vergragt and Quist, 2011) has not gained recognition in climate adaption planning (Carlsen et al., 2013; Girod et al., 2009; Gret-Regamey et al., 2013; van Vuuren et al., 2012; Wallis, 2015), although vision development is occasionally used in climate change adaptation planning e.g. (Carlsson-Kanyama, 2013; Cohen et al., 2012; Foxon, 2009). Over the last decade the relevance of visions in sustainability research has been widely recognised and participatory visioning and backcasting frameworks have increasingly been applied to strategy development and implementation in various domains. Backcasting, for instance, is well-known in both futures and sustainability studies (e.g. Robinson 1990, Quist and Vergragt 2006, Quist 2007) and has been proposed as a suitable approach for developing low-carbon pathways and dealing with global climate change (Giddens, 2009).

Backcasting and other normative vision-oriented approaches are suitable for climate change adaptation because of their applicability at various scales, their compatibility with various tools and methods, and their ability to support various forms of stakeholder engagement. Shaw et al (2009b), Sheppard et al (2011) and, Robinson et al (2011), for example, have provided interesting examples of backcasting for climate change adaptation and water management, but have not addressed how this could be related to other approaches in climate change adaptation like AM. Recently, Van der Voorn et al (2012b) undertook a first attempt to describe backcasting (BC) and AM as complementary approaches for climate change adaptation and have combined these in the Backcasting Adaptive Management (BCAM) methodology (see also Carlsson-Kanyama et al. (2013) and Faldi (2014)). The BCAM methodology combines the strengths of both approaches, as backcasting provides AM a long time frame for the fulfilment of short and mid term management goals, whereas AM aims to secure adaptiveness within this timeframe.

In this paper we strongly argue for further exploration of the potential of participatory normative scenario approaches like backcasting (Foxon, 2009; Van der Voorn et al., 2012b), for climate adaptation. Our advocacy aims to expand work on further methodological development of normative scenario and vision approaches for climate change adaptation planning and how this can be combined with management-oriented frameworks like AM. The objective of the paper is twofold: (i) to evaluate cases on vision development for robust climate change adaptation planning; and (ii) to evaluate the outcomes on their potential for further development of normative approaches in climate change adaptation planning in general and for the BCAM methodology in particular. We are particularly interested in whether stakeholder engagement enables implementation and follow-up, whether the guiding and transformative potential of a vision is different in case of multiple or single vision studies, and how multiple pathways support robust climate change adaptation planning. The cases presented in this paper provide illustrative examples of regional responses to climate change, rendering water systems more resilient and adaptive, which are in line with the related global change adaptation strategy: (i) The Breede–Overberg Catchment Management Strategy in South Africa, (ii) The New Orleans Horizon Initiative Water Management Strategy in the United States, and (iii) The Rhine-Meuse Estuary sub-programme of the Dutch Delta Programme in the Netherlands.

This paper is structured as follows: Section 5.2 introduces the BCAM methodology and presents a framework for the evaluation of cases on vision development for climate adaptation. Section 5.3 discusses the research design and the research methodology applied and presents propositions. Section 5.4 presents the selected case studies in three continents that will be evaluated and compared in Section 5.5. Section 5.6 presents conclusions and recommendations and discusses the global relevance of our regional cases and implications for further development of the BCAM methodology.

5.2 EVALUATING VISION AND STRATEGY DEVELOPMENT FOR CLIMATE CHANGE ADAPTATION PLANNING

5.2.1 Combining backcasting and Adaptive Management

Van der Voorn et al. (2012b) recently reported on a methodology that combines the strong points of adaptive management (AM) and backcasting (BC), which builds and expands on earlier work by Pahl-Wostl et al (2007a; Pahl-Wostl et al., 2007b) and Quist (2007) and Quist et al (2011). These methodologies are mutually complementary as backcasting provides AM a long time frame for the fulfilment of short and mid-term management goals and pathways to robust climate change adaptation futures, whereas AM emphasises adaptiveness (the ability to cope with uncertainty) and reflexivity (the ability to respond to changing conditions).

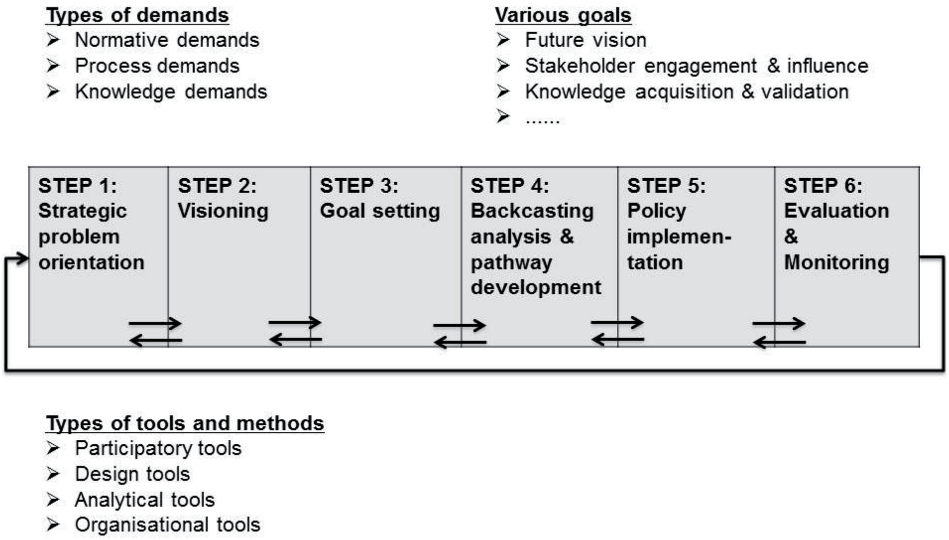

Figure 5.1 The Backcasting Adaptive Management methodology.

As depicted in Figure 5.1, the steps of the BCAM methodology are iterative and cyclic through a feedback loop from step 6 to step 1. Key to the methodology are stakeholder engagement, vision and pathway development, and adaptiveness by learning how to manage uncertainties (Pahl-Wostl et al., 2007a). Ideally, stakeholder involvement is heterogeneous involving stakeholders from all relevant societal domains like business, research, government and civil society. The latter includes both citizens and NGOs. The BCAM methodology includes normative, process and knowledge requirements as well as various goals related to the future vision(s) concerned, stakeholder involvement and their level of influence in the way issues, problems and potential solutions are framed and resolved in the backcasting study. This integration requires various types of tools and methods (Quist et al., 2011; van Vliet and Kok, 2013) including: (i) participatory tools, (ii) design tools, (iii) analytical tools and, (iv) organisational tools.

5.2.2 Evaluation framework

The framework builds on a general structure for evaluating policy analysis activities, as proposed by Thissen and Twaalfhoven (2001) as well as a framework for evaluating participatory backcasting studies and their impact (Quist 2007, Quist et al 2011). Vision and strategy development for climate change adaptation can be seen as participatory policy analysis activities that can be evaluated on: (i) inputs including methods and (ii) actor processes leading to (iii) results and (iv) longer lasting effects in line with Thissen and Twaalfhoven (2001). Further development has led to a framework in which we distinguish six major dimensions of vision and pathway development for climate change adaptation planning: (i) inputs & resources (ii) vision development, (iii) stakeholder engagement, (iv) pathway development, (v) methodological aspects, and (vi) impact. As shown in Table 5.1, for each dimension several evaluation criteria have been defined, as discussed below.

The first dimension covers inputs and resources in climate change adaptation planning and builds on various knowledge bases in the natural and social sciences. These are used to set a baseline for strategic planning and require the availability of data of good quality, as well as sufficient financial resources and capacity. In this phase, actors also need to reflect upon critical knowledge demands for the scientific and contextual, non-scientific knowledge strived for and how these are valued one to another (Quist et al., 2011). Knowledge creation requires an adequate integration of knowledge and expertise to interpret and reframe various bodies of knowledge, as well as data availability. Available knowledge and expertise is assessed separately from stakeholder inputs to the vision, which is adressed in stakeholder engagement below The criteria for characterising inputs and resources in our evaluation study were availability of: (i) financial and human resources and (ii) knowledge and expertise for the case.

The second dimension on vision development is of key importance to backcasting studies. Vision development is about making a set of normative claims about the future by thinking about the kind of future we wish or want to avoid for ourselves (Robinson, 1990; van der Helm, 2009). The potential of a future vision to act as a medium of change lies in its transformative elements, as argued by van der Helm (2009). This also depends on whether the vision has become shared and provides a set of goals, as well as orientation and guidance that motivates stakeholders to commit themselves to the envisioned future and converge in their actions to bring about that future (Berkhout, 2006b). A key issue still remains whether a single vision or multiple visions are most beneficial (see proposition 1 in Section 5.3.1). Like Van der Helm (2009) and Wangel (2011), we also argue that a vision should promote change and the associated goals should be made operational through setting easily adjustable and measurable guiding targets. Whereas goals articulate a desired change in general terms, guiding targets provide criteria that reflect measurable changes e.g., a 30% CO_2 emission (Enserink, 2010). Here, we use the following criteria for assessing the usefulness of a vision to guide transformative change: (i) did the vision include transformative elements that articulate the perceived gap between the present state and the desired future state and (ii) was the vision clearly translated into goals and guiding targets.

Next, concerning stakeholder engagement, stakeholders may have different perceptions of problems and solutions, claim different roles and mobilise different resources to serve their interests (de Bruijn and ten Heuvelhof, 2002). Broad stakeholder engagement is therefore crucial to participatory backcasting studies (Quist and Vergragt, 2006), but there are still different opinions on the added value of broad stakeholder engagement to vision and pathway development (see proposition 2 in Section 5.3.1) (Carlsson-Kanyama et al., 2008). Stakeholder engagement also makes contextual knowledge available, improves the quality and may lead to stakeholder learning and collective support for the outcomes, which in turn increases their legitimacy. We approach the knowledge input from the perspective of participation, by focusing on who contributes to vision development and how. In line with de Bruijn et al (2002) and Quist (2007), the following criteria have been used for evaluating stakeholder engagement in this study: did the process result in (i) stakeholder diversity (i.e., the different types of stakeholders involved, including: business, research, government, civil society, and marginal groups), (ii) stakeholder influence on the way issues, problems, and potential solutions are (re)framed by providing inputs; and (iii) stakeholder commitment showed for the results and implementation (i.e., whether the stakeholders involved endorse the results and their implementation and whether evidence for this can be found in reports or minutes of meetings).

The fourth dimension of pathway development is about defining pathways for bringing about the vision and meeting multiple goals (Van der Voorn et al., 2012b). Pathways should provide a time schedule mapping out when change needs to be realised through milestones and should address not only the types of measures (physical or political) through which change is assumed to occur, but also agency referring to the stakeholders, who are required for the realisation of the vision (Quist, 2007; Quist et al., 2011; Wangel, 2011)). For a pathway to be robust in climate adaption, it needs to be feasible under changing conditions (e.g., climatic conditions). This requires that pathways address various types of uncertainties and include robust elements, which are pathway elements such as signposts i.e., indicator for measuring change (Splint and van Wijck, 2012) and milestones i.e., deadlines for the desired change to be achieved (Enserink, 2010). Robust elements provide critical points of reflection to assess the need for uncertainty management and pathway switching for securing fulfilment of multiple goals under uncertainty (van der Voorn et al 2012 cf. (Haasnoot et al., 2013a)). As such, the elements ensure the robustness of pathways by increasing reflexivity (the ability to respond to changing conditions), flexibility (the ability to reprioritise policy actions within a predefined time frame) and adaptivity (the ability to cope with uncertainty). A major issue is whether and how multiple pathways and robust elements relate to the guiding and transformative elements of visions (see proposition 3 in Section 5.3.1). Moreover, a useful distinction in uncertainty has been suggested by Pahl-Wostl et al (2007b): (i) data uncertainty due to limited availability and the variability of data (ii), uncertainty due to complexity of social ecological

Table 5.1 Evaluation criteria for case assessment and comparison.

Dimension	Evaluation criterion	Description
Inputs & resources	Presence of financial & human resources	Did the project initiator have financial & human resources for the case?
	Presence of knowledge & expertise available	Did the project initiator have knowledge & expertise for the case
Future vision	Presence of transformative elements?	Did the vision include transformative elements?
	Presence of goals & guiding targets?	Did the vision provide goals and guiding targets?
Stake-holder engage-ment & Process	Presence of stakeholder diversity?	How many types of stakeholders involved in the process (out of four types distinguished?
	Presence of stakeholder influence?	Were stakeholders involved able to provide inputs for the process?
	Presence of stakeholder commitment for results?	Did the stakeholders involved show commitment to the results?
Methodological aspects	Inclusion of BCAM methodology elements	Which BCAM methodology elements were included by the methodology applied?
	Inclusion of various types tools and methods	How many types of tools and methods were applied (out of four types distinguished)?
	Inclusion of agency & measures	Were agency & measures present in the pathways developed?
Pathway develop-ment	Inclusion of various types of uncertainties	How many types of uncertainties were included (out of three types distinguished)?
	Inclusion of robust elements	Were robust elements present for uncertainty management and pathway switching?
Impact	Inclusion by formal decision making	Were results included by formal decision-making?
	Examples of follow-up activities for implementation	Did the project lead to follow-up activities for implementation?
	Examples of broader spin-off	Did the project achieve broader spin-off?

systems, cf complex adaptive systems (Pahl-Wostl et al., 2007b), and (iii) uncertainty in the management of these complex systems (Berkes and Folke, 1998; Scheffer and Carpenter, 2003b). The evaluation criteria applied for the dimension pathway development include: the presence of (i) agency and measures, (ii) types of uncertainties, and (iii) robust elements in the pathways.

In addition, both BC studies and studies using AM show a methodological diversity, which we also expect in the three cases studied for which we use two methodological criteria: (i) presence of BCAM methodology elements and (ii) use of various types of tools and methods. Participatory BC studies usually employ all four types of tools and methods discussed in Section 5.2.1.

Finally, key to participatory BC studies is whether implementation, follow-up and spin-off is realised. In line with Quist et al. (2011), the impact of a participatory vision study corresponds to (i) whether the participatory process was included by formal decision making and to examples of (ii) follow-up and implementation activities and (iii) broader spin-off. It has been argued that institutional protection by high levels of decision makers and good institutional embedding is supportive for vision development (Quist 2007, Quist et al 2011), but this needs to be checked for all cases (see proposition 4 in Section 5.3.1).

5.3 RESEARCH DESIGN

5.3.1 Case study characteristics and methodology

A multiple-case study research approach has been designed to investigate three cases on vision and strategy development for climate change adaptation planning: (i) The Breede–Overberg Catchment Management Strategy in South Africa; (ii) The New Orleans Horizon Initiative Water Management Strategy in the United States; and (iii) The Rhine-Meuse Estuary sub-programme of the Dutch Delta Programme in the Netherlands.

Table 5.3 shows some characteristics of the selected cases. The cases show a combination of common characteristics and diversity on other criteria, which can be adequately dealt with through a multiple case study design (Ragin, 1989; Yin, 1994). Common characteristics include: (i) historically vulnerable deltaic or coastal regions with changing climatic conditions and the associated increase of extreme weather events such as floods and droughts, and (ii) a high level of economic activity in major cities or in the region, and (iii) a long tradition of technocratic management paradigm in water resources management.

As described in Table 5.2, diversity is present through (i) the continent (Europe, North America, and Africa), (ii) case study design, (iii) research methods applied, and (iv) type of data collected. Diversity results from a purposeful choice of the cases to: (i) compare climate change adaptation planning effort in different governance contexts and countries and (ii) their relative advancement in this effort. Diversity is also present in the governance contexts, which takes into account the different actors and networks involved in formulating and implementing policy or policy instruments, and the types of participatory vision development process. Based on the typology of governance contexts developed by Pahl-Wostl (2009) and Pahl-Wostl et al (2012), the South African case is characterised by top-down governance. The participatory vision development process was government-initiated but decentralised and empowerment-oriented. In the US case, there is a strong belief in market-based solutions,

Table 5.2 Characteristics of the selected case studies.

Case study	Breede-Overberg Catchment Management Strategy (South Africa)	Horizon Initiative Water Management Strategy (United States)	The Rhine-Meuse Estuary sub-programme of the Delta Programme (the Netherlands)
Governance context	Top-down governance by government	Market-oriented	Polycentric & network-oriented
Type of participatory process	Government-initiated & empowerment-oriented	Bottom-up initiated & facilitated by a private think-tank	Government-initiated & polycentric by different organizations

a small government and private sector initiatives although water safety is a public responsibility. The participatory vision development process was initiated and facilitated bottom-up by a private think-tank. In the Dutch case, polycentric governance dominates, which combines top-down, bottom-up and networked governance with network-based coordination of initiatives and sectors. The participatory vision development process was government-initiated but built upon a polycentric process.

Diversity is a design principle of our study, but also an emergent outcome of the study. It emerges from the nature of the participatory vision development processes investigated and the need to adapt the research design for each case accordingly. As presented in Table 5.3, the South African case has been designed as a qualitative ex-post case study evaluation of a vision-based, regional Catchment Management Strategy development process. In this case, the investigating researcher acted as distant observer reviewing internal documents and reports building on the workshops. In the US case, a participatory action-based research approach for vision development has been applied consisting of two stakeholder discussion meetings preceded by an online standardised survey. In this case, the researcher took on the role of backcasting expert and participant observer. In the Dutch case, visions from various participatory processes were fed into stakeholder workshops, in which the researcher participated as a backcasting expert.

Each case study follows a triangulated research strategy, as multiple research methods can be used and combined to improve our understanding of the same phenomenon under study (i.e., participatory vision development) (Denzin, 1970). Triangulation has enabled us to apply the most suitable research methods to gather data at different times (e.g., project phase) and research settings, involving a variety of stakeholders (Bryman, 2001). These aspects also reflect the ability of the investigating researcher to influence the research design, affecting his choice of research methods and role in the case (Table 5.3). Despite large methodological variety, the participatory vision development processes are the unit of analysis. Triangulation also relates to the various types of data that were used for the qualitative data analyses and collected through the various research methods presented in Table 5.3.

Table 5.3 Characteristics of the research design.

Case study	Breede-Overberg Catchment Management Strategy (South Africa)	Horizon Initiative Water Management Strategy (United States)	The Rhine-Meuse Estuary sub-programme of the Delta Programme (the Netherlands)
Case study approach	Qualitative ex-post case study evaluation	Participatory action-based research	Expert & stakeholder evaluation of existing visions and pathways
Research methods	Desk study, qualitative data analysis, informal interviews;	Desk study, qualitative data analysis, informal interviews, stakeholder workshops, participant observations, online standardised survey	Desk study, qualitative data analysis, informal interviews, stakeholder-expert workshops, participant observations, brainstorm sessions with experts,
Type of data collected	Meeting & project reports, project meeting, expert judgments	Meeting & project reports and expert judgments	Meeting & project reports, expert judgments, stakeholder opinions

5.3.2 Case comparison and proposition testing

A multiple case analysis allows us to evaluate each planning effort within its own context, after which can be looked for general patterns and conclusions from the comparison of individual cases (Yin, 1994). For that aim, we have developed a set of propositions, which will be validated against the evaluation criteria presented in Table 5.1. We argue here in favour of propositions instead of hypotheses, which is in line with Sabatier (1999). He argues that scientists should develop clear and logical interrelated sets of propositions, some of them empirically falsifiable to explain fairly general sets of phenomena. Sabatier (1999:5) based his argument on Ostrom (1999) to distinguish between different stages of theory development and argues that propositions should be applied in early stages of theory development. By contrast, hypotheses are better equipped for statistical evaluation and further advanced levels of theory development.

To bridge the gap in our understanding on theoretical aspects and test their mutual relation addressed in Section 5.2.2, we have developed the following set of propositions:

1. A single, shared future vision is needed for pathway development and implementation.
2. Broad stakeholder involvement enriches vision and pathway development and is needed for endorsement of outcomes
3. Multiple pathways and robust elements strengthen the guiding and transformative potential of visions
4. More institutional embeddedness and inclusion by formal decision making processes are needed for the implementation of the results of participatory vision and strategy development processes.

The propositions will be tested against the outcomes of the evaluation criteria presented in Table 5.1. The protocol applied for the validation is as follows: each proposition proposes a relationship between two dimensions of our evaluation framework. The proposition will warrant acceptance when the presence of two elements can be confirmed for all cases. The rejected proposition will not be reformulated but used as input for our discussion in Section 5.6. In either case, the validation of our propositions will provide further insight into the degree of diversity and general patterns in vision development.

5.4 RESULTS

5.4.1 The Breede Overberg Catchment Management Strategy Case

Case introduction

In 2009, the South African Breede–Overberg Catchment Management Agency (BOCMA) started the development of a Catchment Management Strategy (CMS) to initiate a shift from the traditional technical planning-based management of water resources towards a more adaptive management style. Under the National Water Act, BOCMA has become responsible for protecting, using, developing, conserving, managing and controlling water resources, as well as raising broad awareness of the importance of water to the Western Cape regional economy. The Breede–Overberg catchment (see Figure 5.2) falls entirely within the Western Cape Province and is characterised by tourism and agriculture. The latter includes historically disadvantaged black farmers. Climate change and the associated increase of extreme weather events call for a CMS that meets present and future challenges for water resources management in the catchment area (BOCMA, 2010). These challenges include increased risks of extreme flood events, reduced soil moisture and more severe wildfires during dry periods. In addition, conflicts over water use of various water user groups will intensify due to growing water demand exceeding the average available water resources, which will compromise regional sustainable development.

The CMS development process started in September 2009 and was completed in May 2010. Stakeholder engagement took place during all steps of the CMS process. In February 2011, a first draft CMS was submitted to the Minister of Water Affairs. After July 2011, when the CMS was approved and published as a statutory document, the CMS has been rolled out to the six management zones of the Catchment (see Figure 5.2) and water use associations have been established to facilitate its implementation.

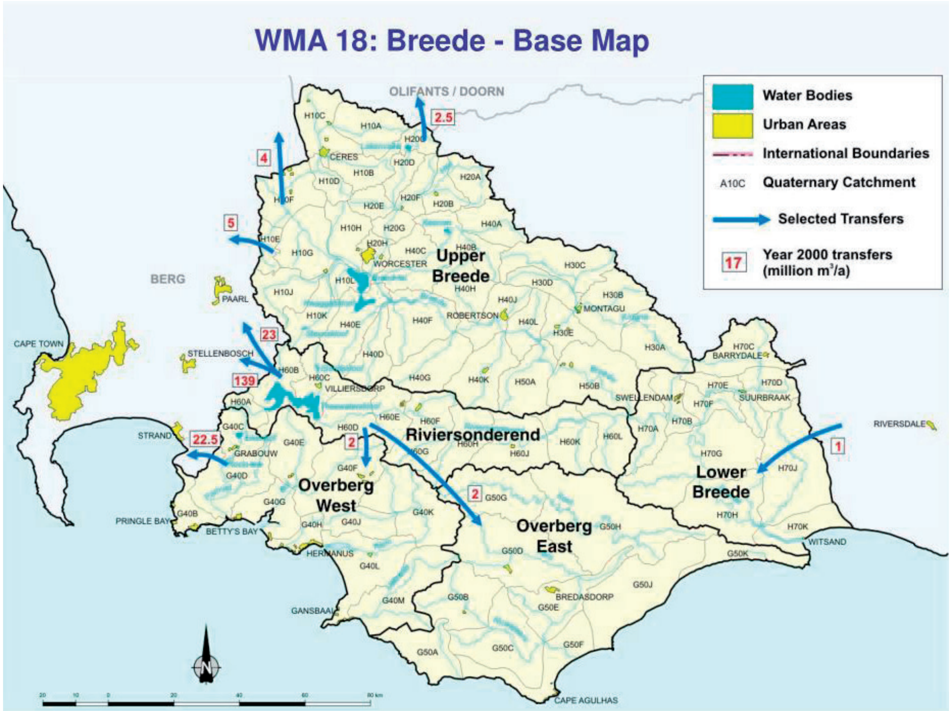

Figure 5.2 The Breede-Overberg Catchment (BOCMA, 2010).

Case results

In terms of inputs and resources, BOCMA made significant financial resources available to contract a consortium of private sector companies in August 2009 to provide the human resources for carrying out the CMS development process (BOCMA, 2009). The consortium provided the expertise and knowledge required for the CMS development process (BOCMA, 2009). Activities included outlining the CMS development and stakeholder engagement process; conducting technical water resources assessments; guiding and organising stakeholder engagement and the supported sub-strategy development.

Vision development for the CMS addressed water resources management in the Breede–Overberg Catchment for the next 20 years. A catchment vision was developed to envision a desirable future social ecological state of the Catchment area. The Quality water for all forever vision emphasises a balance between environmental protection and agricultural, tourism and urban development with a focus on the needs and aspirations of all the catchment's stakeholders. The vision was developed and approved by stakeholders who participated through a series of regional open meetings (BOCMA, 2009). For all six management zones of the Catchment, key issues and priorities were identified and processed into a coherent vision for the entire Catchment. The vision promotes broader development of the Catchment, setting priorities for development planning at provincial and local levels. Stakeholders identified the following transformative elements of the vision (BOCMA, 2010): (i) institutional arrangements for adaptive policy-making to better cope with uncertainties, (ii) a new institutional framework for adequate response to water governance challenges of the Catchment area, (iii) new institutional arrangements for decentralised management that addresses solutions to local problems that are in line with the national water resources strategy. Furthermore, stakeholders elaborated the vision into three vision statements for three sustainable water (resources) management (BOCMA, 2010): (i) environmental protection and conservation for people and nature, (ii) sharing water for equity and development, and (iii) institutional development. These statements were translated into generic and regional goals guiding the implementation of the CMS at the local level in the catchment for the next 5 years. These goals provide short-term guiding targets (BOCMA, 2010; van der Voorn, 2015).

Concerning stakeholder engagement, a bottom-up participatory approach was applied for the CMS development process aiming to make use of local stakeholder knowledge as well as to create a sense of ownership for the CMS among the stakeholders whose concerted efforts are required for its implementation (BOCMA, 2010). Stakeholder engagement was diverse and initiated through a series of open stakeholder meetings held in all six management zones of the Catchment, which included a total of 65 stakeholders such as farm business, civil society organizations, researchers, provincial and local governments, as well as citizens and historically disadvantaged groups like local black farmers (BOCMA, 2009). The 1998 National Water Act prescribed the involvement of these largely illiterate groups. This appeared quite difficult, but was very successful; it was their first time involved in such a participatory process. Stakeholder influence was large regarding the thematic scope and the envisioned outcomes of different stages (BOCMA, 2009). There was considerable stakeholder commitment for the overall outcomes of the CMS (BOCMA, 2009).

Considering pathway development, the CMS development process resulted in an overall implementation scheme for the CMS but did not include any long-term pathways (BOCMA, 2010). The scheme includes short-term implementation paths addressing the issue of agents and measures. For each vision statement an implementation path with milestones has been developed, which illustrates what kinds of actions and measures and by whom, these milestones are to be achieved. The scheme takes into account various types of uncertainties: (i) data uncertainty due to limited availability and reliability of information about hydrology, irrigation, and water use in particular by historically disadvantaged native farmers, (ii) uncertainty about the complexity of the Catchment region and (iii) management uncertainties. However, the overall implementation scheme does not include robust elements, as defined in Section 5.2.2.

When it comes to methodological aspects, the following BCAM elements could be found in the applied CMS methodology: (i) strategic problem orientation, (ii) vision and pathway development, (iii) goals setting, (iv) backcasting analysis, (v) diversity in stakeholder engagement, and (vi) uncertainty awareness and identification. All four types of tools and methods have been used. Analytical, participatory, organisational and design tools were used throughout the CMS development process.

Impact wise, the final draft of the WMS was issued in February 2011. The CMS development process had substantial impact because it was included by formal decision-making at the ministerial level. As a follow-up, BOCMA initiated a validation and verification process to determine exactly how much water is used by whom in the sub management areas of the Catchment area. After ministerial endorsement in July 2011, implementation of the CMS has started step by step. The Minister of Water Affairs endowed BOCMA with management capabilities in support of the CMS implementation but also with more legal responsibility for future follow-up activities and for allocating financial resources to these activities. These endowments have expanded BOCMA's capacity to implement the results of participatory processes. Additionally, 21 Water User Associations have been established in support of operational water resource management in the Catchment. Broader spin-off took place through awareness raising initiatives on other topics as well as in capacity building and knowledge dissemination initiatives within the Catchment region.

5.4.2 The Horizon Initiative Water Management Strategy

Case introduction

Since its foundation in the early 18th century, New Orleans has suffered serious floods caused by both hurricanes and extreme run-offs of the Mississippi River (Klein, 2007; Wright, 2000). Until the 1970s, the principal approach to flood damage reduction had been the construction of levees (WMO, 2004). This levee-only paradigm proved to be effective in controlling flood disasters and damages, but also at the expense of the natural environment in the long run. As a consequence, flood control issues were dealt with in isolation and potentially undesirable long term consequences were not taken into account (McCool, 2005; Wright, 2000). Since the 1970s, more environmentally sound flood damage reduction measures have been implemented, but the region remains vulnerable to flooding and extreme weather events as Hurricane Katrina revealed in 2005 (Van der Voorn, 2012).

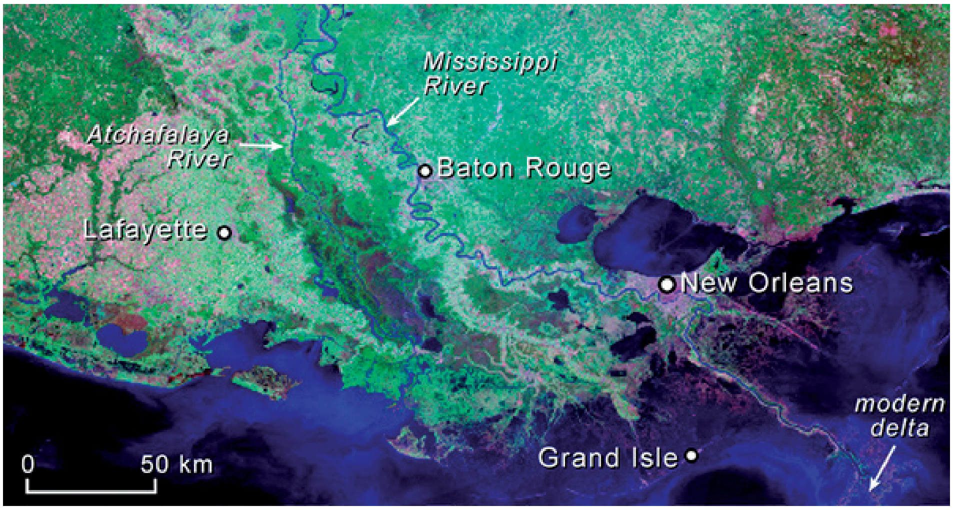

Figure 5.3 The Mississippi Estuary-New Orleans region.

In 2010, the Horizon Initiative Water Management Committee (hereafter referred to as the Committee) further advanced its strategic planning effort over the past years to develop an integrated water management strategy (WMS) for the New Orleans region (Figure 5.3). The Committee is a non-profit organisation providing an informal network of individuals from a broad array of public organisations[19]. The Committee has been acting as a private think-tank, seeking opportunities to establish public-private partnerships to support the City of New Orleans in developing more integrated and adaptive water management approaches.

The WMS development process took place during the period of May-July 2010, in which two committee meetings were held on June 16 and July 14, 2010. Prior to these meetings, a pre-assessment was made to identify the current state of and future challenges for water resources management in the region. In August 2010 the Committee released and endorsed a synthesis report on the WMS, guiding the Committee's effort to promote integrated and adaptive water management approaches in the Mississippi Estuary-New Orleans region (Van der Voorn, 2010).

Case results

In terms of inputs and resources, the Committee lacked financial and human resources for extensive strategy development activities, but its members provided expertise and knowledge on various topics relevant to the WMS. The pre-assessment involved desk

19. The City Council of New Orleans, the City Office of Recovery Management, the City Planning Commission), private firms and architectural offices, and local knowledge bodies, such as Tulane University, Loyola University and the University of New Orleans.

research of several studies for long-term water management in the region (Van der Voorn, 2010). This information on relevant activities in the Mississippi Estuary-New Orleans region was used as input for the Committee meetings.

The starting point for vision development was to evaluate how transformative elements of existing visions could be combined to support the City of New Orleans in promoting adaptive water management in the region. The Committee members identified the following transformative elements for the WMS (Van der Voorn, 2010): (i) development of public-private partnerships to create a new market for water management products and services, (ii) the Dutch Dialogues guiding principle of living with water, from which safety and amenity from water were considered crucial to a robust, vibrant and secure future for New Orleans, (iii) an integrated and adaptive approach to address the challenges of climate change for water resources management and spatial planning. Furthermore, the Committee compiled a list of 39 water management goals, but specific guiding targets were not included (Van der Voorn, 2010; van der Voorn, 2015).

Concerning stakeholder engagement, a participatory yet expert-oriented approach was chosen for the WMS development process (Van der Voorn, 2010). The process included two Committee meetings, providing a venue for the Committee and its members to discuss a wide variety of policy topics relevant to the Committee's mission. Diversity in stakeholder engagement was broad, despite the attendance of the Committee meetings was upon invitation, voluntarily and limited to existing networks leaving out stakeholders like marginal groups and citizens. Furthermore, stakeholder influence was considerable, though an in-group set the agenda prior to meetings and had more influence on results. The in-group was interested in novel ideas, but also sceptical when vested interests were potentially at stake. Stakeholder commitment for the results of the meetings was large among those involved.

Pathway development did not take place in the WMS development process. The resulting report (Van der Voorn, 2010) outlines plausible directions for the WMS, but without any concrete pathways. Regarding the issue of agents and measures the Committee conducted a survey among its members to examine what needs to change and how. These inquiries supported the Committee to compile the list of 39 goals. Various types of uncertainties were addressed in the report including: (i) data uncertainties due to limited availability and variability of climate data, (ii) uncertainty due to the complexity of the ecological systems of the region, and (iii) management uncertainty due to management obstacles in implementing the WMS. The report did not provide an implementation scheme for the WMS, but rather presented desirable endpoints pointing to new policy directions. As such, no robust elements were included.

Methodologically, the BCAM methodology elements identified include: (i) visioning and (ii) goal setting. A limited number of tools and methods were used to support the WMS development process. In addition to desk research, consultation of committee members took place through roundtable discussions and an on-line survey.

Impact wise, the WMS development process had limited impact because it was not included by formal decision-making at the city or state level. As a follow up, the Committee has put more efforts in further advancing the WMS and in seeking new and extending existing strategic partnerships for the implementation of the WMS. Since the Committee lacks the power and resources to implement the WMS, its members started to collaborate with the City of New Orleans (The Master Plan for New Orleans) and with the State of Louisiana (The Louisiana State Coastal Restoration Plan) (Van der Voorn, 2010). By reaching out to citizens through neighbourhood workshops on drainage and building resilience and lobbying with policy makers, the Committee has also put substantial effort in capacity building and awareness raising initiatives on water-related sustainability issues in order to raise public support for the WMS. Broader spin-off took place through knowledge dissemination activities of the Committee to further promote the WMS (inter)nationally. Broader spin-off took place through Committee members who integrated the outcomes of the WMS development process in their daily work in citywide post-Katrina rebuilding initiatives on watershed, storm water, and drainage management.

5.4.3 The Rhine-Meuse Estuary sub-programme of the Delta Programme

Case introduction

Since the construction of the Delta Works in response to the 1953 storm surge, the Dutch Rhine Estuary is considered one of the world's estuaries most protected against flood and sea-level rise (Walraven and Aerts, 2008; Wiering, 2006). To address the challenges of climate change, a Delta Act on water safety and fresh water supply was enacted in 2011. This has led to the Delta Programme to develop an overall framework for both flood safety and a sufficient supply of freshwater up to 2050 (Deltaprogramme, 2011c). It includes a sub-programme on the Rhine-Meuse Estuary, consisting of the greater Rotterdam region and the region around Dordrecht bordering to the closed tidal inlets of the Haringvliet and Hollands Diep in the South (see the area enclosed by the dashed line in Figure 5.4). Changing climatic conditions will continue to pose a significant risk of increased likelihood of sea level rise, river discharge and salinization of the soil in agricultural areas (Deltaprogramme, 2011c). The Delta Programme's adoption of a so-called adaptive delta management approach reflects an on-going shift from traditionally technocratic management of water to a more adaptive style.

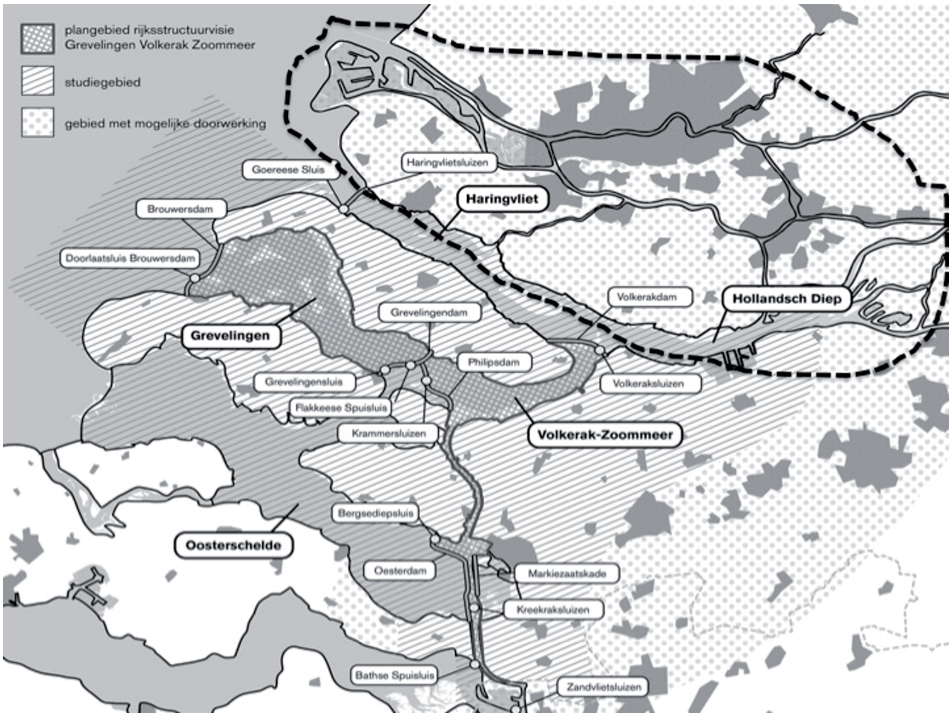

Figure 5.4 The Rhine-Meuse Estuary.

This case consists of various vision studies, followed by strategy development for adaptive delta management in the Rhine-Meuse Estuary sub-programme of the Delta Programme from May to October 2010. The results of the assessment were used as input for two stakeholder workshops on strategy development held in March and April 2011. A major outcome of the workshops was: (i) a better understanding of how various elements of the visions studies support adaptive delta management in the Rhine-Meuse Estuary and (ii) a set of regional climate scenarios, which provide further insight into possible pathways to adaptive delta management.

Case results

In terms of inputs and resources, an important aim was to relate and assess several vision studies that had already been conducted: (i) The Rhine-Meuse Estuary sub-programme of the Delta Programme (A safe and liveable Delta (Deltaprogramme, 2011a, c)) (ii) the Rotterdam Climate Proof 2030 vision study (Rotterdam Climate Proof in 2030 (RCP, 2010)), (iii) The Port Vision 2030: the Port Compass project (Rotterdam as the Global Hub & Europe's Industrial Cluster in 2030 (PoR, 2011)). The assessment was meant to provide relevant input for the two stakeholder and expert workshops and included development of regional climate scenarios. The Delta Programme made financial and human resources available by contracting Deltares that assembled a project team of experts to conduct the assessment[20]. Sufficient expertise was available in the project team to provide relevant knowledge for the workshops and their facilitation. During these workshops, the workshop participants provided inputs for building blocks for adaptive delta management in the Rhine-Meuse Estuary, which describe sets of measures related to the vision studies.

During vision development, workshop participants identified the following transformative elements in the available vision studies: (i) adoption of integrated and adaptive concepts for water resource management (Deltaprogramme, 2011a, c), (ii) recognition of climate change as a driver for physical, economic and social reform of the city and region and where urban planning and water management are combined in an integrated approach (PoR, 2011; RCP, 2010)), (iii) public-private partnerships through which innovations can be fostered (PoR, 2011; RCP, 2010), Furthermore, the goals of the vision studies concerned provide guiding targets for the implementation of these visions in the short and long-run (van der Voorn, 2015).

With regard to stakeholder engagement, broad diversity can be found both in the vision studies (in particular in the Rotterdam Climate Proof 2030 vision study) and in the strategy workshops, despite the absence of stakeholders from the citizenry and marginal groups. In all three vision studies and in the strategy workshops (Deltaprogramma, 2012), there was considerable stakeholder influence. Stakeholders were able to provide input for the participatory processes, in which they were involved. Stakeholder commitment for the results of the processes was large, but limited to the stakeholder groups involved.

With regard to pathway development, the stakeholder strategy workshops did not result in joint pathways that include various types of uncertainties and robust elements (Deltaprogramme, 2011a). However, the Rotterdam Climate Proof (RCP, 2010) and Port Vision 2030 (PoR, 2011) studies generated pathways that include agents and measures, which describe a wide range of policy options for the implementation of the corresponding visions. These pathways take into account various types of uncertainties: (i) data uncertainties, (ii) uncertainty due to the complexity of social-ecological systems in the region, and (iii) management uncertainties due to the absence of a common baseline for risk and uncertainty management and for monitoring and evaluation policy impacts of measures taken. In addition, the pathways include robust elements such as signposts and milestones for uncertainty management and pathway switching for securing the fulfilment of multiple goals under uncertainty.

20. A independent research institute for applied research in the field of water, subsurface and infrastructure

Methodologically, the methodologies applied in the vision studies that are part of the case study include the following BCAM methodology elements: (i) visioning, (ii) goal setting, (iii) backcasting and, (iv) uncertainty awareness and identification. Various types of tools and methods have been used. Participatory tools such as focus groups have also been used to gather expert knowledge. Design and analytical tools and methods such as scenario development and climate impact assessment have been applied for the development of four regional context climate scenarios for the implementation of adaptive delta management in the Rhine-Meuse Estuary. The scenarios are based on different projections of climate change and socio-economic development for the region (Deltaprogramme, 2011a). Organisational tools have been used for process management.

Impact wise, the two stakeholder workshops are fed into formal decision-making as the results have been used as inputs for long-term water management decisions for the Rhine-Meuse Estuary region taken by the Dutch Government in the autumn of 2014, after which follow-up commenced. Broader spin-off took place through knowledge dissemination in particular within the Knowledge for Climate program in the Netherlands and among stakeholders involved in other parts of the Delta program.

5.5 CASE COMPARISON AND TESTING PROPOSITIONS

5.5.1 Case comparison

Inputs and resources

In all three cases, sufficient knowledge and expertise were made available but in different ways that corresponded to the availability of financial and human resources. In the South African and Dutch cases, there were sufficient financial and human resources available to obtain the required knowledge and expertise for stakeholder workshops by contracting external partners. Due to a lack of financial and human resources, internally available knowledge and expertise were used for strategy development in the US case.

Future visions

In the South African and in two vision studies of the Dutch case, a single shared vision was successfully developed, whereas multiple existing visions were the starting point for the US case and for the second - integrative - part of the Dutch case. In all three cases, transformative elements were identified that clearly articulate a perceived gap between the present and the desired future state, and contained novel ideas and approaches for bridging this gap. A common key transformative element in all three cases is the desire for a shift from traditionally technocratic management of water resources to a more adaptive and integrated management style.

Furthermore, the cases confirm the presence of overall goals but considerable diversity can be found in the way they were set. In the South African case, a single shared vision was translated into a set of shared goals to guide the implementation of the CMS in the catchment. In the US case, an initial goal set was extended using a range of existing vision studies. The Dutch case shows overlap between the goals of the existing vision studies, although shared goals are yet to be developed in the next phase of the Delta program.

Moreover, there is substantial diversity in the guiding targets of the goals associated with the future visions investigated. Two vision studies of the Dutch case include guiding targets and the South African case shows guiding targets for the short term, whereas the guiding targets are yet to be determined in the US case and in the second (integrative) part of the Dutch case.

Stakeholder engagement

All three cases show broad and diverse stakeholder engagement. In the South African case, major capacity building effort was required because marginal groups had never been involved before in water management decision processes. The case demonstrates that considerable effort is required to mobilize and secure the involvement of marginal groups and citizens. In the US and Dutch cases there was diverse stakeholder involvement, though stakeholders from the societal domains, in particular citizens and marginal groups, did not participate. Moreover, all cases show both considerable stakeholder influence and commitment for the results among the stakeholders involved.

Remarkably, in the US case, it was a non-governmental stakeholder who took the lead and role of convenor in the process, whereas it were governmental organisations that took the lead in the other cases.

Pathways

In the South African and US cases, no long-term pathways were developed. The South African case resulted in a scheme with short-term implementation paths that include uncertainties but no robust elements. Long-term pathways are present in the two vision studies in the first part of the Dutch case. These pathways include not only agency and measures, but also various types of uncertainties and robust elements that enable both uncertainty management and pathway switching.

Table 5.4 A summary of the cross-case comparison.

Criteria	The South African case	The US case	The Dutch case
Dimension: Inputs & resources			
Availability of financial & human resources	Yes	No	Yes
Availability of knowledge & expertise	Yes	Yes	Yes
Dimension: Future vision			
Presence of transformative elements	Yes	Yes	Yes
Presence of goals and guiding targets	Goals and short-term guiding targets	Only goals	Goals and guiding targets (Rotterdam Climate Proof and Port Vision 2030)
Dimension: Stakeholder engagement & process			
Presence of Stakeholder diversity	All types	All types, except marginal groups & citizens	All types, except marginal groups & citizens
Presence of stakeholder influence	Yes	Yes	Yes
Stakeholder commitment for results	Yes	Yes	Yes
Dimension: Methodological aspects			
Inclusion of BCAM methodology elements	Visioning; goal setting; backcasting analysis; pathway development; uncertainty awareness & identification	Visioning & goal setting; uncertainty awareness & identification	Visioning; goal setting; backcasting analysis; pathway development; uncertainty awareness & identification
Inclusion of various types of tools and methods	Yes (four types)	Yes (two types)	Yes (four types)
Dimension: Pathway development			
Inclusion of agency & measures	Yes (in short-term implementation paths)	No	Yes (pathways of Rotterdam Climate Proof and Port Vision 2030)
Inclusion of various types of uncertainties	Yes, (three types)	Yes, (three types)	Yes, (three types)
Presence of robust elements	No	No	Yes (uncertainty management & pathway switching)
Dimension: Impact			
Inclusion in formal decision making	Yes	No	Yes
Examples of Follow-up activities of the project	Yes	Yes	Yes
Examples of Broader spin-off	Yes	Yes	Yes

Methodological aspects

In all three cases BCAM methodology elements could be identified in the methodology applied, especially those related to adaptive management, goal setting, vision development and stakeholder engagement. In the South African and Dutch cases, all four types of tools and methods were applied whereas mainly participatory tools were used in the US. Several tools and methods were applied that can be used for further development of the BCAM methodology: (i) regional climate scenarios, (ii) capacity building supporting involvement of marginal groups, (iii) multiple existing vision studies as input for goal setting and strategy development, and (iv) robust elements for uncertainty management and pathway switching, which were present in the two vision studies of the Dutch case (Section 5.4.3).

Impact

All three cases show impact, but the extent of follow-up and implementation varies considerably. The South African case shows substantial impact as the strategy development process was included in formal decision-making. Governmental endorsement of the newly drafted water management strategy led to additional financial resources for implementation and other follow-up activities. In the US case, there was limited impact because the strategy development process was not included in formal decision-making and therefore the Committee worked on agenda setting through awareness rising, and capacity building. Follow-up activities were established through new strategic partnerships and capacity building initiatives, which were needed because the Committee lacked resources and regulating power. In the Dutch case the strategy development process has been included by formal decision-making completed in 2014, and follow-up activities have commenced at the beginning of 2015. All cases also show broader knowledge dissemination as examples of broader spin-off. An overview of the cross-case comparison is given in Table 5.4.

5.5.2 Testing propositions

P1: A single, shared future vision is needed for pathway development and implementation.

Proposition P1 assumes a relationship between a single, shared future vision on the one hand and the prospects for pathway development and implementation on the other hand. The South African case confirms this proposition, whereas the Dutch case partly supports and partly rejects this proposition. The US case did not aim at developing pathways, and thus does not provide evidence for this proposition. Consequently, proposition P1 cannot be confirmed or rejected.

P2: Broad stakeholder involvement enriches vision and pathway development and is needed for endorsement of outcomes.

Proposition P2 suggests a relationship between broad stakeholder engagement and vision and pathway development and endorsement. The South African case partly supports the proposition because it involves broad stakeholder engagement that enriched vision development with stakeholder input, whereas only short-term pathway development took place. As stakeholder engagement enriched goal setting in the US case without vision development, the first part of the proposition can be confirmed by the two vision studies of the Dutch case. Furthermore, all cases show considerable stakeholder influence and stakeholder commitment for results. Consequently, proposition P2 is confirmed by the Dutch case, whereas the US and South African cases do not provide sufficient evidence for this proposition.

P3: Multiple pathways and robust elements strengthen the guiding and transformative potential of visions.

Proposition P3 assumes a relationship between multiple pathways and robust elements and the guiding and transformative potential of visions. Multiple pathways and robust elements are present in the two vision studies of the Dutch case, but there is no evidence that they strengthen the guiding and transformative potential of visions. The South African and US cases show that pathway development is complex and cutting edge, for which expertise is yet limited. In the South African case, sufficient resources and knowledge were available for pathway development, but there was limited expertise on how to develop pathways and robust elements. Pathway development did not take place in the US case due to a lack of knowledge and expertise. Hence, proposition P3 cannot be confirmed.

P4: More institutional embeddedness and inclusion by formal decision making processes are needed for the implementation of the results of participatory vision and strategy development processes.

Proposition P4 suggests a relationship between the extent to which participatory vision and strategy development processes are institutionally embedded and supported and the implementation of the results of these processes. All three cases show clear impact and spin-off, but vary in implementation. However, inclusion in formal acts or plans and the presence of a commissioning actor like a government agency, which takes responsibility for generating and using the outcomes for implementation and follow-up activities at the national or local level, are conditions for implementation, but are not sufficient. Another condition is inclusion of the strategy development process by formal decision-making. Both the South African and Dutch cases meet these conditions, whereas this is not the case for the US. Consequently, the cases confirm proposition P4 in two ways.

5.6 DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.6.1 Discussion and conclusions

In this paper, we have developed and applied a framework for the evaluation of cases on vision development for robust climate change adaptation planning. In addition, the outcomes are useful for further methodology development for the BCAM methodology and other vision-based normative approaches in climate change adaptation planning (see Section 5.2). The framework has been useful to describe and analyze a diverse set of cases (Table 5.2) showing both differences and similarities in very different contexts (as summarized in Table 5.4).

The study results show considerable diversity in our cases on regional participatory vision development, which is both an emergent outcome and a design principle of the study. The cases provide valuable insight into the different ways, in which vision development took place in different governance contexts. The nature and design of vision development are characteristic for the related governance context, which appears to have less impact on the outcome of the process than expected. This may indicate that other dynamics are at play such as learning processes, which are beyond the scope of our evaluation framework. Such processes provide further insight into how expertise and knowledge have affected the development and stakeholder endorsement of the visions in the cases.

Cross-case comparison and testing propositions have led to the following findings, providing general patterns in vision development for climate change adaptation planning. First, all three cases demonstrate the presence of visions in climate change adaptation planning, regardless whether a single or multiple visions were used for pathway development. Moreover, the cases demonstrate that a single, shared future vision is not a prerequisite for vision and pathway development and endorsement, which is counterintuitive and defies the dominance of single, shared visions in the current literature. The material even suggests that multiple visions for climate change adaptation may be more beneficial than single visions to better address uncertainties, but this issue warrants further investigation.

Second, the cases confirm that broad stakeholder engagement is essential for enriching vision and pathway development. It generates stakeholder commitment for and co-ownership of the results of stakeholder processes, although the latter does not guarantee implementation. The involvement of marginal groups requires major capacity building effort, but broadens both stakeholder involvement and commitment considerably (van der Voorn, 2006; van der Voorn, 2008)). This supports inclusion of divergent and marginal perspectives on the vision, which may not happen otherwise (Cuppen et al., 2010).

The cases show that developing long-term pathways and robust elements refers to a conceptual and methodological novelty for which resources are not always available and expertise seems limited. The Dutch case is more advanced in pathway development than the other cases, which may point to the leading position of the Netherlands in climate change adaptation effort. A longitudinal study would be useful to investigate and compare advancements in the case study regions over long periods of time.

The influence of the governance context on the extent of follow-up and implementation seems less important in the cases than a good connection to formal decision-making process. Instead, both institutional embeddedness of participatory processes and their outcomes and a good connection to formal decision-making processes are highly required for follow-up and implementation.

It must be noted that the study did not look into blocking and opposition by (non-involved) stakeholders that see their interests affected. It should be realized that this can also be applied to non-involved groups of citizens or non-involved marginal groups.
Third, government agencies play an important role in the observed impact of the vision studies, because they are responsible for managing stakeholder processes and provide institutional protection for follow-up activities and broader spin-off, including the allocation of resources required for these activities.

Based on these insights, major conclusions can be drawn: (i) participatory vision development is a strong tool for climate change adaptation planning in different governance contexts, and shows considerable diversity in its application in these contexts, (ii) a single, shared future vision is not a prerequisite for vision and pathway development and endorsement, (iii) broad stakeholder engagement supports strategy development, but the involvement of marginal groups is complicated and requires substantial efforts, (iv) multiple pathways and robust elements are helpful but require novel expertise, and (v) more institutional embeddedness of participatory processes through connecting to formal decision-making processes leads to better implementation of the outcomes of these processes.

The global relevance of our regional cases on participatory vision development includes the more advanced tools and methods like the use of robust elements and testing pathways against different context scenarios. Broad stakeholder engagement, including marginal groups, is important to develop better visions and stimulate their endorsement. Furthermore, exchange of cases and their learning results between different regions is needed and could be used to enhance capacity building and to speed up the dissemination of new advanced tools and methods.

As such, we propose the following recommendations for global climate change adaptation strategy development, which can be downscaled to the regional level:

- Include broad stakeholder engagement for vision and pathway development
- Develop multiple, long term pathways with robust elements and test pathways against different context scenarios
- Build capacities and expertise on the application of robust elements and pathways and establish the transfer of best practices
- Develop a global agenda and framework for disseminating knowledge and experience to transfer global, national and regional climate change adaptation efforts, cases and knowledge, e.g. on robust elements and multiple pathway development

5.6.2 Recommendations and implications for methodology development

Based on the case study results, the following recommendations can be given for further BCAM methodology development is necessary to increase its potential for global application:

- Enhance the involvement of marginal groups and citizens.
- Mention clearly the benefits of institutional embedding of participatory processes, as it enables implementation, and provides methods for this.
- Extend with tools and methods that grasp, employ and reconcile existing visions and pathways.
- Further methodological development is needed on multiple pathways, robust elements and testing against different global context scenarios.
- Long-term pathways were not present in all the cases, but their presence is important and should be enhanced in the BCAM methodology.

The general recommendations above can be detailed for different steps in the BCAM methodology, which is presented in Table 5.5. Further integration of AM principles, policy implementation, indicator development and monitoring would make the BCAM methodology a comprehensive and promising methodology for climate change adaptation planning.

Table 5.5 Overview of recommendations for methodological refinement.

Step	Recommended refinements
Step 1	• Identify and involve relevant marginal groups and use capacity building. • Develop new or use existing context scenarios depicting different options how climate change adaptation can occur in the region. • Use both existing vision studies as input for the participatory process and assess on similarities, differences and usability.
Step 2	• Reconcile capacities, existing visions and various bodies of knowledge to replace developing visions from scratch
Step 3	• Integrate guiding targets in goal setting for striking a balance between short-term and long-term goals
Step 4	• Include robust elements in pathway development to include adequate responses to uncertain external developments
Step 5	• Use performance indicators (e.g., milestones) for adaptive policy making
Step 6	• Include indicators of change (e.g., early warning mechanisms and signposts) in evaluation and monitoring • Use indicators of change to signal uncertain and/or unforeseen future developments and perceived discrepancies in goal fulfilment. • Use indicators of change for the development of context scenarios supporting adaptive policy implementation.

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CHAPTER 6

ADVANCING PARTICIPATORY BACKCASTING FOR CLIMATE CHANGE ADAPTATION PLANNING USING 10 CASES FROM 3 CONTINENTS

In the face of climate change, a major challenge is to inform and guide long-term climate change adaptation planning under deep uncertainty, while aiming at transformative change. Normative futures studies approaches, such as participatory backcasting, visioning and transition management, are increasingly applied, but their potential for climate change adaptation research and practice remains undervalued. This paper aims to advance the potential of backcasting in climate adaptation, by comparing various climate change adaptation studies that have used backcasting or visioning approaches. A framework has been further developed and applied to evaluate 10 cases in Africa, Europe and North America, using four dimensions: (i) inputs and settings; (ii) process and methods (iii) results, and (iv), impact. Our evaluation provides key insights into the use and further development of backcasting for climate adaptation. Key elements to add are advanced system modeling, robust elements, pathway switching and hybrid pathways, enhancing participation of marginal groups, and contributing to impact by facilitating the utilization of results and knowledge in practice and decision making.

Keywords: *climate adaptation, backcasting, visions; pathways; scenarios; transformative adaptation*

This article is reproduced here as published in its original source:Van der Voorn, T., Quist, J., Svenfelt, A., Kok, K.,Hickman, R. Sheppard, S., Carlsson-Kanyama, Banister, D. (2023). Advancing participatory backcasting for climate change adaptation planning using 10 cases from 3 continents,Climate Risk Management, 2023, 100559. https://doi.org/10.1016/j.crm.2023.100559

6.1 INTRODUCTION

Due to climate change and the associated impacts of extreme weather events, floods and droughts observed in all continents (IPCC, 2022), a major challenge is to inform and guide long-term climate change mitigation and adaptation planning under deep uncertainty (Lempert and Schlesinger 2000, Lempert and Groves 2010, Haasnoot, Kwakkel et al. 2013, Van der Voorn et al., 2017. In the pursuit of the Paris Agreement, countries have not only agreed on limiting global temperature increase to 1.5 °C above pre-industrial levels (Hooper et al. 2018) by reducing carbon emissions, commonly referred to as climate mitigation, but also to strengthen the global climate change response by increasing the ability of society to adapt to adverse impacts of climate change and foster climate resilience, referred to as climate adaptation.

However, climate adaptation and mitigation have been criticized for focusing more on adaptive change rather than transformative change and for neglecting the potential of normative approaches (Nalau and Cobb 2022). Transformative change entails reducing the root causes of vulnerability to climate change in the long-term by shifting systems away from unsustainable or undesirable trajectories (Fedele, Donatti et al. 2019). After Park, Marshall et al. (2012), we define transformative change as "a process that fundamentally (but not necessarily irreversibly) results in change in the biophysical social or economic components of a system from one form function or location (state) to another thereby enhancing the capacity for desired systems states to be achieved given perceived or real changes in the present or future environment".

Without transformative change, climate adaptation runs the risk of focusing on incremental changes in adaptation to climate change, rather than achieving radical system change for transformative adaptation (Holden, Robinson et al. 2016). Transformative change involves transformative and incremental adaptation as long as they are on the same path towards climate resilience (Wilson et al. 2013; Patterson et al. 2016). Nevertheless, due to the focus on transformative change and normative futures, climate change adaptation could obviously benefit from envisioning climate change adaptation futures, including exploring what decisions can move us towards these futures (Van der Voorn et al. 2017, Nalau and Cobb, 2022).

Normative futures studies approaches, such as backcasting, are useful in engaging stakeholders in the co-creation of climate change adaptation futures (Nalau and Cobb 2022). Backcasting is particularly useful for addressing different stakeholder interests, perceptions and perspectives to inform climate decision making and establish stakeholder support and commitment for climate adaptation that are guided by adaptation pathways (Van der Voorn et al., 2017, Bukvic and Harrald 2019). Backcasting supports envisioning alternative futures and exploring which options and adaptation pathways enables us to reach the desired futures, which may add value to pathways approaches for adaptation planning like (Wise, Fazey et al. 2014, Butler, Bohensky et al. 2016, Star, Rowland et al. 2016, Pandey, Prakash et al. 2021, Vizinho, Avelar et al. 2021, Werners, Sparkes et al. 2021, See, McKinnon et al. 2022). Backcasting is also beneficiary for social learning, enabling stakeholders to explore and open up a possibility space for empowering transformative climate adaptation to reach desired impact, as acknowledged in recent studies on transformative climate adaptation (Lonsdale et al., 2015, Holden, Robinson et al. 2016, Mendizabal, Feliu et al. 2021). Due to its compatibility with various types of tools and methods, backcasting has potential to address climate uncertainties in long-term decision making on climate adaptation (Van der Voorn et al., 2017).

Compared to forecasting and exploratory scenario approaches, participatory backcasting and related vision-oriented normative approaches are the least applied futures approach in climate change adaptation planning (Van der Voorn, Pahl-Wostl et al. 2012, van der Voorn, Quist et al. 2017). Backcasting can be defined as generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved (Quist and Vergragt, 2006; Quist, 2007).

A recent review by Nalau and Cobb (2022) shows that normative approaches are applied to climate adaptation but involve mainly visioning rather than backcasting. We define visioning as the process of creating a vision, as a representation of a desirable future state (Wiek and Iwaniec, 2013), which is also a key step in backcasting. In this paper we focus on backcasting approaches and their potential for use in climate adaptation research, as there is little research applying backcasting to climate adaptation (see section 2.1).

Backcasting for climate adaptation can draw from the substantive literature of backcasting on other topics (for overviews, see (Quist and Vergragt 2006, Bibri 2018). It can also benefit from backcasting for climate mitigation and climate related topics, e.g. urban climate adaptation (Carlsson-Kanyama, Carlsen et al. 2013), flood management (Sheppard, Shaw et al. 2011), adaptive water management (van Vliet and Kok 2015). Moreover, a large variety and diversity in backcasting studies and methodologies can be found in the recent literature, which reflects the different ways in which backcasting traditions and practices have evolved over time (Vergragt and Quist 2011). Backcasting for climate adaptation may also benefit from related approaches, such as transition management (Loorbach, Frantzeskaki et al. 2017) and visioning for climate adaptation (Nalau and Cobb 2022), which also use stakeholder engagement, future visions and pathways. Nevertheless, the relevance of backcasting for climate adaptation remains an under researched topic.

The aim of backcasting for long-term climate adaptation is to develop long-term visions and robust adaptation pathways that could lead to such visions in a participatory manner. In contrast to other futures methods, focusing on likely or possible futures, the key distinction with backcasting is its explicit normative nature, based on setting normative goals and envisioning (un)desirable but radically different futures, by thinking radically different about these futures and exploring how the required changes can be achieved incrementally. According to Dreborg (1996), backcasting is particularly useful when applied to complex and persistent problems, when dominant trends (climate change) are part of the problem, when externalities are at play, when there is a need for major change and when time horizon and scope allow development of radical alternative options. Climate adaptation obviously combines all these characteristics.

A key question that needs further investigation is: how to advance backcasting for climate adaptation? We therefore aim to investigate what is needed to apply backcasting to climate adaptation, making use of widely acknowledged strengths of backcasting as well as to identify elements that could add value for the topic of climate adaptation.

For this purpose, we have conducted a comparative study that complements other recent review efforts that focus on visioning (Nalau and Cobb 2022). We have done a systematic comparison of selected participatory backcasting studies on climate adaption to identify key insights and findings and to better understand under what conditions these approaches can be applied to reach impact. An existing framework has been refined and further developed before applying it to this comparative study with 10 cases in Africa, Europe and North America. The framework uses four dimensions: (i) inputs and project settings, and (ii) process, stakeholder engagement and methods, leading to (iii) results, including visions, scenarios and pathways, and (iv), impacts, including use of results and longer-lasting effects. Our study provides in depth insight into key aspects of backcasting studies. Moreover, we also looked into what approaches have been applied in different contexts?

This article proceeds as follows. Section 2 briefly describes recent progress in the use of backcasting approaches. Section 3 presents the research methodology and evaluation framework applied. Section 4 presents the case results. In Section 5, we discuss key insights and findings from the usage of backcasting and visioning approaches applied for climate change adaptation planning in the selected cases. We identify potential avenues for further methodological advancement. In Section 6, we present concluding remarks.

6.2 BACKCASTING FOR CLIMATE ADAPTATION

6.2.1 The current progress in the use of backcasting for climate research

To assess progress in the use of backcasting for climate research, we conducted a quick bibliometric analysis of publications using the SCOPUS database (see Table 6.1). A search query with the keywords "backcasting" and "climate adaptation" results in just a few publications. Adding "OR adaptation" in the query leads to a larger variety of backcasting studies across various domains and sectors, addressing climate-related topics, but also bringing in less relevant studies.

The first query shows that backcasting has been applied in the field of climate adaptation, but there are few studies (4 records) where backcasting has been explicitly applied for climate adaptation (Van der Voorn, Pahl-Wostl et al. 2012, van der Voorn, Quist et al. 2017, Jiricka-Pürrer, Wachter et al. 2019, Roggema, Tillie et al. 2021). For example, Van der Voorn et al. (2012) proposed a methodology for how backcasting in combination with adaptive management could be used for implementing adaptation strategies and policies, with an example from South Africa. Van der Voorn (2017) evaluated three cases on vision-based approaches for climate adaptation in coastal regions in three continents. The second query shows a larger number of backcasting studies (26 records) showing diversity across various domains and sectors, addressing climate-related topics.

The third query highlights that quite a few backcasting studies (25 records) focus on low-carbon futures and climate change mitigation. Banister and Hickman (2013), for instance, applied different backcasting scenarios to explore potential transport futures. The fourth query results in 134 studies, linking backcasting to other kinds of climate-related topics). Grêt-Regamey and Brunner (2011), for example, suggested a methodological framework for backcasting to support spatial adaptation to predicted climate change. In addition, the fifth query identifies 109 studies using visioning, but sometimes without explicitly referring to the term backcasting. Nalau and Cobb (2022) reviewed the current progress in the use of visioning approaches for climate adaptation. Their review includes cases on visioning, with a few as part of a backcasting approach. Finally, there is some overlap between the fifth and sixth query, showing six studies mentioning both visioning and backcasting for climate adaptation (2 studies) or mitigation (4 studies).

Table 6.1 The results of the search queries in the SCOPUS database.

Search query	Records
TITLE-ABS-KEY ("backcasting" OR "back-casting" AND "climate adaptation")	4
TITLE-ABS-KEY ("backcasting" OR "back-casting") AND ("climate adaptation" OR "adaptation")	26
TITLE-ABS-KEY ("backcasting" OR "back-casting") AND ("climate mitigation" OR "mitigation")	25
TITLE-ABS-KEY ("backcasting" OR "back-casting") AND ("climate")	134
TITLE-ABS-KEY ("visioning") AND ("climate")	109
TITLE-ABS-KEY (("backcasting" OR "back-casting") AND "visioning") AND "climate"	6

This quick bibliometric analysis shows that some papers report on the use of an explicit backcasting method, while others use the term visioning, without a clear reference to backcasting.. Similarly, the terms backcasting and visioning are often used interchangeably in the literature. Backcasting refers to the entire methodology of which visioning is an integral part of the methodology. Despite the variety in the use of both terms, visioning and backcasting share a similar focus on long-term visions for change.

6.2.2 The relevance of visioning and impact

It has been argued that the impact of backcasting studies is key to making change happen, which is key to climate adaption studies as well (Van der Voorn 2017). The same also applies to visioning studies. Recently, Nalau and Cobb (2022) have conducted a comprehensive review of how visioning is presently used in the field of climate change adaptation and identified where there is room for improvement. Their findings show that most visioning studies focus on the regional scale, involve mainly formal decision makers and employ a vast array of different methods, tools and data in the coproduction of futures. Predictive, exploratory and normative scenarios were used across all studies to support visioning. Compared to predictive and exploratory scenarios, normative scenarios were used the least but are highly suitable for addressing the potential to mobilize resources for future change (e.g., future water availability and access). Nalau and Cobb (ibid) also identified main constraints and enablers for visioning. For example, most studies did not report on learning processes to capture participant feedback, which is usually important for impact but could also enable more robust methodology development. A lack of stakeholder inclusion in terms of race, age, gender, education and professional background imposes a constraint on a representative co-development of futures. As pointed out by Nalau and Cobb (ibid:1), *"unintended and unexpected outcomes include increased anxiety in cases where introduced timeframes go beyond an individual's expected life span and decreased perceived necessity for undertaking adaptation at all"*. Nalau and Cobb (ibid) conclude that more explicit reporting on these constraints of the visioning process, a focus on transparent evaluation processes, diversity and inclusion of different viewpoints and interests as well as unintended and unexpected outcomes could improve visioning approaches.

Despite the relevance of impact, limited effort has been made to systematically evaluate the impact of backcasting studies, and more work is yet needed in order to improve the current and future backcasting practices (Vergragt and Quist 2011). Several authors like Quist (2007), Quist, Thissen et al. (2011), and Van der Voorn (2017) have developed frameworks for evaluating the impact of participatory backcasting studies, which offer relevance for framework development for impact evaluation in the context of climate adaptation.

In our study, we provide a more detailed and comprehensive analysis than the review by Nalau and Cobb (ibid), which focuses on visioning. Their aim was to distill key learning and general patterns across the growing literature on visioning for climate adaptation, revealing several key considerations that are fundamental in developing and conducting more robust visioning exercises for climate adaptation. Nalau and Cobb (ibid) guided their inquiry by straightforward questions like who is being involved in the studies, which tools, methods and data are most frequently used, and what are the key reported constraints, enablers and outcomes?

Through our study, we provide a complementary view to the Nalau and Cobb (2022) overview based on an in-depth case analysis, addressing how backcasting and visioning approaches could support dealing with climate uncertainties, stakeholder engagement in long-term climate adaptation planning and the use of various supporting tools and methods all of which influence the impact of backcasting studies. This offers a more comprehensive analysis of what factors constrain and enable participatory backcasting processes for climate adaptation and to what extent this leads to implementation and other impacts.

6.3 FRAMEWORK AND METHODOLOGY

6.3.1 Analytical framework

For our comparative evaluation, we have adapted the framework by Van der Voorn et al (2017), which builds on the evaluation frameworks developed by Quist (2007) and Quist, Thissen et al. (2011), and propose four main dimensions along which backcasting studies for climate adaptation can be evaluated: (i) inputs & project settings, (ii) process and methods, (ii) results and (iv) impact of backcasting studies.

As shown in Table 6.2, for each dimension we identify several evaluation criteria. These criteria allow for descriptive evaluation, but are here aggregated as scores on a three-point or five-point scale, or are dichotomously (yes or no). The dimensions are summarized below.

- **Dimension 1 on Inputs and project settings:** relates to different kinds of *inputs* allocated to backcasting for climate change adaptation, which involves the usage of different types of *knowledge* for vision, scenario and pathway development. Climate adaptation draws on various types of knowledge, which are valued to one another.. Building on Van der Voorn et al. (2017), the availability of knowledge and expertise in the project is evaluated from the perspective of participation in the project consortium, as participants bring in knowledge.

  This dimension also includes aspects regarding other project settings, such as the time duration of the project, design and goals of the project. An important aspect is the presence of a commissioner, who authorizes the project, has an interest in the results and may take care of follow-up. Building on Van der Voorn (2017), the criteria for characterising inputs and resources in our evaluation are: (i) level of financial resources, (ii) presence of knowledge and expertise and (iii) types of knowledge, (iv) presence of commissioner, (v) project duration, (vi) project goals.

- **Dimension 2 on Process and methods:** addresses (i) key aspects of stakeholder engagement and (ii) applied methods. Stakeholders have different perceptions of problems and possible solutions, aspire different roles and may mobilize different resources to serve their interests. Stakeholder engagement improves the quality of the process and may lead to collective endorsement and implementation of the results generated in participatory backcasting studies. Quist (2007) and Quist (2013), building on Van de Kerkhof (2004), have used three levels of participation, clustering the eight levels from the participation ladder of Arnstein (1969). The level of participation reflects the degree of influence and involvement in the decision-making process. Stakeholder participation is important to account for stakeholders' knowledge and expertise and their different worldviews (Quist, 2007; van de Kerkhof, Hisschemöller et al. (2002).). The following criteria are used for evaluating stakeholder engagement (see Table 2): (i) Presence of stakeholder involvement?; (ii) Degree of stakeholder diversity (i.e. the different types of stakeholders involved, including business, research, government, civil society & ngo, and marginal groups); (iii) Presence of stakeholder commitment for the results?; and (iv) Degree of stakeholder influence.

Table 6.2 Evaluation criteria.

Dimension	Criteria	Score description
Inputs & project settings	Level of financial resources	0 = none; 0,33 = <10k€; 100k€ <; 0,67 = < 500k€; 1 = >1M€
	Availability of knowledge & expertise	Yes /no
	Types of knowledge used	Scientific; contextual or interdisciplinary knowledge;
	Presence of a commissioner	Yes/no
	Project duration	0 – 1 yr; 2 -5 yr; > 5yr
	Project goals	Content, process, methodological impact
Process & Methods Stakeholder engagement	Degree of stakeholder diversity	Degree of various stakeholder groups involved in the process (Out of 5 types distinguished: - business; research; government; civil society & ngo; citizens, including marginal groups? Low = (1 type); Medium = (3 out of 5 types); High = (all types)
	Degree of stakeholder influence	Low; Medium; High
	Presence of stakeholder involvement	Yes/no
	Presence of stakeholder commitment to results	Yes/no
Methods	Inclusion of various tools & methods	Examples of tools & methods for (i) analysis; (ii) Modelling and simulation; (iii) Design, scenario development, visioning, including process, model and system design; (iv) Stakeholder engagement and interaction; (v) Communication & dissemination
Results in backcasting studies Visions	Presence of multiple visions	Yes/no
	Presence of transformative elements	Yes/no
	Presence of goals & guiding targets?	No; partly = goals or targets; Yes = goals & targets
Pathway	Addressing uncertainties	Yes/no
	Inclusion of agency and measures	Yes/no
	Inclusion of robust elements	Yes/no
Scenarios	Inclusion of various types of uncertainties	Yes/no
	Types of scenarios	Qualitative or quantitative
	Scenario approach	Scenario-centered; Pathway-centered, Combinatory
Impact	Inclusion in formal decision making	Yes/no
	Examples of follow-up activities for implementation	Yes (what?)/no
	Examples of broader spin-off	Yes (what?)/no

This dimension is also used to evaluate the methodological diversity present in the cases for which several methodological criteria are used. Building on Quist et al (2011) and Van der Voorn et al (2017), the use of various types of tools and methods is evaluated as follows: (i) *analytical*, (ii) *modelling and simulation*, (iii) *design*, (iv) *stakeholder*, and (v) *communication & dissemination*. Participatory backcasting studies usually employ all five types of tools and methods (Van der Voorn et al. 2017, cf. Quist et al., 2011)..

- **Dimension 3 on Results in backcasting studies:** distinguishes visions, pathway and scenario development. Building on Van der Voorn et al. (2017),visions are evaluated in terms of (i) the number of visions, (ii) inclusion of the *transformative elements* that set directions for adaptation, and (iii) *goals* and *guiding targets* related to these visions. Whereas goals articulate a desired change in general terms, guiding targets provide criteria that reflect measurable changes, such as 40% heat stress reduction.

  Pathways, also building on Van der Voorn et al. (2017), are evaluated in terms of (i) *addressing uncertainties* about the implementation, (ii) *agency* (presence of actors with the capacity to contribute to or mobilize resources for goal fulfilment) and *adaptation measures* (physical, technological, social), and (iii) *robust elements*. Robust elements are pathway elements that allow for uncertainty management and pathway switching (van der Voorn et al. 2012; Haasnoot et al. 2013)

  Scenarios are important because these can address (i) *uncertainties,* such as related to climate, social and political uncertainties (Kok, van Vliet et al. 2011, van Vliet and Kok 2015). Therefore, cases are also evaluated on (ii) *types of scenarios*: quantitative and qualitative and, (iii) *scenario*. Quantitative scenarios are usually based upon models or simulations, which have the advantage of providing transparent and comprehensive sets of assumptions in the form of model equations, model inputs and coefficients. Qualitative scenarios describe the changing context of a vision in words, narratives or visual symbols rather than numerical estimates. Such scenarios provide the context for (normative) visions. Scenarios can be used in different ways. A *scenario-centred* approach first develops (exploratory) scenarios, as a basis for and input to a quantitative model, which can be followed by a backcasting exercise. A *pathway-centered* approach first develops (normative) visions and pathways that can be subsequently tested by exposing them to different scenarios, possibly resulting in robust management options. A *combinatory approach* is when exploratory scenarios and (desirable) policy actions are combined . Scenarios are evaluated in terms of common characteristics such as the type of scenarios (qualitative or quantitative) and the types of usage of scenarios (scenario-centered, pathway-centered or combinatory).

- **Dimension 4 on Impact** addresses whether participatory backcasting studies lead to implementation, follow-up and spin-off (Quist et al, 2011; Van der Voorn et al, 2017). Impact is evaluated on (i) whether the results of the backcasting study was *included by formal decision making,* and no examples of (ii) *follow-up* and implementation activities and (iii) broader *spin-off* in science (scientific debate and research), society (societal debate and initiatives) and, policy and practice (policymaking and application).

Table 6.3 Case characteristics .

Case study settings	**Case 1: SA**	**Case 2: US**	**Case 3: NL1**	**Case 4: SE1**	**Case 5: SE2**	**Case 6: UK**	**Case 7: NL2**	**Case 8: EU1**	**Case 9: EU2**	**Case 10: CA**
Continent	Africa	North America	Europe	Europe	Europe	Europe	Europe	Europe	Europe	North America
Governance context	Top-down governance by government	Bottom-up & market-oriented	Polycentric & network-oriented	Polycentric & network-oriented	Polycentric & network-oriented	Polycentric & network -oriented	Polycentric & network -oriented	Polycentric & network -oriented	Polycentric & network-oriented	Bottom-up by local government
Type of participatory process	Government-initiated & empowerment-oriented	Bottom-up initiated & facilitated by a private think tank	Government-initiated & polycentric by different organizations	Research-initiated	Research-initiated	Research -initiated	Research -initiated	Research -initiated	Research-initiated	Government-initiated & research-initiated
Overall case approach	Back-casting approach	Visioning	Expert-led Backcasting approach	Visioning	Back-casting approach	Expert-led Back-casting approach	Expert-led Back-casting approach	Expert-led Back-casting approach	Expert-led Back-casting approach	Expert-led Backcasting approach

In this study we consider suitable assessment criteria of backcasting studies to evaluate sufficient inputs, favorable project settings, broad stakeholder engagement, and combining various types of tools and methods to achieve endorsed results that can contribute to long-term impact. Successful backcasting thus depends on various criteria from all dimensions of our framework. Moreover, we distinguish between conditional, result-oriented and impact-oriented criteria as follows. Conditional criteria refer to requirements for successful backcasting related to inputs, methods and stakeholder engagement. Result-oriented criteria reflect results in terms of visions, analyses, pathways and stakeholder commitment. Impact-oriented criteria reflect changes and impact achieved, but these can only be determined several years after completion of the backcasting study or even later.

6.3.2 Case selection and methodology

For our purpose, we conduct a multiple-case analysis that allows us to evaluate and compare backcasting studies within their own context, after which general patterns and conclusions can be drawn from the comparison of individual cases (Yin 1994).

This paper investigates ten climate change adaptation and mitigation studies that show a combination of common characteristics and diversity on other criteria. Common characteristics include: (i) vulnerable regions with changing climatic conditions, (ii) with a focus on climate change adaptation, (iii) application of backcasting approaches, (iv) conducted before 2020, and (v) availability of in-depth information and data on the cases accessible to the authors. Conducted and finalized before 2020 was a selection criterion, as it allows us to identify possible impact and spin-off. Availability of in-depth information was met by selecting cases, in which authors were involved themselves. As presented in Table 6.3 , diversity is present through (i) the continent, (ii) governance context, (iii) type of participatory process, and (iv) overall case approach. Based on these criteria, we could select 10 cases from Africa, Europe and North America (see Table 3), including South Africa (SA1), USA (US), Netherlands (NL1 and NL2), Sweden (SE1 and SE2), United Kingdom (UK), two European cases (EU1 and EU2) and Canada (CA). The selected cases include backcasting studies that were conducted in the period between 2009 and 2019. The case selection agrees with our quick bibliometric analysis in Section 6.2.1, which confirms our initial assumption that there is a limited number of studies that explicitly applied backcasting for climate adaptation (search query 1).

In our view all selected cases are relevant to our research question and aim, because they contribute to our understanding how backcasting for climate adaptation can be defined, developed and applied. We take a broad view on backcasting, by including cases on vision development (case 2 and 3), as visioning is essential to backcasting. We consider these cases as relevant to backcasting as they involve visioning, including pathway or scenario development, like backcasting, but without explicitly referring to the term backcasting.

For the case analysis we applied the following procedure: the evaluation framework was used as a case assessment protocol to guide a secondary analysis of the cases, conducted by the authors most familiar with the case using a range of sources including reports, articles and project documents. Case studies were subject to internal validation and reflective discussions with all co-authors, enabling validation of findings and interpretation of the case results. By doing so, we analyzed and concisely report the ten cases and describe main similarities and differences in the use and potential of backcasting for climate change adaptation planning. Based on this analysis, we discuss methodological and conceptual developments and their potential for further methodological development of backcasting for climate change adaptation planning in section 5.

6.4 RESULTS

6.4.1 Case descriptions

Case 1: SA – The South African Breede–Overberg Catchment Management Strategy
The SA case reports on the development of a Catchment Management Strategy (CMS) for the Breede-Overberg Catchment Water Management Area (BOCMA 2009, BOCMA 2010), which took place from 2009 to 2010 (van der Voorn, Pahl-Wostl et al. 2012, van der Voorn, Quist et al. 2017). The aim was to develop a single, shared vision for the CMS for the BOCMA. A backcasting approach was applied to develop short-term implementation pathways from the vision that supports local, provincial and national development objectives. Broad and diverse stakeholder engagement took place through a series of open stakeholder meetings in six management zones of the catchment to ensure support and ownership for the CMS. Substantial capacity building took place to support the participation of marginal people like poor black farmers, as prescribed by the 1998 National Water Act. Various types of tools and methods were used to support the CMS development process. The Minister of Water Affairs endorsed the CMS in July 2011, after which it was implemented step by step. The Minister endowed the leading Catchment Management Agency with management capabilities for the implementation, but also more legal responsibilities for future follow-up activities, for which financial resources were allocated. The implementation of the CMS has been evaluated in 2015.

Case 2: US – The US Initiative Water Management Strategy

The US case reports on the US Initiative Water Management Committee (HIWMC), which conducted a strategic planning effort in 2010 to develop an integrated water management strategy (WMS) for the New Orleans region (Van der Voorn 2017). The aim of the project was to seek opportunities to establish public-private partnerships to support the City of New Orleans in developing more integrated and adaptive water management approaches. The WMS development process took place during the period of May-July 2010, when two committee meetings were held. Prior to these meetings, a pre-assessment was made to identify the current state of water resources management and its future challenges in the region. Stakeholder engagement was limited since the WMS development process involved only HIWMC members, which form a think-tank group. During this process, vision development was conducted to evaluate how transformative elements of existing visions could be combined to guiding the Committee's effort to further promote integrated and adaptive water management in the region (Van der Voorn et al 2017). This resulted in a list of 39 water management goals and plausible directions for further WMS developed but without any concrete pathways at that time. The WMS development process had limited impact due to limited inclusion by formal decision making at the city or state level and limited financial resources for the implementation of the WMS. Follow-up activities took place through establishing strategic partnerships and awareness raising initiatives.

Case 3: NL1 – The Rhine-Meuse Estuary sub-program of The Dutch Delta Program

The NL1 case reports on various vision studies on the Dutch Delta Program Rhine-Meuse Estuary, followed by strategy development for adaptive Delta management in the Rhine-Meuse Estuary sub-program of the Delta Program from May to October 2010 (Van der Voorn 2017). The study involved an assessment of three visions studies that had been conducted, as part of the overall backcasting approach. The results of the assessment were used as input for two stakeholder workshops on strategy development held in March and April 2011. The aim of the workshops was to develop a better understanding of how various elements of the visions studies could support adaptive Delta management in the Rhine-Meuse Estuary and a set of regional climate scenarios, which provided further insight into possible pathways to adaptive delta management. Mainly experts were involved in the workshops, while broad and diverse stakeholder engagement took place in the vision studies; two of these studies produced pathways. The workshops resulted in regional climate scenarios for possible pathways to adaptive delta management and were used as inputs for formal decision making on adaptive delta management in the estuary. Follow-up and broader spin off activities were coordinated by the Dutch Government and took place in 2015.

Case 4: SE1 – Barriers in climate change adaptation in two Swedish municipalities.
The SE1 case refers to a six month study conducted in 2013, which aimed at investigating barriers to adaptation in municipalities that were due to inaction by external decision makers themselves (Carlsson-Kanyama 2013). The case study was part of a larger research program commissioned by the Swedish Environment Protection Agency. This study involved civil servants from two municipalities in Sweden, and resulted in five visions of the ideally adapted local society. Vision development was done during two stakeholder workshops, which had been supported by stakeholder tools and methods. The visions corresponded to what local civil servants considered as preferable solutions in order for the municipality to be fully adapted to climate change within 20–30 years. No real pathways were developed, but rather an action plan. Based on this exercise, civil servants were able to identify a group of external decision makers upon whose input these municipalities depend for achieving their goals. The results were included in formal decision making and used for follow-up activities. Moreover, at the municipal level, broader spin-off took place.

Case 5: SE2 – Understanding consistencies and gaps between desired forest futures: An analysis of visions from stakeholder groups in Sweden
The SE2 case reports on an exploratory study in Sweden on desired forest futures, which has relevance for climate adaptation. Its aim was to move beyond the current state by applying a long-term and integrated perspective through participatory backcasting, to identify stakeholders' desirable forest futures and then to compare these visions in order to highlight contemporary trajectories and identify changes that were conceived as desirable (Sandström, Carlsson-Kanyama et al. 2016). Six workshops took place at the Swedish Defense Research Agency (FOI), Kista, in April to June 2014. Three additional workshops were held in Lycksele in 2014 for the backcasting exercise. Stakeholder tools and methods were applied to support the stakeholder process, involving also indigenous Sami people. The aim of these workshops was to create group visions and to sketch possible policy events, including policy measures, necessary to reach these visions. This resulted in five visions, after which short-term pathways were derived from a backcasting analysis to coordinate actions for the coming 10 years. There was limited impact as the results were mainly used as input for an academic paper. There was no specific follow-up, but broader spin-off took place within academia and at the local level.

Case 6: UK – Visioning and Backcasting for Transport CO_2 reduction in London
The UK case refers to a London-based project from 2007 to 2009, which was developed as part of the UrbanBuzz program run by University College London, commissioned and funded by the UK Higher Education Funding Council (Hickman, Ashiru

et al. 2010). The project aimed to (i) assess how London might reduce transport CO_2 emissions by 60% from 1990-2025 and subsequently to 80% by 2050, (ii) review policy measures and develop policy packages and scenarios to reduce CO_2 emissions supporting climate adaptation, and (iii) quantify the impacts of scenarios relative to CO_2 reduction using the London Transportation Studies model (Hickman, Hall et al. 2013, Hickman 2014). A distinctive feature was that it combined backcasting with a transport and CO_2 simulation game (TC-SIM) and transportation models to explore strategic policy choices. Backcasting was used to assess whether the transport CO_2 reduction targets were possible to meet. Expert-led workshops were held at different stages throughout the study, which resulted in multiple visions tested against five central scenarios. Policy pathways were developed for each scenario, but there was no focus on uncertainties and pathway switching. These pathways were hybrid addressing both climate mitigation and adaptation options. The study had some impact as results were not directly used in formal decision making, but rather in the research context of transport strategy development in London. Follow-up research activities were carried out by the UK Department for Transport. Broader spin-off occurred in transport planning and consultancy practice.

Case 7: NL2 – Multi-scale visions, wild-cards, and participative backcasting to develop adaptation pathways for the future of the Overijsselse Vecht

The NL2 case refers to a study in the Overijsselse Vecht in the east of the Netherlands, an intensely used area with a long history of participatory management and cooperation between public and private sector stakeholders and scientists. It was carried out in the context of a larger EU funded project called SENSES, from 2017 to 2019. SENSES aimed at developing a "Climate Change Scenario Toolkit" to support the understanding of the new generation of climate change scenarios. In this Dutch case, local, bottom-up participatory and empirical knowledge was combined with top-down scientific input translated from global socioeconomic and climate impact scenarios, which were derived from the Shared Socioeconomic Pathways scenarios (Auer, Kriegler et al. 2021). A backcasting approach in combination with exploratory scenarios were used to develop pathways towards the vision on a climate robust and CO_2-neutral Overijsselse Vecht, while addressing both climate adaptation and mitigation in hybrid pathways. A novel aspect was that the project operated in a very information-rich environment, using several existing visions, pathways, and scenarios. Combining existing knowledge to develop pathways led to novel ways to develop a multi-scale vision and using exploratory scenarios to test the robustness and feasibility of resulting adaptation pathways.

Case 8: EU1 – Combining participative backcasting and explorative scenario development for envisioning the future of water in Europe.

The EU1 case refers to a pan-European case study as part of a larger FP6 EU-funded project SCENES that run from 2006 to 2011, which set out to undertake a multi-dimensional multi-scale scenario process, with a strong foundation in science and broad participation of stakeholders. SCENES aimed to develop and analyze a set of comprehensive exploratory scenarios of Europe's freshwater futures up to 2050, including climate change impacts (Kok, van Vliet et al. 2011). A distinct feature of the SCENES project was its aim to combine exploratory and backcasting scenarios with a spatial explicit water quality and quantity model (WaterGAP) to assess the feasibility of the overall backcasting approach and the usefulness of the results for a pan-European case study. The case study consisted of similar processes in 10 regional and local cases. Stakeholders were involved for the duration of the SCENES project. The study produced stakeholder-determined products in an iterative procedure with expert modelers to ensure internal consistency, using a story and simulation approach. This was done in backcasting workshops, which resulted in several visions that were backcasted against the scenarios to develop roadmaps for actions up to 2050. A list of robust actions and strategies was compiled independently of the scenarios. The study had scientific impact as results were not used in formal decision making. Follow-up research activities took place in subsequent future studies in Europe, where the scenarios had been used. Broader spin-off occurred especially in academia (Kok, van Vliet et al. 2011).

Case 9: EU2- Combining participative backcasting and explorative scenario development for envisioning the future of water in Europe

The EU2 case was conducted under the umbrella of the SCENES project. This study reports on the results of nine local case studies and a Baltic regional case study. The aim of the study was to analyze the combined use of exploratory and backcasting scenarios, Fuzzy Cognitive Maps, System Dynamics models (van Vliet and Kok 2015). The socio-environmental exploratory scenarios for this study were developed in two consecutive workshops. The workshops were held in local-, regional and pan-European-scale case studies between June 2009 and February 2010. Like in the EU1 case, stakeholders were involved in a longer process during the lifetime of the SCENES project. In this study, various types of tools and methods were used to produce meaningful outputs and support broad stakeholder engagement. The study resulted in a set of exploratory scenarios and visions for 2050. Like in the EU1 case, these visions were backcasted against the scenarios to develop roadmaps to set up actions up to 2050. Similar to the EU1 case, a list of robust actions and strategies was compiled independently of the scenarios. The study had limited impact as results were not used in formal decision making. Follow-up research activities took place across the different case studies of the SCENES project, whereas broader spin-off occurred mainly in academia (van Vliet and Kok 2015).

Case study 10: CA – Envisioning local climate change futures in the Delta context
The CA case includes a study that examined a new process for envisioning local climate change futures, which used an iterative, collaborative, multi-stakeholder approach to produce spatial scenarios with computer-generated 3D images of climate change futures in the flood-prone municipality of Delta, British Columbia, Canada (Sheppard, Shaw et al. 2011). A novelty is the combined use of backcasting and 3D visualization tools. The study was conducted between 2005 and 2008. It projected scenarios up to 2100, using a local working group of experts and stakeholders, to co-develop four alternative narratives (visions) within a holistic framework integrating climate mitigation targets and adaptation options (Shaw, Sheppard et al. 2009). The aim of the project was to inform the revision of Delta's flood management strategy in the context of local land use and climate change scenarios, with the goal of carrying out public consultations to evaluate the desirability of a range of flood risk responses at some stage. A backcasting approach was applied to develop pathways from the visions and scenarios with some stakeholder input, which further advanced sea level rise modelling (Barron, Canete et al. 2012). Hybrid pathways were developed to address climate mitigation and adaptation options. The study had limited impact. Results were not used in formal decision making, but rather raised the awareness of Delta's political leaders on the implications of future climate change impacts in their region. As a follow-up, a similar study was conducted in the adjoining City of Surrey, British Columbia, while broader spin-off was identified in science and society.

6.4.2 Case study results

This section provides a concise and comparative overview of the case results. A more detailed description of the individual case results can be found in Tables S1-7 in the Supplementary Material (Appendix B).

Inputs & project settings

The cases showed a wide range of project budgets (see Table S1 in Supplementary Material). In the two cases (EU1 and EU2) with the highest budgets, significant financial resources were allocated to the project (>1M€), whereas resources were lacking in the US case (Figure 6.1). Only in three cases (SA, NL1, SE1), a commissioner was present, which comes together with funding and a higher interest in utilization and diffusion of the results. There were also differences in the project goals. For instance, all types of project goals were pursued in eight cases, while in two cases (US and SE1) the project goals were only content-related and impact-related.

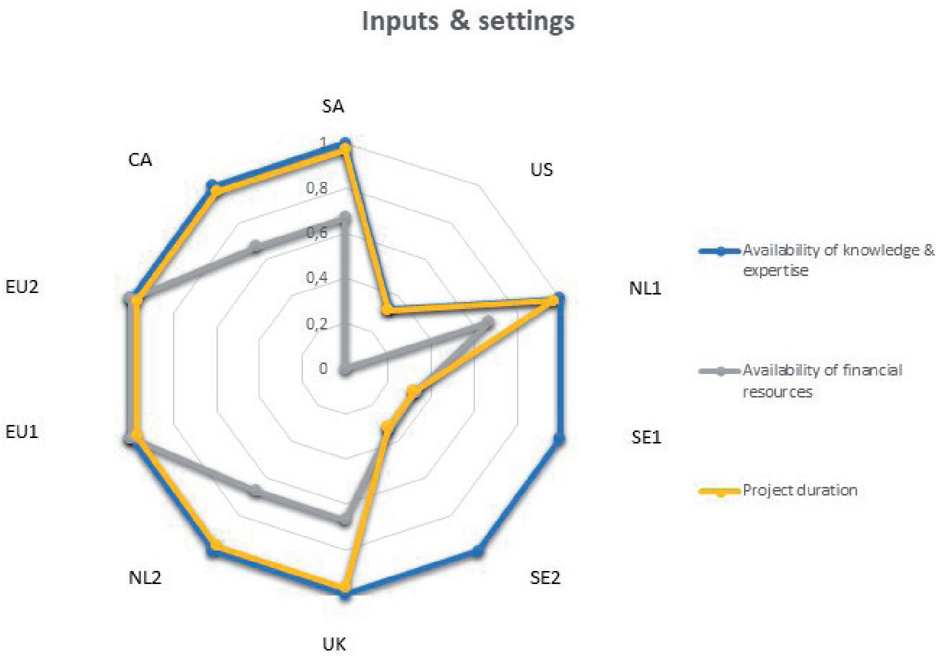

Figure 6.1 Project inputs and settings (scores have been normalized between 0 and 1 to make the differences more visible).

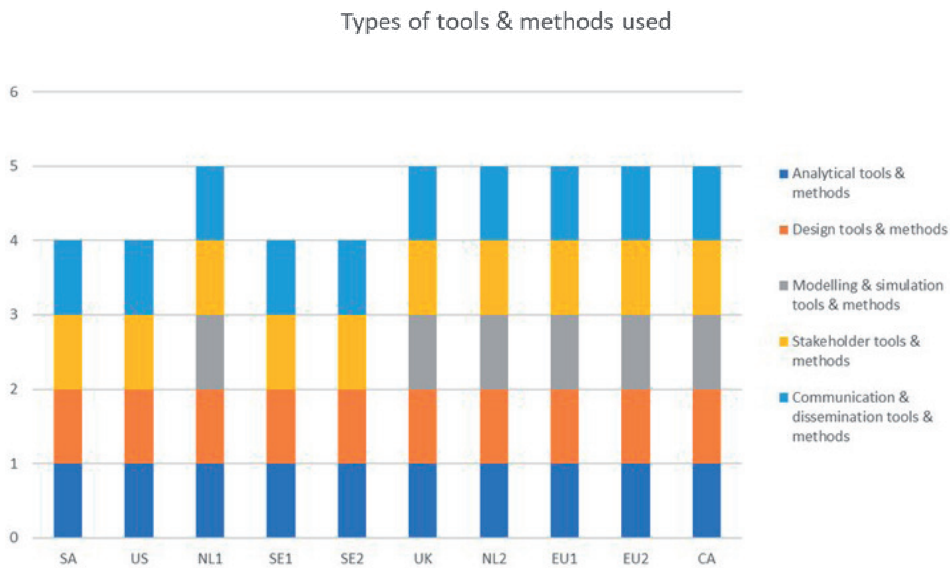

Figure 6.2 Overview of various types of tool and methods used.

Process and methods

All cases showed stakeholder involvement and their commitment (Table S2 in Supplementary Material). Differences can be observed in the degree of stakeholder diversity and influence. In one case (SA), there was not only a high degree of stakeholder diversity, but also a high degree of stakeholder influence, due to the presence of process arrangements that enabled stakeholders to influence the stakeholder process and content. Two cases (US and UK) showed lower degrees of both stakeholder diversity and influence. In these cases, stakeholder participation was limited to certain groups of stakeholders, such as experts or think tank members. In the remaining cases, there was a medium degree of stakeholder diversity and influence.

All cases used various types of tools and methods to support exploring different plausible futures by means of exploratory scenarios (See Table S3 in Supplementary Material), while all cases utilized stakeholder as well as communication and dissemination tools and methods. Five cases employed four types of tools and methods (Figure 6.2). Moreover, in 6 cases (NL1, UK, NL2, EU1, EU2 and CA) advanced modelling and simulation tools and methods were also part of the overall backcasting approach. This allowed scenarios and pathways to be quantified in order to identify and discuss likely impacts and trade-offs.

Results in the backcasting cases

Whereas a single, shared vision was the starting point for the SA case, multiple visions were developed in the other 9 cases. Most cases included transformative elements and goals or guiding targets (Figure 6.3). In 9 out of 10 cases, transformative elements as well as goals or guiding targets were developed (Table S4 in Supplementary Material). Differences surface in the NL2 case, where thresholds were defined as guiding targets, while in the SE1 case vision development did not result in transformative elements, nor in goals and guiding targets, but rather resulted in an action plan.

Except for the US, SE1 and SE2 case, cases included scenario development (see Table S5 in Supplementary Material). In those cases where separate scenario development took place, scenarios were quantitative. In the UK, NL2, EU1, EU2, CA case, where scenario development was part of a backcasting framework it provided input for modelling to develop robust pathways. Cases that did not include scenario development, also lacked addressing uncertainty. Differences relate to the usage of scenarios, which can be either exploratory or combinatory (Figure 6.4). In addition, in the UK, NL2 and CA case both climate mitigation and adaptation options were included in pathway development.

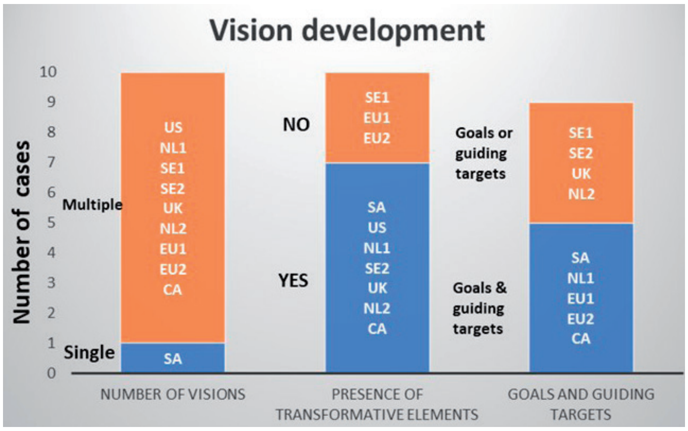

Figure 6.3 Overview of results of vision development.

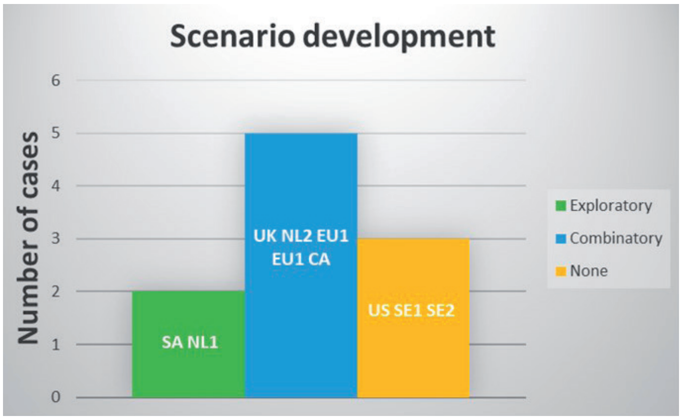

Figure 6.4 Overview of results of scenario development.

Considerable diversity can be found in pathway development and robust elements (Figure 6.5 and Table S6 in Supplementary Material). In cases where short-term pathways were developed, these pathways do not include robust elements because uncertainty is considered low or negligible in the short run. Differences are also present in the types of pathways. In some cases, roadmaps were developed, whereas policy implementation pathways were developed elsewhere. It shows that different terms are used to refer to short-term long-term pathways. Only in the NL1 case long-term pathways were generated that allow for pathway switching. In the NL2, UK and CA case, hybrid pathways, which address climate mitigation and adaptation options, were developed.

Impacts

Our analysis shows that most cases resulted in rather limited societal impact, though scientific impact occurred through accumulating knowledge on backcasting

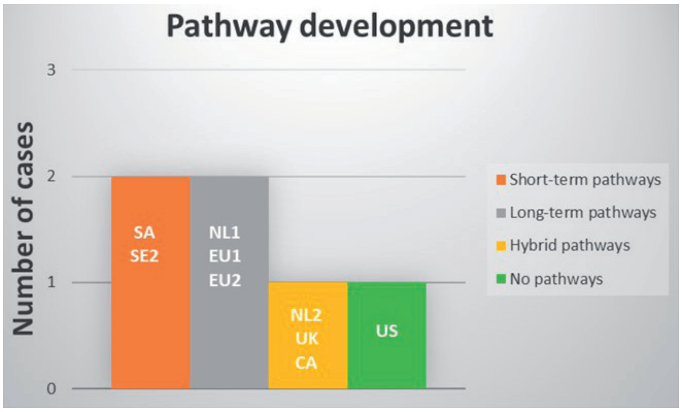

Figure 6.5 Overview of results of pathway development.

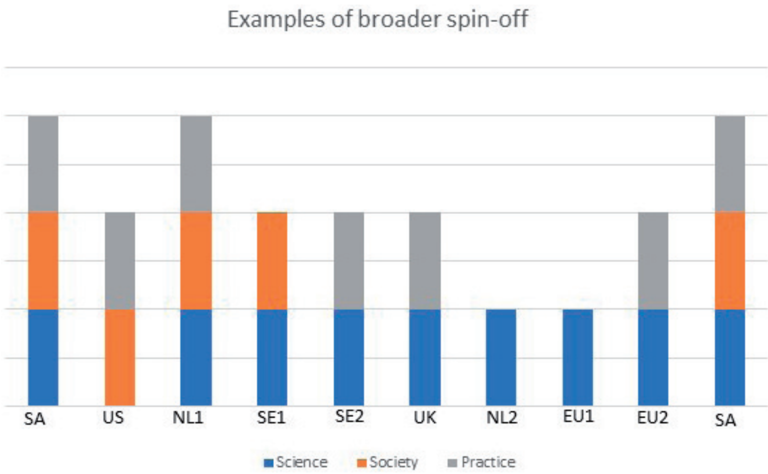

Figure 6.6 Overview of examples of broader spin-off

approaches, broader dissemination, follow up research or how widely cited. Only two cases (SA and NL1) resulted in significant impact because of inclusion in formal decision making (see Table S7 in Supplementary Material) leading to implementation in plans and practice. These cases show a varying degree of broader spin-off in science, society and practice (Figure 6.6). The SE1 case did not result in significant impact despite being included in formal decision making. This suggests that inclusion in formal decision-making is 'necessary but insufficient' for enabling impact and that there are additional mediating factors (see inputs and settings in 6.4.2).

Other cases revealing limited and moderate impact due to a lack of inclusion in formal decision making. This led to limited examples of follow-up and spin-off (see Table S7 in Supplementary Material).

6.5 DISCUSSION

6.5.1 Key insights and findings from the use of backcasting approaches

In this paper, we have reviewed cases to advance backcasting for climate adaptation. Our aim is to identify what is needed to apply backcasting in an advanced way for climate adaptation, by drawing key insights and findings across these cases and offer new insights that can assist adaptation scholars and practitioners in developing and conducting more comprehensive design of backcasting studies (see Table 6.4).

Inputs & project settings

Larger project budgets allow for a more comprehensive backcasting study, enabling the required knowledge and expertise for advanced modelling for system analysis from which possible adaptation pathways follow, as well as options for pathway switching. However, our results indicate that such budgets do not necessarily lead to more impact of the study in practice or among practitioners, as this depends on other factors like a commissioner or results being used in decision making (see 6.1.4). Short-term projects with relatively small project budgets are generally more focused, but lack sufficient resources to employ sophisticated tools and methods for advanced system analysis, which leads to results more at the level of visions. Both the size of the project budget and availability of relevant knowledge and expertise are essential for a backcasting study. A larger project budget is an important factor for the deployment of tools and methods for advanced system analysis, but is not decisive for the impact of a backcasting study.

Furthermore, the presence of a commissioner is important for reaching impact (see also Quist et al, 2011 and Van der Voorn et al, 2017). Such a key person has the capability to include the outcomes of the study to inform formal decision making and reflects the relevance of the results for the organization or network, contributing to the impact of the study (see 6.4.2).

Process & methods

In participatory backcasting, broad stakeholder engagement is important for addressing and reconciling different normative stakeholder interests, perceptions and perspectives to enrich vision, scenario and pathway development and establishing stakeholder support and commitment to the outcomes of the backcasting study. Our evaluation shows that backcasting proved effective in engaging stakeholders in the co-creation of (alternative) climate change adaptation futures and scenarios, as well as pathways that could lead to these futures. Except for the US, SE1 and UK case, the cases show, building on observations of the researchers involved, that broad stakeholder engagement enabled social learning in which stakeholders explore and open up a possibility space for empowering transformative adaptation (Van der Voorn, Pahl-Wostl et al. 2012, van der Voorn, Quist et al. 2017). Although we did not investigate learning effects in this study in detail, the authors involved in the cases confirmed that such learning processes took place in the cases.

The involvement of marginal groups is beneficiary for enhancing stakeholder engagement resulting in more comprehensive results and for enabling the stakeholder process more democratic, which increases the legitimacy of its outcomes (Muiderman 2022). However, their participation has methodological and procedural implications. For these groups to produce relevant inputs, their involvement may require capacity building effort as part of or prior to the backcasting study (Faldi and Rossi 2014, Faldi and Macchi 2017, van der Voorn, Quist et al. 2017). Hence, the participation of marginal groups is important, but we also consider adequate process arrangements to be prerequisites for fostering effective participation.

In the context of climate adaptation, identifying robust options for climate adaptation is challenging due to large climate uncertainties and the complexity of the social-ecological systems under study. The use of comprehensive modelling and simulation tools and methods is therefore necessary for advanced system analysis, scenario and pathway development and switching for dealing with uncertainties (Muiderman 2022), while participatory (multi-)modelling in combination with backcasting has also advanced (Cuppen, Nikolic et al. 2021).

Results in backcasting studies

The development of visions, scenarios and pathways supports stakeholders and decision makers in mapping out the possibility space for adaptation. Transformative elements reflect the perceived gap between the current and desirable situation in climate adaptation (van der Helm 2009). In order to address climate uncertainties, multiple visions for climate adaptation are more beneficiary than single, shared visions because they broaden the possibility space for climate adaptation see (Van der Voorn et al, 2017). Goals and guiding targets help to operationalize visions into climate actions and their monitoring and evaluation, which is also key to advancing climate adaptation plans and actions (Van der Voorn et al, 2017).

As part of the overall backcasting approach, scenario development is considered important for modelling and developing robust pathways (Kok, van Vliet Mathijs et al. 2011, van Vliet and Kok 2015). The NL1, NL2, EU1 and EU2 cases show that combining exploratory scenarios with backcasting makes it also possible to conduct robustness checks of visions and pathways against the backdrop of key drivers for change described in such scenarios (Kok, van Vliet et al. 2011, van Vliet and Kok 2015).

Pathway development is essential for determining adaptation actions in the short and long run, while taking into account uncertainties about these actions (Kok, van Vliet Mathijs et al. 2011). Robust elements in pathways and transformative elements in multiple visions are also necessary for empowering transformative adaptation. The inclusion of robust elements in pathways allows for pathway switching, as a means for dealing with uncertainty (van der Voorn, Quist et al. 2017, Haasnoot, van 't Klooster et al. 2018). Whereas scenarios are well equipped for mapping contextual uncertainties (climate uncertainties), pathways should include implementation-related uncertainties. Interestingly, pathways addressing synergies between mitigation and adaptation actions and options result in more hybrid pathways (van der Voorn, Svenfelt et al. 2020). The UK, NL2 and CA cases combine adaptation and mitigation options in the pathways, which could also counteract goal conflicts as suggested by van der Voorn, Svenfelt et al. (2020).

Impact

With regard to impact, it makes a difference whether the backcasting study is initiated by government, civil society and NGOs, or research. Research-initiated backcasting studies are usually less connected to formal decision making, resulting in limited implementation-oriented follow-up activities and spin-off, yet generally showing more scientific impact. In a similar way civil society can use visioning or backcasting for lobbying and advocacy purposes providing input for public debates, as was done in the US case. By comparison, government-initiated backcasting studies are usually connected to formal decision making, which facilitates follow-up activities and broader spin-off. However, such studies can be less ambitious, being consensus driven and influenced by short-term interests. Therefore, we also argue that those backcasting studies that include transformative elements that go beyond the business-as-usual practice have the potential to contribute to transformative adaptation.

Our results indicate that the presence of a commissioner is important for ensuring institutional embedding and protection of the results and realizing follow up activities, as also shown in previous research (Quist et al, 2011). A connection to decision making is also a prerequisite for impact (see also van der Voorn, Quist et al. (2017). A commissioner represents an authority or organization with power and interests, being able to set the agenda for follow up. However, power relations could prevent the outcomes from being included in formal decision making (Muiderman 2022).

Finally, there is no relationship between the size of project budgets (see section 6.4.2) and the degree of impact. Even though limited financial resources were present in the SE1 and SE2 case and none in the US case, limited impact was generated.

6.5.2 Reflections and research limitations

Methodological reflections

Our main findings, shown as highlights in Table 4, have relevance and methodological implications for the further development of backcasting for climate adaptation. For effective backcasting for climate adaptation, essential add-ons are needed to conduct more advanced system analyses, develop more robust pathways and cope with uncertainty. These add-ons include more combinatory use of quantitative and qualitative scenarios, comprehensive modelling and simulation tools and methods for advanced system analysis, inclusion of robust elements for pathway switching and uncertainty management, and hybrid pathways for climate adaptation, e.g. (van der Voorn, Svenfelt et al. 2020), which can be combined in new backcasting frameworks or can be added to earlier backcasting frameworks proposed like for instance proposed by Van der Voorn et al (2012).

Modelling and simulation tools and methods, scenarios and pathways are powerful tools to envision how nature might respond to different pathways of future human development and policy choices. The usage of different types of modelling and simulation tools helps to conduct advanced systems analyses and identify transformative elements for visions and robust elements for pathway switching and uncertainty management. The combined use of these tools could support backcasting in generating more transformative visions and transformative pathways to more sustainable societies. As such, we consider these add ons important to advance backcasting for climate adaptation.

We consider some of the key highlights (6, 7, 11 and 12) presented in Table 6.4 as novel contributions to the current understanding of backcasting for climate adaptation in the literature.

Backcasting for climate adaptation involves increasing resilience of social-ecological systems, whereas backcasting for climate mitigation focuses more on technical solutions for CO_2-emission reduction (Klein, Schipper et al. 2005, Grafakos, Viero et al. 2020). As climate adaptation and mitigation can reinforce each other in exploring shared goals, assessing trade-offs and seeking mutually supportive outcomes (Klein, Schipper et al. 2005, Kim and Grafakos 2019, Nwedu 2020, Iacobuţă, Brandi et al. 2022), future backcasting studies for climate mitigation and adaptation would benefit from addressing synergies between mitigation and adaptation actions and options.

Table 6.4 Overview of key highlights from cases and discussion.

Dimension	Key highlights
Inputs & project settings (Table S1 in Supplementary Material)	• Larger project budgets enable the deployment of comprehensive tool and methods for advanced system analysis • A commissioner has a positive effect on the impact of the project
Process & methods (Table S2 and S3 in Supplementary Material)	• Broad stakeholder engagement enriches vision and pathway development and increases stakeholder support and commitment to results • Involvement of marginalized groups increases legitimacy of results but requires capacity building efforts • The degree of stakeholder influence is determined by arrangements for stakeholder influence on content or process • Advanced system analysis requires comprehensive modelling and simulation tools and methods
Results in backcasting studies (Table S4, S5 and S6 in Supplementary Material)	• Multiple visions for climate change adaptation are more beneficial for addressing uncertainties than single visions • Adaptation pathways determine actions in the short and long run and can address uncertainties about these actions • Robust elements enable pathway switching and managing uncertainties • Pathways addressing synergies between mitigation and adaptation actions result in more hybrid pathways and allow for pathway switching • Scenarios enable robustness checks of visions and pathways and pathway switching • The monitoring and evaluation of climate actions requires goals and guiding targets • *When pursuing transformative adaptation this must become part of visions and pathways
Impact (Table S7 in Supplementary Material)	• Inclusion by formal decision making has a positive effect on the impact of the project • Different types of impact can distinguished: scientifically, societal, policy, domain/sector specific (field of application) • *Transformative adaptation requires all types of impact* • * Power relations may prevent the project outcomes from being included in formal decision making*

*Key highlights from the discussion.

Conceptual reflections

Our evaluation offers room for conceptual reflections regarding the use of backcasting for climate adaptation and transformative climate adaptation and impact of backcasting studies. We consider the add-ons discussed in 6.5.2 important to advance backcasting for climate adaptation because they allow for advanced system analysis, vision and scenario and pathway development and switching for dealing with uncertainties, all of which seem relevant to climate adaptation.

Moreover, our cases show that backcasting is generally applied for regular climate adaptation, despite its potential to accommodate transformative change. In backcasting, usually limited attention is paid to the broader societal context, which is key to achieve transformative change. Instead, the existing system remains the point of reference for such changes, while backcasting has the potential to shift the societal debate from 'what is already there?' to 'what is needed?". It is important to combine the critical stance towards business as usual and the drive for systemic, transformative change with the ability to show society what is desirable and possible (Loorbach, 2022).

Yet more is needed to make backcasting fit for transformative climate adaptation. After Park, Marshall et al. (2012), we define transformative climate adaptation as a process that results in fundamental change in the biophysical, social or economic components of a system from one form function or location to another, thereby enhancing the capacity for desired system states to be achieved given perceived or real changes in the present or future environment. Whereas regular climate adaptation involves relatively incremental changes in these system components or in their management, transformative climate adaptation relates to future desired fundamental system changes that can be envisioned through backcasting.

For backcasting studies to support transformative climate adaptation, it requires transformative capacity, as the ability of actors to create novelties and embed them in structures (social-cultural), practices and discourses. O'Brien (2011) proposes that building transformative capacity requires a combination of technological innovations, institutional reforms, behavior shifts and cultural changes among relevant stakeholders at various governance levels. A climate governance perspective on transformative capacity helps explaining and evaluating what new types of conditions for integrated, innovative and reflexive approaches to addressing climate change, sustainability and resilience (Holscher 2019). This perspective allows us to frame backcasting processes as a governance-related capacity building processes that shape the conditions for transformative capacity for climate governance (Faldi and Machi, 2017; Holscher et al., 2019a, b).

There seem to be an unrealized potential in backcasting to support transformative change, which is likely to observed in the long run because fundamental systems changes take a long time to occur, although it needs to be included in visions and pathways.

For backcasting studies to achieve transformative impact, it is important to consider impact as a design criterion for the backcasting process. Different types of impact can be distinguished: scientific, policy, societal, domain or sector specific. We suggest that transformative adaptation requires all these types of impacts to contest default practices. However, we propose backcasting to be well equipped for making explicit vision statements influencing the potential direction of transformation, as well as to explore how transformative change can be achieved gradually. Building on Van der Voorn et al (2012), we consider transformative change as a prerequisite for transformative adaptation. Without transformative change, climate adaptation remains incremental changes in adaptation to climate change, failing to achieve radical system change for transformative climate adaptation.

Reflections on analytical framework

In section 3.1, we distinguished three types of criteria (conditional, result-oriented and impact-oriented) to determine meaningful or successful use/application of backcasting for climate adaptation. As a starting point, we consider successful backcasting studies to involve inputs related to the goal set, favorable project settings, broad stakeholder engagement, and combining various types of tools and methods to achieve endorsed results that can contribute to long-term impact. Our criteria involving all dimensions of our framework need to be met for successful backcasting. In this sense, the three types of criteria appear to be conditional with respect to each other. For example, backcasting studies with small budgets can also lead to results, but not as comprehensive as backcasting studies with larger budgets. Also, implementation and other impacts require good results that are based on broad and meaningful participation and good application of methods and tools.

In our analytical framework, change is only addressed by the criterion of 'transformative elements' in visions. We acknowledge that other aspects can also contribute to the transformational backbone for visions, which are not included in our framework. Wiek and Iwaniec (2014), for example, provided criteria for assessing the transformational quality of visions, including sharedness, motivational, nuance, and relevance. We suggest that inclusion of soft criteria could support evaluating the transformative potential of backcasting studies, as a driver for structural, technological and cultural change. Addressing the issue of transformation of a socio-ecological system also implies the consideration of further variables/criteria. As this is not currently included in our framework, we consider this as a limitation of our study, which merits further research.

Limitations

The execution and design of the backcasting processes are influenced by the related governance context, which appears to have less impact on the outcome of the process than expected. This may indicate that other dynamics are at play, such as learning processes among stakeholders, which were beyond the scope of our evaluation. Likewise, we have evaluated the results of vision, pathway and scenario development, but did not look into the underlying knowledge generation process. Such processes could provide further insight into how expertise and knowledge would have affected these results and stakeholder endorsement of the results. The scope of our analysis did not account for the blocking and opposition power by (non-involved) stakeholders that see their interests affected. Although we did not account for power relations in this study, the authors involved in the cases indicate that this most likely would have played a role. This can also be applied to non-involved groups of citizens or non-involved marginal groups. In addition, we have not compared the different modelling and scenario tools in a detailed way whereas this interesting for further research (see 6.2.1). Finally, most of our cases show rather limited impact, while a longitudinal study would be useful to develop a more in depth understanding of impact and their mechanisms over longer periods of time e.g., the political aspects (political will and power relations) that affect impact.

In our study, we analyzed a significant sample of cases. However, a larger number of cases could further substantiate our findings. Nevertheless, the sample size is typically smaller in qualitative research while acquiring more data does not necessarily lead to more information (Ragin 2014). In addition, determining an adequate sample size in qualitative research is ultimately a matter of judgment and experience in evaluating the quality of the information and the particular research method and purposeful sampling strategy employed (Blaikie 2018).

Our sample size can be justified according to the research methodology of multi-case study, ensuring adequate collection of relevant data as well as the case selection. The selected cases provide valuable insight into the different ways, in which backcasting processes took place in different governance contexts. We consider that the current set of cases have relevance, as there are more cases to compare, and that there is considerable added value in having cases from different contexts and different research groups, to get clearer differences and similarities. We agree that a smaller set of cases allows for more in-depth evaluations and some of the authors have previously done this (e.g. Van der Voorn et al, 2017), although our ambition was to bring this to a more aggregated level, as that is hardly done.

We have applied the selection criterion of "conducted and realized before 2020".. However, the cases show limited impact. In earlier work it has been found that in case of impact after 5-10 years clear institutionalization can be found, but still at a niche level, though with the potential to act as a stepping stone in an emerging transition if concerted effort takes place or relevant regulation is developed.

Backcasting processes aim to shift people's mindset from which follow up activities are likely to emerge after the backcasting study it is necessary for a researcher to create some distance from the study and prevent bias in the interpretation of case results. Changing people's mindset is part of the learning processes, which have not been evaluated in this study, but has been shown in other studies e.g., Quist et al. (2011) Robinson, 2003). As our focus is on best practices based on available studies, it was not our aim to evaluate such processes in more detail in this study, but we suggest that this aspect warrants further research.

Our analysis increases our understanding what criteria determine successful backcasting for climate adaptation, although further evaluation of backcasting studies against these criteria would support building a strong case for participatory backcasting for climate change adaptation. In our view, successful backcasting is considered as a well-designed (see 6.2.2) and well-assessed conducted study that leads to measurable results and draws on endorsed visions and pathways used by stakeholders. As discussed in section 6.2.4, conditional, results-oriented and impact-oriented criteria, covering all dimensions of our framework, have to be met for having successful backcasting. We consider it is important that the three types of criteria appear to be conditional with respect to each other.

6.6 CONCLUSIONS AND RECOMMENDATIONS

In this paper, we have adapted and applied an existing framework for the evaluation and comparison of cases to advance participatory backcasting approaches for climate change adaptation. The framework has been useful to describe and analyze a diverse set of cases, showing both differences and similarities in very different contexts.

Our analysis also provides insights into how to further advance backcasting for climate adaptation. Based on these insights, we argue that there is indeed a considerable potential in using backcasting for enhancing climate change adaptation. The potential of backcasting lies in its capability to support adaptation in a participatory manner for building more resilience of socio-ecological systems in different contexts e.g., water, mobility and forest management. To make backcasting fit for climate adaptation it requires the use of different types of different types of modelling and simulation tools and methods for advanced system analysis, inclusion of transformative elements in visions and pathways and robust elements for pathway switching and uncertainty management, and hybrid pathways.

In our view there is a so far unrealized potential of backcasting to enable a shift from incremental-based adaptation to transformative adaptation. The starting point for realzing that potential would be to explore transformative futures that could lead to pathways to different (sustainable) societies in which economic, ecological and societal structures will have fundamentally changed. This can be done in a backcasting study, which (i) adopts a systems approach, (ii) learns from practice, (iii) co-creates transformational knowledge, and (iv) invests in capacity building for inclusive transformational adaptation. These aspects enable backcasting to support transformative change, but transformative change must be present in visions and pathways too. Whether backcasting enables a transition to transformative adaptation can be considered a hypothesis that needs to be substantiated through further research.

Despite limitations, our review has scientific merit as it provides a detailed examination of how various backcasting approaches can be used for climate adaptation, while it provides clear suggestions and directions for further methodological improvement and methodology development. Our study also suggests that further development is possible for backcasting to support transformative adaptation. Comprehensive modelling and simulation tools and methods as applied in some of our cases are also useful for consolidating synergies between mitigation and adaptation actions and options in scenarios and pathways, which has not yet become mainstream in other domains like urban planning (Grafakos, Viero et al. 2020). These approaches work better when backcasting studies become more transdisciplinary reporting on key aspects of backcasting processes, including interdisciplinary teams from relevant knowledge fields, broad stakeholder involvement and connection to decision making processes, all of which can assist us in moving our knowledge forward in this area (Muiderman 2022).

Addressing the transformative potential of backcasting merits further research.
As such, we propose the following recommendations for future backcasting studies:

- More transdisciplinary research on backcasting studies for climate adaptation is needed to gain further insight into methodological advancements and other key aspects of backcasting supporting transformative adaptation;
- Broad stakeholder engagement is needed to increase the legitimacy, accountability and credibility of stakeholder processes and support and commitment to the results of backcasting studies;
- Backcasting studies benefit from interdisciplinary teams of experts and practitioners from various disciplines to mobilize various stocks of knowledge, expertise and skills needed for the use of comprehensive tools and methods for advanced system analysis;
- The use of robust elements and pathway switching combined with advanced tools and methods merits further attention, especially in domains that deal with large climate uncertainties and the complexity of the social-ecological systems under study.
- Backcasting for climate adaptation and mitigation would benefit from addressing synergies between mitigation and adaptation actions and options across various domains e.g., water, energy, land-use, resulting in more hybrid pathways and integrated scenarios.

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CHAPTER 7

DISCUSSION & CONCLUSIONS: TAKING STOCK OF LESSONS LEARNT, MOVING FORWARD

This thesis takes stock of key insights and the lessons learnt regarding the relevance of the use of visioning and backcasting for transformative climate adaptation in water management during the last ten years. The climate crisis the world is facing has become more severe in the past decade. My main research problem and premise when I started was that climate change clearly revealed the limitations of adaptive water management that aims at accommodating the impact of climate change through minor alterations that build the resilience of people and nature. Due to the increased complexity of the human-environmental context and the expected increase in the frequency and intensity of extreme weather events, a shift seemed necessary in water management. A shift to move beyond the incrementalism that is inherent to adaptive water management but insufficient to address the current and future challenges of climate change. It had to be a move towards water management that supports, guides and accelerates long-term, fundamental changes in water systems to make them more resilient to climate change.

Against this backdrop, I have explored the use of backcasting as a complementary approach to adaptive management for supporting transformative adaptation. To substantiate this, I first critically reflected upon how backcasting has been applied to climate adaptation in three specific cases in order to identify what is needed to further advance the potential of backcasting for transformative climate adaptation. It is necessary to improve our understanding of the relevance of visions and visioning in water management transitions. Furthermore, insight can be gained from historical water management transitions (more details can be found in the first paper (the WATER-paper).

Drawing on such insight, I investigated to see how normative vision-oriented approaches like backcasting and climate adaptation approaches can be combined to develop more robust climate strategies. This investigation included methodology development with validation through a single case, resulting in the BackCasting Adaptive Management (BCAM) methodology (for more details see the second paper (FUTURES-paper)). Further methodological development of the BCAM methodology was accompanied by framework development for the evaluation of cases focusing on visioning and strategy development for robust climate change adaptation planning. The outcomes were evaluated on their potential for the further development of normative approaches in climate change adaptation planning in general and for the BCAM methodology in particular (for further details see my third paper (the MITI-paper). A multi-case study research on the use of participatory backcasting approaches was conducted to identify the best practices in the use of backcasting for climate adaptation. That research serves to elaborate on the potential of backcasting for climate adaptation and what is needed to advance backcasting for transformative adaptation (more details can be found in the fourth paper (CLRM-paper)).

The outline of this chapter is as follows: In Section 7.1, I discuss my research contributions and revisit the research questions formulated in Section 1.5. Section 7.2 presents an integrated discussion on the findings from the papers that underlie this thesis. Section 7.3 takes stock of key insights and the lessons learnt from the use of backcasting for climate change adaptation and the implications for transformative adaptation. That section also addresses the research limitations of this research, including the recommendations. Finally, Section 7.4 proposes a vision on backcasting for transformative water management.

7.1 RESEARCH CONTRIBUTIONS AND REVISITING THE RESEARCH QUESTIONS

In light of the research aim, my main research question was as follows: ***How can visions, visioning and backcasting enhance transformative adaptation in water management?***

This central question was further broken down into a number of sub-questions:

1. What is the role of visions and visioning in long-term water management transitions and what is their relevance to current water management challenges?
2. How can vision-oriented approaches and climate adaptation approaches be combined to develop visions for climate adaptation planning?
3. How can visioning and backcasting for climate adaptation be systematically evaluated and compared and what results and impacts have been realized?
4. How can backcasting for climate adaptation be further advanced and what is needed to advance backcasting for transformative adaptation?

By answering these research questions, my research has offered some empirical and conceptual contributions related to different aspects regarding the use of backcasting for climate adaptation.

7.1.1 What is the role of visions and visioning in water management transitions and what is their relevance to current water management challenges?

Chapter 3 (the WATER-paper) presents a qualitative historical single-case study on water management transitions in the Lower Mississippi River in the US. The aim of this case study was to analyze water management transitions and emerging visions and niches and to enhance our understanding of the role of visions and visioning in water management transitions. This case study facilitated the development of a framework for analyzing water management transitions and emerging visions and niches, which builds on the Multi-level Perspective (MLP) proposed by Geels (2002c); an analytical angle associated with the transitions approach.

The historical case study was designed as a longitudinal study on the important role of visions in past water management transitions over a period of 200 years (for more details see Van der Voorn and Quist, 2018). Its findings are relevant to water management policy and transition studies. Theory development on visioning and visions is still limited and many authors do not go beyond the confirmation that it is important to have or develop a vision, mostly in relation to a specific need for action.

Firstly, visions reflect the dominant thought in water management (Van der Voorn and Quist, 2018). Visions represent perspectives on water management, which are rooted in beliefs, values and mental frameworks. Dominant visions are reflected in guiding principles and rules for water management, all of which are rooted in the dominant water management paradigm. Secondly, visions have the potential to articulate cognitive challenges and provide guidance for transitions. Transitions in general start from within niches from which new visions, practices and structures emerge and develop. Visions can especially be seen as cognitive activators for the generation and mobilization of knowledge, resources and actors (Quist, 2007; Van der Voorn and Quist, 2018). For example, climate visions convey a message that may trigger actors to take action in relation to climate. Thus, visions provide guidance, particularly when they are shared by a large group of actors, all of which helps to generate shared goals and synchronize learning processes among actors.

Opposed to dominant visions are emerging visions that play an important part in guiding transitions as they challenge mainstream discourse, empower alternatives, give guidance to change-makers and open up perspectives to new futures for larger groups of people in general. Emerging visions are motivators for change because they reveal the shortcomings of the prevailing paradigm for water management (Van der Voorn and Quist, 2018). Emerging visions also provide alternative perspectives to compensate for these shortcomings. Like dominant visions, emerging visions are rooted in different belief systems, values and mental frameworks, initially not shared by larger groups of actors. Emerging visions can function as seeds for change co-shaped by one or a group of actors, typically involved in challenging the dominant water management paradigm. Emerging visions are usually associated with 'outsiders' (e.g., vision champions, frontrunners), who oppose the dominant water management paradigm and are likely to display rule-breaking behavior.

Visioning involves the process of mapping a possibility space for transitions. For example, visioning helps to explore a realm of plausible alternatives for water management. Learning is key to visioning as it explains why some emerging visions with divergent perspectives are more promising or plausible than others or why some actors are more successful in building a supportive network for the vision (Van der Voorn and Quist, 2018). The level of guidance provided by visions is determined by the way agency is provided by actors. Vision champions play an important role in the further diffusion of visions and niches (Quist, 2007; Van der Voorn and Quist, 2018), but they are not decisive. It also depends on their power positions and relations. The historical case study shows that only one of these visions became successful in guiding transitions. Alternative visions compete with each other in order to become the most promising visions offering an alternative to current practices in water management. In the process, there is no single factor or decisive development (Van der Voorn and Quist, 2018) see also the WATER-paper. The historical case study shows that some vision champions were more successful than their counterparts in creating supporting networks for the niche visions. Therefore, vision champions become embedded in larger networks, in which the type of membership, role, connections, and power of actors influence the successful adoption of a niche vision.

Historical case studies underline the relevance of understanding the role of visions as well as the need to better understand how historic visions have helped shape the present. Of particular interest is the previous transition towards adaptive water management that started in the late 1990s in response to the technocratic paradigm on which water management was based. Accordingly, adaptive water management strategies were developed and implemented to accommodate the impacts of climate change by making minor alterations that build the resilience of people and nature. However, the current policy practice in water management still remains adaptive management, which is incremental and responsive by nature. This type of adaptation proved to be insufficient or counterproductive though in the face of more extreme weather events (see Section 1.3.2). Due to the increased complexity of the human-environmental context, in which the climate crisis is unfolding and the anticipated increase in the frequency and intensity of weather events, a shift is taking place in the dominant thought on climate adaptation in relation to water management. In the short term, societies need to adapt physically to the impacts of climate change but they also mitigate the causes of climate change. Both climate adaptation and mitigation generate solutions that may lead to new problems or side-effects in the future. Water management and its climate adaptation strategies need to extend beyond incrementalism – to be more transformative – to establish climate security in the long run. Backcasting can offer a suitable approach to dealing with the short and long term challenges of climate change, as it recognizes the incremental nature of climate adaptation and is able to anticipate system shocks.

7.1.2 How can vision-oriented approaches and climate adaptation approaches be combined to develop visions for climate adaptation?

As discussed in Chapter 4 (FUTURES-paper), a single case study was conducted and its aim was to conceptualize backcasting as a complementary approach to adaptive management in the interests of developing climate adaptation strategies and policies. It also facilitated methodology development, a design component validated in the context of the case study. This study expands on further methodological development of normative scenario and vision approaches to climate change adaptation planning and how it can be combined with management-oriented frameworks like AM. In so doing, some relevant conceptual and methodological contributions have been made.

As discussed in Section 2.2.1, there are various foresight approaches in the Futures Studies domain that are suitable for addressing different kinds of long-term aspects and uncertainties associated with climate change. Exploratory foresight approaches, for instance, are well-equipped for mapping uncertainties but often fail to account for normative aspects such as preferences or desirability. In climate adaptation research, normative vision-oriented approaches are proposed for climate change adaptation. Due to their normative and problem-solving character, normative vision-oriented approaches like, for instance, visioning and backcasting are considered to be much better suited to addressing long-term problems and sustainability solutions. However, normative approaches have their limitations too. For example, they are thought to be most likely to be effective where a widely shared goal already exists, and where foresight can then help to make visions of the future explicit. In cases where a long-term goal already exists, normative approaches can mobilize inputs into priority-setting and other elements of decision-making by providing pathways and indicators that can be used to monitor progress for the desired future. Nonetheless, the limitations of normative approaches take precedence over those associated with forecasting and exploratory approaches. The problem context described in Section 1.2 argues in favor of normative foresight approaches for dealing with climate uncertainty and the complexity of water systems and addressing normative aspects such as different worldviews, norms and values, and preferences.

As described in Chapter 4, it can be concluded that backcasting and AM are complementary approaches as backcasting provides AM a long time frame for the fulfilment of short and mid-term management goals and pathways to robust climate change adaptation futures, whereas with AM the emphasis is on adaptiveness (the ability to cope with uncertainty) and reflexivity (the ability to respond to changing conditions) within this timeframe. These aspects are essential for transformative water management when seeking to address short, mid, and long-term goals while coping with uncertainty. When combined, these approaches provide a long-term, iterative, learning-based participatory perspective on guiding the management of complex adaptive systems. Both approaches attempt to create institutional frameworks so as to achieve the desired changes in complex multi-level and multi-stakeholder systems, in the face of climate uncertainties.

Backcasting and AM can be combined to develop visions and pathways for transformative water management, through the development of the Backcasting Adaptive Management (BCAM) methodology that combines the strengths of backcasting and Adaptive Management. Backcasting enables us to envision and reach out to desirable or undesirable but radical futures, by thinking radically differently towards these futures and exploring how the required change can be incrementally achieved. When combined with backcasting, adaptive management takes on a different orientation and meaning. Backcasting helps us to conceive of the most preferred futures we would wish for ourselves. These futures have a particular character and the (incremental) adaptation process towards that end is transformative. This reflects the very essence of what transitions entail (see Section 2.2.2), which is also implicitly discernible from the cases. In retrospect, the case study and its approach goes together well with the theoretically developed BCAM methodology.

7.1.3 How can visioning and backcasting be systematically evaluated and compared and, what results and impacts have been realized?

Chapter 5 (MITI-paper) presents a qualitative multi case study on the impact of backcasting studies. The aim was (i) to evaluate cases on vision development for robust climate change adaptation planning and (ii) to evaluate the outcomes regarding their potential for the further development of normative approaches to climate change adaptation planning in general and for the BCAM methodology in particular. It presents the development of an evaluation framework suitable for systematically evaluating cases on the development and implementation of visions in three coastal regions. The research findings reveal various methodological novelties related to the use of backcasting for climate adaptation purposes. The relevance of regional cases for participatory visioning and backcasting contributes to a better understanding of such approaches where climate adaptation is concerned.

The research question prompted the development of an evaluation framework for the qualitative comparative analysis of three backcasting studies. Building on Quist (2007) and Quist et al. (2011), who developed frameworks for evaluating the impact of participatory backcasting studies, I developed a framework for the impact evaluation of backcasting studies within the context of climate adaptation. This framework includes six major dimensions of vision and pathway development as distinguished for climate adaptation planning: (i) inputs & resources (ii) vision development, (iii) stakeholder engagement, (iv) pathway development, (v) methodological aspects, and (vi) impact. These dimensions provide the key building blocks that underlie different types of vision and pathway development processes, including implementation, and the various impacts of backcasting studies.

Using the evaluation framework, the comparative case analysis provides valuable insights into how visions were developed and implemented in varying ways and contexts. Visions were generated and implemented through a participatory process applied to different governance contexts. The nature and design of vision development are characteristic for the related governance context of the cases. The South African case is characterized by top-down governance. The participatory vision development process was government-initiated but simultaneously decentralized and empowerment-oriented. In the US case, the governance context can be characterized by the strong belief in market-based solutions, a 'small government' and private sector initiatives, while water safety remains a public responsibility. The participatory vision development process was initiated and facilitated bottom-up by a private think tank. In the Dutch case, the presence of polycentric governance combines top-down as well as bottom-up and links networked governance with the network-based coordination of initiatives and sectors. The participatory vision development process was government-initiated but based on a polycentric process.

General patterns can be found in the way visions have been generated and implemented and the precise impacts that have been realized. Firstly, in all three cases, visions, regardless of whether those were single visions, shared visions or multiple visions, were present and used for pathway development. The cases show that a single, shared future vision is not a prerequisite for vision and pathway development and endorsement. Moreover, it appears that multiple visions for climate change adaptation are more beneficial when it comes to addressing uncertainties than single or shared visions. This points to a deviation from the dominant perspective on single and shared visions in Futures Studies literature. This research also reveals that the development of multiple long-term adaptation pathways, including robust elements and pathways that switch to dealing with these uncertainties can be considered conceptual and methodological novelties that require novel knowledge and expertise.

Secondly, the cases show that broad stakeholder engagement is essential for enriching vision and pathway development. It generates stakeholder commitment to and co-ownership of the results of stakeholder processes neither of which guarantee successful implementation, as that depends on other aspects. In three cases, stakeholder diversity and influence was evident. Compared to the US and Dutch cases, stakeholder diversity was greater in the South African case study because it included the involvement of marginal groups, which enhanced stakeholder engagement and commitment. As these groups concerned illiterate and poor black farmers who had never been involved in decision making processes, their involvement was challenging and therefore required substantial capacity building efforts before they could contribute to the process.

Moreover, from the cases, it can be concluded that the development of multiple long-term pathways and robust elements is a conceptual and methodological novelty that requires novel expertise. The Dutch case was more advanced in terms of pathway development than the other cases, which may well reflect the leading position of the Netherlands in climate change adaptation planning (Haasnoot et al., 2013b; Haasnoot et al., 2018).

All three cases show a varying degree of impact. Two cases show impact in terms of follow-up activities for implementation and broader spin-offs. All cases also show broader knowledge dissemination as examples of broader spin-offs. The South African case governmental endorsement of the newly drafted water management strategy led to additional financial resources for implementation and other follow-up activities. In the US case, there was limited impact because the strategy development process was not linked to formal decision-making and therefore the focus was on agenda setting by raising awareness, and capacity building. Follow-up activities were established through new strategic partnerships and capacity building initiatives, which were needed because the committee lacked the required resources and regulating power. In the Dutch case, the outcomes of the visioning process were included by formal decision-making which led to follow-up activities. More institutional embeddedness of participatory processes, through which connectedness to formal decision-making processes becomes apparent leads to better implementation of the outcomes of these processes. Finally, the nature and design of vision development are characteristic for the related governance context, but have less impact on the outcome of the vision development process than expected.

7.1.4 How can backcasting be further advanced for climate adaptation and what is needed if transformative adaptation is to be established?

As discussed in Chapter 6, a qualitative multiple case study on best practices in the use of participatory backcasting approaches was conducted to elaborate on the potential of backcasting for climate adaption. Based on the literature review presented in Section 1.4, backcasting has been applied in the field of climate adaptation, but there are fewer studies that have explicitly applied backcasting to climate adaptation. Broader search terms led to a greater range of backcasting studies across various domains and sectors, addressing climate-related topics, but also introducing less relevant studies for this multiple case study. The aim was to identify what is needed to apply backcasting to climate adaptation by making use of the widely acknowledged strengths of backcasting as well as identifying elements that could add value to the topic of climate adaptation. The findings of the multiple-case study research have their own scientific merit as they provide a detailed examination of how various backcasting approaches were used in the field of climate adaptation, while providing suggestions and directions for further methodological improvement and methodology development.

This aim motivated framework development for the multi-case study. Table 6.4 summarizes the key aspects enabling the impact of backcasting studies for climate adaptation (for more details see Van der Voorn et al. (2023)), which provides further insight into what is needed if backcasting is to be advanced for transformative adaptation. In general, backcasting for climate adaptation involves increasing the resilience of socio-ecological systems, whereas backcasting for climate mitigation focuses on technical CO2-emission reduction solutions (Grafakos et al., 2020; Klein et al., 2005a). Therefore, advancing backcasting for transformative adaptation requires the integration of climate adaptation and mitigation. Such integration can help backcasting: address the altering of fundamental features or interaction in social-technical systems and social-ecological systems like water systems; switch the trajectory of a given water system to a different direction; span multiple, jurisdictional or sectoral scales; trigger systemic changes at large and across scales; introduce new functions or states for specific regions; achieve long-term impacts, even if they are not necessarily irreversible.

As climate adaptation and mitigation factors can reinforce each other in exploring shared goals, assessing trade-offs and seeking mutually supportive outcomes (Iacobuţă et al., 2022; Kim and Grafakos, 2019; Klein et al., 2005a; Nwedu, 2020), backcasting for transformative adaptation would benefit from addressing synergies between mitigation and adaptation actions and options. Such synergies enable backcasting to: address the root causes of climate-related vulnerabilities; plan anticipatory and long-term adaptation; avoid ineffective adaptation and maladaptation; implement robust adaptation options.

Overall, historical insights provide valuable input for visioning and backcasting studies as part of the experiments needed to acquire knowledge and all the experience regarding new management practices and schemes for transformative water management. Backcasting has features that support water managers and policy makers in developing long-term climate solutions that can effectively reduce climate change

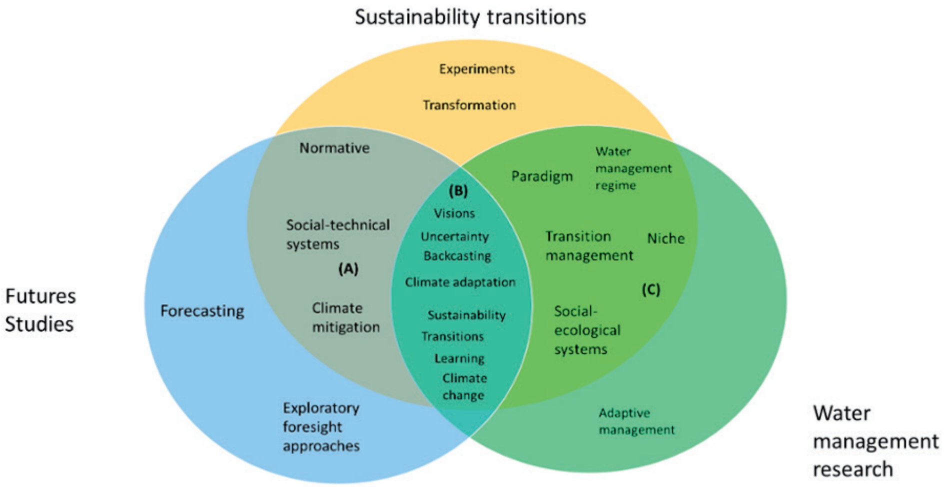

Figure 7.1 Overview of the key terms and concepts.

risks so that they can develop their own agenda. Such solutions are typically developed in what are termed niches, which have not yet been institutionalized but are potentially embryonic nuclei for the future. Niches need to be facilitated and nurtured by water managers and policy makers to enable knowledge development and learning processes for crafting visions, scenarios and transition pathways for transformative change to take place.

7.2 INTEGRATING DISCUSSION

7.2.1 Overview of the key concepts and papers

This research integrates and fuses concepts from sustainability transitions, futures studies and water management research to form an interdisciplinary and transdisciplinary area, as introduced in Chapter 2. As illustrated in Figure 7.1, the Venn-diagram summarizes the key terms and concepts for each research area. Of particular interest are the ones that dominate in all areas (situated in the overlapping space) because they are also revealed in the empirical parts of this study. The terms and concepts located in overlapping area A are addressed in the FUTURES-paper. The overview of these terms and concepts from sustainability transitions and futures studies has enabled me to develop the BCAM methodology.

Furthermore, the overlapping area B includes terms and concepts that are addressed in the MITI and CLRM papers. The integration of these terms and concepts from sustainability transitions, water management research and futures studies has allowed me to further refine the BCAM methodology, as published in the MITI paper. It also helped me to systematically evaluate and compare 10 backcasting studies, which laid the foundation for conceptual reflections on transformative adaptation published in the CLRM-paper. It is shown that most backcasting studies are related to climate mitigation and concern social-technical systems, whereas backcasting studies on climate adaptation and water research concern social-ecological systems. This also corresponds to the Venn diagram.

Finally, the overlapping area C includes terms and concepts that are addressed in the WATER-paper. The integration of these terms and concepts from sustainability transitions and water management research allowed me to develop a framework for analyzing historical water management transitions. The outcomes of the historical inquiry helped me to critically reflect on the role of visions and visioning in historical water management transitions and their relevance to current water management challenges. The historical inquiry confirms that visions are developed in niches, which is also the case in the context of research done on backcasting. This is also congruent with the Venn diagram. In addition, both sustainability transitions and water research use regime concepts (i.e., a social-technical versus a water management regime, both of which are closely interrelated as explained in the WATER-paper.

7.2.2 Reflections

My research reveals the complexity of water management transitions, which are contingent on social, environmental, political, and economic factors. It critically reflects upon the viability of past and current water management practices in the light of vision development and experiments for transformative water management in niches. It enables water managers and policy makers to acquire knowledge and experience about new management practices and schemes for transformative water management. Such niche developments need to be facilitated by water managers and policy makers to enable knowledge development and learning processes in order to craft visions for transformative water management. Therefore, this research has relevance for transition studies, as it contributes to a better understanding of the interplay of visions, actors, and niches in water management transitions, which have been hitherto underexplored in the transition literature. It demonstrates that water management transitions are not unidirectional developments, but rather path-dependent processes that may be affected by various drivers, including sudden disruptive events. Backcasting is particularly useful for managing transitions in water management as it allows water managers and policy makers to deviate from the current situation, by thinking about radically different futures and how such futures could be achieved in an incremental way.

Backcasting is a transdisciplinary and interdisciplinary approach (Quist, 2007). It is interdisciplinary because it brings together and integrates methods and knowledge from various disciplines. It is transdisciplinary because it involves stakeholders, stakeholder knowledge and stakeholder values. Depending on the goals backcasting strives to achieve, there are different demands that need to be met. Quist (2007) and Quist et al. (2011) made a distinction between normative, process and knowledge demands. Normative demands reflect the goal-related requirements for the future vision, as well as how sustainability is defined in the case under study and turned into principles or criteria that future visions should meet. Additionally, process demands are requirements regarding stakeholder involvement and their level of influence in the way issues, problems and potential solutions are framed and resolved in the backcasting study. Finally, knowledge demands are required in order to set the requirements for the scientific and non-scientific knowledge strived for and how these are valued one to another. The demands need to be specified at the beginning of a backcasting study. This research provides potential avenues for advancing interdisciplinary and transdisciplinary research according to the demands of backcasting for transformative adaptation. In essence, backcasting is all about exploring and developing future visions and pathways that could lead to the implementation of these visions.

My research findings confirm the large variety in the types of visions that have been developed as well as the way in which they have been developed and implemented. For example, the visions I have evaluated in this research differ in terms of content and scope, reflecting the goals of the corresponding backcasting studies. Despite these differences, a common characteristic remains the inclusion of transformative elements. Drawing on Van der Helm (2009), I initially conceptualized such elements to reflect the perceived gap between the current and the desirable situation in climate adaptation (see the MITI-paper and Van der Voorn et al., (2017)). Due to the new insight gained during my research, I reframed transformative elements as aspects that create new directions for transformative adaptation (see Van der Voorn et al. (2023)). It is important to note that most of these backcasting studies were academic studies that generated little or no impact on climate adaptation in practice and did not contribute to transformative change. This does not come as a surprise given the recent shift from climate adaptation to transformative adaptation in the field of water management (Fedele et al., 2019; IWMI, 2021). This explains why transformative adaptation was not considered in the backcasting studies that were conducted in the period between 2009 and 2020. Content-wise, I therefore conclude that visions for transformative adaptation differ from visions for climate adaptation. The reason is because the former visions target fundamental system changes on a large scale, shifting the current trajectory of social-ecological systems in a different direction, spanning multiple spatial, jurisdictional and sectoral scales, introducing new societal functions or system states, and long-term impacts, while the latter visions focus on incremental change. In other words, different normative demands apply to visions for transformative adaptation. From the perspective of normative demands, further investigation on such demands is warranted alongside what can be learned from other literature (e.g. sociotechnical) in relation to the developing of new visions, utopias, alternative worlds, vision entrepreneurs, niche experiments, 'sharp breaks', small scale initiatives, learning and innovation.

Process-wise, backcasting is usually conducted in a project or study in which backcasting is applied explicitly and a broad range of stakeholders are involved. In such projects or studies, stakeholders meet and are involved in developing, assessing, discussing and adjusting future visions. A backcasting study is often conducted in informal settings (e.g., niches) that function as a protected experimental space in which ideas can be articulated and discussed, while ignoring the interests and rules of the outside world. Backcasting helps to engage stakeholders in the co-creation of possibly alternative climate change adaptation futures (Nalau and Cobb, 2022). Backcasting is particularly useful for addressing different stakeholder interests, perceptions and perspectives in a bid to inform climate decision making and in order to establish stakeholder support and commitment to climate action that is steered by adaptation pathways (Van der Voorn et al, 2017). In the process, backcasting supports the exploring of alternative futures and looking to see which options and adaptation pathways enable us to achieve the desired futures (Butler et al., 2016; Pandey et al., 2021; See et al., 2022; Vizinho et al., 2021; Werners et al., 2021; Wise et al., 2014). Backcasting is also beneficial for the enabling of social learning, for enabling stakeholders to explore and open up possible space for empowering transformative adaptation action to achieve the desired impact (Holden et al., 2016; Lonsdale et al., 2015; Mendizabal et al., 2021).

Overall, this research show that broad stakeholder engagement is key to enriching vision, scenario and pathway development, but also for securing the legitimacy, accountability and credibility of stakeholder processes as well as obtaining stakeholder support and commitment to the results of backcasting studies. Securing legitimacy, accountability and credibility can be complicated. Without broad stakeholder participation, climate adaptation decisions run the risk of appearing illegitimate and untrustworthy, which I consider to be counterproductive to transformative adaptation. Achieving legitimacy, accountability and credibility requires process arrangements to be secured and looked after by those who are in charge of the backcasting study and who are subsequently held accountable for the process and its outcomes. Such arrangements may include 'the rules of game' or protocols for conflict resolution, degree of stakeholder influence on decision making, and the level of transparency within the stakeholder process. Consequently, more systematic impact evaluation of backcasting studies is still needed to gain further insight into the process demands that contribute to legitimate, accountable and credible stakeholder processes, and how they influence the overall impact of backcasting studies.

This thesis also suggests that further development is possible if backcasting is to support transformative adaptation, which entails fundamental system change rather than incremental adaptation (Lonsdale et al., 2015). For instance, pathway development, robust elements and pathway switching, as proposed here and earlier by Van der Voorn et al. (2017), may be of relevance to transformative transitions in other domains like energy, but have not yet been really applied. Transformative elements reflect social motivation and principles for fundamental change in transformative adaptation (Holden et al., 2016). Comprehensive modelling and simulation tools and methods as applied by Van Vliet and Kok (2015), Hickman (2014) and Sheppard et al. (2011) are also useful for consolidating synergies between mitigation and adaptation actions and scenario and pathway options, which have not yet become mainstream in other domains like urban planning (Grafakos et al., 2020). This may work better when backcasting studies become more transdisciplinary and start to report on key aspects of backcasting processes. Such studies include interdisciplinary teams from relevant knowledge fields, broad stakeholder involvement and connection to decision making processes, all of which can assist us in moving our knowledge forward in this area (Muiderman, 2022). However, more research is still needed to further advance backcasting for transformative adaptation purposes. For example, the use of robust elements and pathway switching combined with advanced tools and methods merits further attention, especially in domains that deal with substantial climate uncertainties and the complexity of the social-ecological systems under review.

Overall, the findings of the empirical research are useful for supporting the further development of the BCAM methodology and other vision-based normative approaches for climate change adaptation planning. More importantly, current developments in the literature provide potential avenues for shifting from backcasting for climate adaptation towards backcasting for transformative climate adaptation:

- Given the momentum of inclusiveness in climate adaptation (see e.g. Ziervogel et al. 2022), enhancing the involvement of marginal groups and citizens is seen as beneficial to backcasting for transformative climate adaptation;
- For backcasting to achieve the desired results and transformative impact, governance arrangements need to be put in place for the institutional embedding of participatory backcasting processes (Van der Voorn et al., 2017).
- Backcasting for transformative adaptation can be supported by comprehensive modelling and simulation tools and methods that grasp, employ and reconcile existing and alternative visions, scenarios and pathways (Van der Voorn et. al. 2023).
- Further methodological and conceptual development is required for finding multiple pathways, pathway switching and robust elements as well as for testing those things in relation to different global context scenarios (Van der Voorn et al., 2017).

- Although the development of long-term pathways can be challenging in climate adaptation, their presence is important for maintaining a long-term perspective on transformative change (see Werners et al., 2021).
- Backcasting would also benefit from examining synergies between mitigation and adaptation strategies as well as options across various domains e.g., water, energy, land-use, culminating in more hybrid pathways and integrated scenarios. I propose that such developments could be aligned with recent advancements in scenario development. Auer et al. (2021), for example, provide an example of how scenario development can support the development of robust adaptation pathways. They combined existing knowledge to develop pathways that led to novel ways to develop a multi-scale vision and used exploratory scenarios to test the robustness and feasibility of the resultant adaptation pathways see e.g. Auer et al. (2021).
- Backcasting studies could benefit from interdisciplinary teams of experts and practitioners drawn from various disciplines to mobilize the various types of knowledge, expertise and skills needed for the use of comprehensive modelling and the simulation tools and methods required for advanced system analysis. Such research contributions are needed to advance backcasting for transformative adaptation, which is likely to occur when backcasting studies become more transdisciplinary and start to report on key aspects of backcasting processes, including interdisciplinary teams from the relevant knowledge fields, which can assist backcasting scholars and practitioners in moving their knowledge forward in this area (Muiderman, 2022).

7.3 KEY INSIGHTS AND LESSONS, IMPLICATIONS AND RECOMMENDATIONS FOR TRANSFORMATIVE ADAPTATION

This section takes stock of key the insights and lessons learnt from the use of backcasting for climate change adaptation together with their implications for transformative adaptation.

7.3.1 Key lessons on visioning and backcasting for transformative adaptation

In this section, I shall draw on the key lessons learnt from the use of backcasting for climate change adaptation and for developing and applying more comprehensive visioning and backcasting that is deemed suitable for transformative adaption.

Lesson #1: Backcasting to transform the water management sector

The empirical findings provide insight into methods for improving current and future backcasting practices for climate adaptation and they indicate that more is still needed for water management if we are to address the long-term challenges of climate change. What is needed is transformative adaptation, which in turn implies that a transformation of the water management sector itself is required (Section 1.3.2). As discussed in Section 1.3.2, the transformation of water management is likely to emerge from a paradigm shift in water management, which makes it easier to better address the future challenges of climate change. Transformative adaptation is, in its essence, a kind of practice deeply embedded in culture and institutions. It is also all about the ability to capture momentum in order to establish systemic change. However, in water management, various mechanisms are at work that give rise to inertia and path dependency which manifest themselves in sociocultural structures and water management itself. Despite the urgency to act on climate change and the subsequent pressure for change, radical changes in water management still lag behind. The absence of such change indicates that the results generated by backcasting studies are rapidly translated into roadmaps or action plans, but have not resulted in rapid institutional change. This is due to the very nature of backcasting that traditionally targets system change, for which institutions institutional change is needed. In other words, backcasting aims to achieve system change, but does not account for the greater sociocultural changes that are required at a higher societal level. Institutional changes do take place, but sociocultural changes fail to get through to the masses. Whereas culture and structure are typically followed by or adhere to system change, transformative climate adaptation requires innovation in the pursuit of system change. System changes for transformative change do not come easily, because water management organizations are not responsible for bringing about sociocultural and structural changes at societal level, which is something that often involves politics. Instead, these organizations tend to abide by incremental-based and instrumental-based adaptation as that is what best serves business-as-usual water management practices. For water management to become transformative in relation to its environment, it is first necessary to transform from within (culturally and structurally) so that water becomes leading in terms of water management practices (Quist et al., 2013); water management is geared to extreme weather events as well as the rapid and disruptive societal changes that are, by nature, social-institutional.

Through the principles of caselaw, backcasting is often applied at the science-policy interface within the water system itself. It has subsequently become part of incremental-based adaptation, despite the potential to accommodate transformative change. In practice, both backcasting practitioners and policy makers engaged in backcasting studies have not yet paid sufficient attention to the broader societal context, which is key to achieving transformative change. Instead, the existing system remains the main point of reference for such changes, while backcasting has the potential to shift the debate from 'what is already there?' to 'what is needed?". Backcasting is also considered useful for increasing the awareness of policymakers about the dynamics in the natural environment in which they operate. So it makes sense for policymakers to be engaged in backcasting exercises as that encourages them to become more context-sensitive ('what is happing outside?'), which helps them to think outside-in (i.e., 'how to refer to what is happening outside?').

Lesson #2: Shifting from adapting to transformative change

Climate adaptation is an iterative and incremental process, often effected through trial and error. Adaptation pathways generated by backcasting describe how actors can continuously evaluate and make decisions related to adaptation and its different outcomes. Such pathways illustrate the key decision and intervention points that can influence the transition of a system toward a desired direction in the face of several uncertainties. They help underscore adaptation as a dynamic process over the course of time, in which certain decisions are influenced by previous choices and circumstances. In this regard, Backcasting and the Adaptation Pathways approach share a similar focus on exploring short-term actions, while keeping open the possibility to modify, extend or otherwise alter the plans in response to how the future develops (Haasnoot et al., 2013, Kwakkel et al., 2016).

Climate adaptation is often framed as a 'wicked' (Rittel & Webber, 1973) or 'super wicked' (Levin et al., 2009; 2012) problem or a Type III problem (Handmer & Dovers, 1996) that can be characterized as complex, uncertain, potentially urgent and for which both the problem description and the response may be either controversial or disputed. Addressing such issues requires the involvement of different groups of stakeholders since there is no best practice, only the option to 'sense' and 'probe' the system (Snowden & Boone, 2007) through experimentation in order to identify possible 'improvements' (Armson, 2011). To do this in an appropriate way, the deliberate design of processes and mechanisms is required to mobilize such groups to articulate the issues of concern, share understanding and perspectives and collaborate to achieve improvements (Lonsdale et al., 2015). Whole system approaches can be used in various ways to support this process e.g. change labs; design labs; create learning systems and innovation platforms; and systems (Colvin, 2014; Colvin & Abidi-Habib, 2013). Such approaches recognize the significance of 'start conditions' and the need to understand how the system of interest first developed in order to understand how to intervene (Lonsdale et al., 2015). In backcasting, a current system state is often a starting point for looking ahead and envisioning a desired system state for the future, after which usable but not yet evident pathways to that same future system state are explored, including the pathways that could be (e.g., adaptation pathways or roadmaps).

Transformative adaptation is seen as the most appropriate strategy in the context of climate change impacts affecting particularly vulnerable people or assets. In certain situations, other adaptation strategies that maintain the status quo might be more suitable but it is likely that these situations will become less common with climate change. As climate change impacts are likely to increase, coping strategies or incremental adaption are likely to be ineffective. Poorly designed adaptation strategies might fail, thus leading not only to a loss of money, but also to the degradation of nature and disruption of livelihoods.

The empirical part of this research shows that there is a so far unrealized potential of backcasting to enable a shift from incremental-based adaptation to transformative adaptation. As discussed in 6.6, the starting point for realizing that potential would be to explore transformative futures that could lead to pathways to different (sustainable) societies in which economic, ecological and societal structures will have fundamentally changed. This can be done in a backcasting study, which (i) adopts a systems approach, (ii) learns from practice, (iii) co-creates transformational knowledge, and (iv) invests in capacity building for inclusive transformational adaptation. These aspects enable backcasting to support transformative change, but transformative change must be present in visions and pathways too. Whether backcasting enables a transition to transformative adaptation can be considered a hypothesis that needs to be substantiated through further research

Lesson #3: Adopting a systems approach, learning from practice, and co-creating transformational knowledge

Backcasting can target transformative change, but such changes are generally difficult to realize. This is even more apparent in the context of climate adaptation, due to the huge climate uncertainties and the high complexity of social-ecological systems. A systems approach helps to establish the complexity of such systems in terms of their constituting components that are highly interconnected and interdependent, all of which complicates transformation. Such an approach enables us to address key questions (Lonsdale et al., 2015) regarding the institutional infrastructure that will allow us to adopt a systemic approach? What impedes or enables our ability to encourage transformational change? How might we fund it? How should we decide to invest our resources? Lonsdale et al., 2015 also point to the knowledge demands for transformative adaptation. The term ‘pathway’, for instance, implies a rational approach, whereas transformative adaptation requires something more revolutionary than business-as-usual practices. This requires an understanding of the history of the current situation and why it is currently dysfunctional or creates maladaptation, which then helps us to address the elements that have led to it becoming 'locked in' to the current set of management perspectives on climate adaptation or 'path dependency' (Ramalingam, 2013; Schreyögg and Sydow, 2011). Transformative pathways support the creating of new ways forward while destabilizing and dismantling the old ways, e.g. coastal defenses as a response to sea level rise (Lonsdale et al., 2015). Such ways have to be embedded both in time, (by creating pathways with continual re-evaluation and learning) and process (through incremental decision-making embedded in longer-term transformational pathways) see (Barnett & O'Neill, 2010). Developing long-term futures help to avoid path-dependency driven maladaptation in the nearby or distant future. Backcasting can support this endeavor, as it provides a retrospective and anticipatory approach that reasons from the perspective of 'what is yet needed or desired' rather than considering 'what is already there'.

In transformational processes, learning can be regarded as a constant activity both for the stakeholders involved and for the intermediaries (e.g., vision entrepreneurs (Meijerink and Huitema, 2010)) or vision champions (Dierkes et al., 1996; Quist, 2007) shaping the on-going process (Hargreaves et al., 2013). The role of intermediary actors, organizations and other mechanisms (e.g. intermediary projects, networks, regulations) is necessary for mobilizing the different types of knowledge needed to provide a suitable space to advocate for, and explain the range of, different perspectives whilst allowing for the reframing of the issue, and in building confidence in the process of engagement to develop partnerships that can enable all to participate effectively.

Learning needs to be an intentional aspect of designing and advancing future adaptation in order to obtain the level of detail and depth that we need to understand the complexity of the systems we are dealing with (Lonsdale et al., 2015). This requires openness and profound enquiry that can seem risky and counter-cultural, as it involves a shift from 'best practice' practices that prevail over 'failure' to real, messy practices. The roles of brokerage and intermediation are key to developing intentional learning, transferring it to other contexts, creating the required space and enabling environment for transformative change to develop (Lonsdale et al., 2015). In this regard, key questions that warrant further attention include: Are we learning effectively from what is already happening in relation to transformational change, and could this research and practice be more effectively shared in the future? How we can develop our capacity to notice things and learn from our experiences?

Lesson #4: Investing in capacity-building for inclusive transformational action
There are several strategies that can be pursued in response to the impacts of climate change. Policymakers can modify social behaviors, physical infrastructure, ecologi-

cal properties, or governance mechanisms (Fedele, 2019; Fedele et al., 2019). However, there is no 'one-size-fits-all-solution' because the adaptation options are highly dependent on the context and properties of the system that is affected. The more transformative the adaptation strategy is, the more human input and re-organization will be required. Transformative adaptation fundamentally changes the properties of systems and serves to address the root causes of vulnerability caused by climate change (Fedele et al., 2019). Implementing transformative adaptation requires significant resources (i.e., time, budget, and skills), but also governance capacities. Holscher et al., 2019a,b,c), for instance, proposed unlocking capacity, transformative capacity, orchestrating capacity as essential governance capacities for transformative adaptation. A lack of such capacities makes it harder to enable transformative adaptation compared to other adaptive response strategies (Fedele et al., 2019). Demands for transformative adaptation to climate change require attention to the type of capacity building that can support it. Backcasting assumes that the building of different types of capacity, which are key to co-creating knowledge and contextual understanding, are important; that enhancing the stakeholder process, including marginal groups for more inclusive stakeholder processes and transformational action is necessary (see Ziervogel et al., 2022); that applying comprehensive tools and methods to support the process is what is needed, and that producing meaningful outcomes, all of which contribute to increasing the impact of backcasting studies is essential.

Experimenting is key to backcasting, since visions are often developed in backcasting experiments, which can grow into a set of niches from which visions, supporting networks and activities can emerge (Quist et al., 2011). The capacity for experimentation has long been understood to be integral to building resilience (Fikret et al., 2003) or adaptive capacity (Levine, 2011). However, the ability to experiment is also a key component of transformation (Olsson, 2006), which is needed if radically new systems are to be created when incremental adaptation and adjustments are no longer possible or desirable. It is argued that if capacity building processes shift from the top-down transferal of existing knowledge to the co-creation of contextual understanding, they will have the potential to deliver more transformative adaptation (Ziervogel et al., 2022).

Lesson #5: Extending the methodological repertoire of backcasting to support transformative adaptation

Backcasting can target transformative change, but such changes are generally difficult to realize. This is even more so the case with climate adaptation, due to the large climate uncertainties and the high complexity of social-ecological systems. Backcasting can empower transformative adaptation in various ways. It enables the co-creation of alternative futures for current default water management practices, including pathways that could lead to those futures. It also takes into account different stakeholder perspectives and existing knowledge for the co-creation of the contextual understanding of such futures, which trigger social leaning among the stakeholders involved. Moreover, backcasting supports mapping out a possible space for empowering transformative adaptation moves (Holden et al., 2016; Ligtvoet et al., 2016).

Extending the methodological repertoire of backcasting is what is needed if backcasting is to support transformative adaptation. For example, the use of comprehensive tools and methods allows backcasting to address the complexity of social-ecological systems and large climate uncertainties . Similarly, the use of comprehensive modelling and simulation tools and methods facilitates advanced system analysis, scenario and pathway development and switching in order to deal with uncertainty (Muiderman, 2022), while participatory modelling in combination with backcasting is also advancing (Cuppen et al., 2021) as it combines stakeholder engagement and modelling. The empirical research confirms that some cases address adaptation and mitigation aspects in integrated backcasting studies, which could also counteract goal conflicts as suggested by Van der Voorn et al., (2020).

Lesson #6: Potential for methodology development in backcasting for transformative climate adaptation

The main findings of the multi-case study shown as key aspects in Table 6.4 have relevance and methodological implications for the further development of backcasting when it comes to transformative climate adaptation. For the effective use of backcasting in transformative adaptation, essential add-ons are needed in order to conduct more advanced system analyses and develop more robust pathways. These add-ons include more combinatory use of both quantitative and qualitative scenarios, comprehensive modelling and simulation tools and methods for advanced system analysis, inclusion of robust elements for pathway switching and transformative elements and hybrid pathways for transformative adaptation e.g., (Van der Voorn et al., 2020), which can be combined in new backcasting methodologies or added to existing ones. The key aspects presented in Table 6.4 can be useful for refining existing backcasting methodologies like, for instance, the BCAM methodology developed by Van der Voorn et al. (2012), including the refinement of existing frameworks for evaluating the impact of backcasting studies, but also for developing new backcasting methodologies for transformative climate adaptation. Paper 3 provides recommendations for methodological refinement of the BCAM methodology for climate adaptation, which can be further specified according to its different steps, as presented in Table 7.2. Further integration of the principles of transformative adaptation, policy implementation, indicator development and monitoring would make the BCAM methodology a comprehensive and promising methodology for climate change adaptation planning.

Table 7.2 Overview of recommendations for methodological refinement of the BCAM methodology Van der Voorn et al., 2017.

Methodological Step	Recommended refinements
Strategic problem orientation	• Identify and involve relevant marginal groups and use capacity building. • Develop new scenarios or use existing context scenarios depicting different options on how climate change adaptation can occur in the relevant region. • Use both existing vision studies as input for the participatory process and assess the similarities, differences and usability.
Visioning	• Align capacities, existing visions and various bodies of knowledge to replace developing visions from scratch
Goal setting	• Integrate guiding targets in goal setting to strike a balance between short-term and long-term goals
Backcasting analysis & pathway development	• Include robust elements in pathway development to include adequate responses to uncertain external developments
Policy implementation	• Use performance indicators (e.g., milestones) for adaptive policy making
Evaluation & monitoring	• Include indicators of change (e.g., early warning mechanisms and signposts) in evaluation and monitoring • Use indicators of change to signal uncertain and/or unforeseen future developments and perceived discrepancies in goal fulfilment. • Use indicators of change for the development of context scenarios supporting adaptive policy implementation.

Finally, incorporate a longitudinal study to investigate and compare methodological advancements in the case study region as well as methodological advancement in the use of backcasting and visioning over longer periods of time. There is scientific merit to further investigating the potential of other approaches that could further advance the use of backcasting for transformative adaptation. For example, the combined use of Transition Management and backcasting has been occasionally proposed (Foxon, 2009; Quist et al., 2013). Both share a strong focus on stakeholder involvement, stakeholder learning and the development and assessment of desirable future visions, including turning long-term visions on actions and action agendas (Quist et al., 2013). Both approaches explicitly seek to challenge and influence the existing path-dependencies of the current water management regimes and their technological, institutional and behavioral lock-ins in early stages of the transition processes (Loorbach et al., 2021; Quist et al., 2013).

7.3.2 Research limitations

As a result of the research paradigm and research design I applied to my research (see Section 2.3), my research has several limitations. The study provides details regarding application, theory and the method employed in backcasting studies, which allows for replicability and reproducibility thus providing valuable insight into future applications of participatory backcasting for adaptation. However, this study has its limitations, especially at the conceptual, analytical level.

Conceptual limitations

At a conceptual level, transformative adaptation entails fundamental system change rather than incremental adaptation. How to measure the 'transformative capacity' or the 'transformative elements' of a certain backcasting exercise, as well as the potential direction of transformation (e.g. a transformation can be positive or negative) remains difficult to assess. This was particularly the case with the multiple case study, because the backcasting studies have a limited impact. Similarly, it is also difficult to make statements about the potential direction of transformation. Therefore, I argue that transformative change can only be observed in the long run.

Analytical limitations

In the analytical framework used for the multiple case study, the issue of transformative change is only addressed by the criteria of 'vision', in particular through the presence of goals and guiding targets that represent a change from the current conditions. However, it can be argued that the question of the transformation of a socio-ecological system implies the need to consider further variables or criteria. In this respect, further research is needed to elaborate on the difficulty (or impossibility) of considering other potentially transformative elements, which also relate to the different dimensions of the framework:

- The 'input' dimensions: What does transformation mean and for whom? What knowledge mobilized in this regard is prevailing? What are the relevant context-dependent factors?
- The 'process' dimension related to power and social learning issues: What kind of transformation idea emerges in the process? What are the learning effects (see below)? What was the role of blocking and opposing by (non-involved) stakeholders that see their interests affected? What power relations came into play?
- The 'impact' dimension related to transformation: Has a transformation taken place in the case study? If so, what kind of transformation took place e.g. towards more sustainable systems or not. It can be argued that transformative adaptation in social-ecological systems, especially in highly vulnerable contexts, must also be assessed through normative criteria, such as poverty reduction of the persons involved, increased equity in access to a service/resource, social/environmental justice, which may go beyond possible climate objectives and targets set in a given case study.

Methodological limitations

Case study selection

With regard to the case selection for the multi-case study, an important selection criterion was that the cases had to be conducted and finalized before 2020 in order to identify any possible impact and spin-offs. It can be argued that the cases are slightly outdated, but I would argue that they have not lost their relevance because of that. The process actually creates sufficient time distance for us to look back at the long-term impact of these studies in a neutral way. As backcasting processes aim to shift people's mindset from which follow up activities are likely to emerge after the backcasting study, it is necessary for a researcher to become distanced from the cases. Within the relevant time frame, the multi-case study showed that the cases achieved low impact. Therefore, an updated review of the cases could provide further insight into the long-term impact of all the cases. As discussed in the fourth paper, long-term impact can be scientific, societal, policy linked, domain/sector specific (field of application).

The scope of evaluation

For the multiple case study, I further refined and adapted the framework created by Van der Voorn et al., 2017 to provide a detailed and inclusive analysis of what factors constrain and enable participatory backcasting processes and how they influence different kinds of implementation and the impacts of backcasting studies. The scope of the multiple case study is constrained by certain limitations reflecting the availability of data, the case characteristics and the research design (see Section 2.4.4).

Although learning is key to vision development and niche formation as discussed in Section 2.2.2, my research focus was more on the interaction between visions and actors in niches and less on learning processes and knowledge. These limitations are related to the framework for evaluating the backcasting studies. The multi-case study, for instance, confirmed that the nature and design of these processes are characteristic for the related governance context, which appears to have less impact on the outcome of the process. This may indicate that other dynamics are at play, such as learning processes among stakeholders, which went beyond the scope of the evaluation. Likewise, I evaluated the results of vision, pathway and scenario development, but did not look into the underlying knowledge generation process. Such processes provide further insight into how expertise and knowledge would have affected these results and stakeholder endorsement of the results. The multi-case study did not account for the blocking and opposition power by (non-involved) stakeholders who see that their interests are affected. This can also be applied to non-involved groups of citizens or non-involved marginal groups. Finally, most of the evaluated cases show limited impact, while a longitudinal study would be useful for developing a more in-depth understanding of their impact and their mechanisms over longer periods of time e.g., the political aspects, including the political will and power relations, that may affect impact.

Despite these limitations, the multi-case study still has its scientific merit as it provides a detailed examination of how various backcasting approaches were used in the field of climate adaptation, providing clear suggestions and directions for further methodological improvement and methodology development. However, more research is still needed to further adapt and refine the evaluation framework in order to obtain a more detailed and inclusive analysis of what factors constrain and enable participatory backcasting processes and how they can influence different kinds of implementation and the impacts of backcasting studies.

Level of detail/aggregation of data
As described in the fourth paper, the evaluation framework includes four main dimensions against which backcasting studies for climate adaptation have been evaluated: (i) inputs & project settings, (ii) stakeholder processes and methods, (iii) results and (iv) the impact of backcasting studies. This framework differs from the framework produced by Van der Voorn et al., 2017 in terms of the number of dimensions resulting from aggregation. The relevance of the findings of the multiple case study may be constrained due to the level of aggregation applied to the data. Aggregation has enabled me to capture sufficient diversity in the evaluation outcomes and to make the similarities and differences between the evaluation outcomes for the criteria within and across the dimensions more visible. Aggregation also serves to present the evaluation in an organized way. Vision and pathway development have been aggregated into an overall dimension classified as 'results in backcasting studies', which also includes scenario development. Aggregation allowed me to highlight the linkages between vision, pathway and scenario development. Methodological aspects and stakeholder engagement and process have also been termed: methods and stakeholder engagement and have, as such, become subdimensions of the overall dimension of process. Furthermore, aggregation enabled me to highlight the various methods applied that supported the process, but also the different research tools and methods implemented in each case i.e. data collection and analysis. However, there is still space for discussion on whether the applied level of aggregation comes at the expense of the relevancy of the findings.

7.4 A VISION FOR BACKCASTING FOR TRANSFORMATIVE WATER MANAGEMENT

In the face of climate change, we are entering a new era of climate-related water risks. As the Intergovernmental Panel on Climate Change (2022b) recently reported, water risks are intensifying around the world as climate change tightens its grip and shocks the planet's hydrological systems. What lies ahead, is more droughts, floods, and extreme rainfall, more variable and less reliable tropical monsoons, melting glaciers, and sea-level rise. These impacts will inevitably get worse. As I have described in this thesis, climate change has clearly revealed the limitations of adaptive water management approaches. Current water management approaches, including the provision of water services (e.g. drinking water supply) and the associated infrastructure, often prove relatively insufficient in the face of intensifying climate change. The urgency of climate change and the need for climate action presents global society with an unforeseen challenge. Without immediate and bold transformative action, climate factors and water security are set to worsen. Therefore, a shift towards transformative water management is urgently needed in order to address this challenge.

So, with this in mind, what can be envisioned for backcasting for transformative water management both now and in the future? Based on my experience as a backcasting practitioner and climate adaptation consultant over the last 10 years, I am convinced that the climate crisis we are facing compels us to take urgent steps to adapt to the inevitable impacts climate change will bring for the sake of the well-being of people and species across the globe as well as to mitigate climate change and its impacts, by reducing greenhouse gas emissions.

Transformative water management is likely to emerge from a paradigm shift in current water management, which can account for the increased complexity of water systems and the implications for such management see e.g., Van Der Voorn and Quist (2018). It is evident that current adaptive management approaches are designed to make water infrastructure more climate resilient, but not in a way that could contribute to the development of other sectors e.g., land-use, agriculture. Furthermore, water is traditionally managed by water managers, but it has also become an essential part of other sectors (e.g., agriculture, land-use). This compels water managers to collaborate proactively with their counterparts from other sectors, which inevitably requires changes in their current roles and power positions. In addition, water has become a broader socio-economic problem, involving concerns linked to water quality and quantity. Limited water supply during long periods of drought, for instance, intensifies concerns about water quality. Low water levels could lead to warmer stream temperatures as well as increased algal growth and more frequent toxin-producing algae blooms. Variability in climate influences water quantity, and may equally influence water quality through the increased intensity of precipitation events. This, in turn, may lead to serious health issues. Moreover, water has become more political and societal, due to the increasing conflicts of interests. For example, long periods of drought may lead to water scarcity, increasing the chance of competition and conflict in the allocation of water resources, which will make water security even more uncertain. Finally, the water sector needs to come up with solutions and an innovation agenda. Novelty and innovation help to develop a set of benefits that can be associated with transformative approaches. Transformative adaptation supports innovative concepts, which could be entirely novel or could form an integrated combination of existing concepts and resources provided by various collaborators to be deployed across or within sectors (Filho et al., 2022). Altogether these aspects call for a different coordination mechanism and a long-term transition perspective, but what remains the question is whether water managers are sufficiently able to fulfill this need. Backcasting can support the transition towards transformative water management. It supports water managers in changing their mindsets, but also in forcing them to critically reflect on the dominant water management paradigm which needs to become more transformative than incremental.

Backcasting typically targets system change, involving fundamental change in the structures, cultures and practices of the societal system for it to become, for example, sustainable or climate resilient. Addressing the broader societal context in backcasting has become increasingly important for achieving transformations, but current backcasting practice in water management has not yet resulted in such changes. It could suggest that people do not wish to change, which is something not to be ignored but rather to be tackled by backcasting practitioners. As discussed in Section 7.3.1, this also underscores the need for a type of backcasting that does not only target systemic change, but also accounts for the greater sociocultural changes that are required at a higher societal level. To conclude, if backcasting is implemented in current adaptive water management according to these intentions, it is likely to create space for such changes to happen.

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CHAPTER 8

SUMMARY | SAMENVATTING

SUMMARY

Climate change has emerged as one of the biggest environmental challenges the world is currently facing. The impacts of climate change: increases in temperature, shifts in precipitation patterns and in snow cover are leading to more frequent and more intense extreme weather events, such as flooding and droughts, all of which can be observed in many parts of the world, particularly in coastal and deltaic regions. The rise in weather and climate extremes has led to some irreversible impacts as natural and social systems are pushed beyond their ability to adapt. Across sectors in the relevant regions, the most vulnerable people and social-ecological systems are observed to be disproportionately affected by these extremes. Adapting to these extremes requires an analysis of the risks caused by climate change and the implementation of all the measures that must be taken in time to reduce these risks. These risks necessitate water management so that the impacts of a changing climate can be anticipated.

Obviously, climate change affects water management in multiple ways. In the past two decades, adaptive water management has become the main response in water management to the impact of climate change effected by making minor alterations in order to build the resilience of people and nature. However, climate change has laid bare the limitations of adaptive water management which is aimed at reducing the impact of climate change through resilience-building and minor alterations. This responsive approach, which is based on incremental-based adaptation, has proved to be insufficient or counterproductive in the face of more extreme weather events. Due to the increasing complexity of water systems, which are not only self-organizing complex adaptive systems, but also unpredictable and non-linear in their response to intervention and climate change, all of which poses uncertainties regarding their management, a shift is taking place in the dominant notions behind water management. Water management and its strategies need to move beyond incrementalism – to become more transformative – and in order to maintain people's well-being in the long run in the face of the expected impacts of climate change.

It is against this backdrop that this research on backcasting for climate adaptation can help to contribute to a better understanding of the potential of backcasting for adaptation and how it could be applied in water management. Backcasting can be defined as something that generates ideas for a desirable future, before looking backwards from that future to the present in order to strategize and plan how that could be achieved. Due to its normative, reflexive and iterative nature, backcasting can support water managers in seeking opportunities to invest in long-term solutions that effectively reduce climate change risks while furthermore developing their own climate adaptation strategy amid uncertainty. It also allows them to envision climate adaptation futures and robust adaptation pathways that could lead to such futures.

Despite progress in the use of backcasting, limited efforts have been made to systematically evaluate the impact of backcasting studies, and more work is still needed if the current and future backcasting practices are to be improved. This thesis focuses on backcasting approaches and their potential for use in climate adaptation because up until now there has been little research involving backcasting in conjunction with climate adaptation. Compared to forecasting and exploratory scenario approaches, participatory backcasting and related vision-oriented normative approaches are the futures approach to climate change adaptation planning that have been the least frequently implemented. Therefore, the aim of the present research is to improve our understanding of the relevance of normative approaches to climate adaptation, particularly where visioning and backcasting are concerned, and to discover what is needed to further advance backcasting for transformative climate adaptation purposes.

This research aim has led to the following main research question: ***How can visions, visioning and backcasting enhance transformative adaptation in water management?***

This thesis answers this question on the basis of a number of contributions:

- **Theoretical contribution**: The thesis integrates and fuses concepts drawn from sustainability transitions, futures studies and water management research to form an interdisciplinary and transdisciplinary area. An overview was made to summarize the key terms and concepts for each research area. Of particular interest are the ones that dominate all areas because they also emerge from the empirical parts of this thesis. This overview allowed me to position this research into backcasting in respect to sustainability transitions, futures studies and water management research. Backcasting and Transition Management share similar key terms and concepts to those derived from sustainability transitions and futures studies. Both have a strong focus on stakeholder involvement, stakeholder learning and the development and assessment of desirable future visions, including turning long-term visions into actions and action agendas. Despite these similarities, Transition Management is rooted in transition theory like, for instance, the multi-level perspective which stresses that novelty starts in niches and may replace or adjust the dominant regime or paradigm. By comparison, backcasting is not rooted in a particular social system theory and becomes obsolete if novelty starts in a niche or in the regime itself. Building on the existing literature on transition management and backcasting, this thesis aims to provide further insight into the relevance of visions and visioning to water management transitions in general and to the transition to transformative water management in particular.

- **Empirical contribution**: This thesis advances the current understanding of participatory backcasting approaches and the potential for use in climate adaptation research. That is done by contrasting backcasting with other foresight approaches to climate adaptation, characterizing its different usages and analyzing and reflecting on its promises and challenges for climate adaptation in water management. The empirical results provide further insight into how backcasting can be applied to climate adaptation and how it can be systematically evaluated in order to further advance backcasting for climate adaptation. Insights gained from empirical research provide input for critical reflection on what is needed to apply backcasting to climate adaptation, making use of the widely acknowledged strengths of backcasting as well as identifying elements that could add value to the topic of climate adaptation. The empirical part of this research addresses what is needed to advance backcasting for transformative adaptation in water management. In contrast to the impact of visioning studies, limited effort has been put into systematically evaluating the impact of backcasting studies. This thesis aims to contribute to a better understanding of the key aspects of backcasting studies in order to improve current and future backcasting practices.

- **Methodological contribution**: This thesis explicates and further develops a mixed-methods strategy of inquiry involving a purposeful mixing of methods in the fields of data collection, data analysis and in the interpreting of the empirical evidence. The mixed-method research approach that I applied consists of three main steps: (i) the development of a conceptual framework through the use of theory; (ii) transitions analysis based on a single historical case study and comparative evaluation of ten cases. A mixed-method research approach allows for a better understanding of connections between the qualitative and quantitative data that has to be constructed. It provides opportunities for participants involved in the research to have a strong voice and to share their experiences throughout the research process. It also facilitates different avenues of exploration that could enrich the empirical evidence and enable questions to be answered more deeply. A mixed-method approach is therefore congruent with process-oriented approaches like visioning, backcasting as put into practice during the empirical research of this study. The empirical research involves the comparative evaluation of backcasting studies that show varying degrees of action research where I took on various roles that correspond with the ideal-type roles in action research. In relation to the empirical contribution, this thesis sets out to contribute to the further development of backcasting approaches for climate adaptation research which still lack a systematic understanding of what is needed to make backcasting suitable for transformative adaptation.

This thesis is based upon four journal articles and framed by an overall introduction, methodology and conclusion.

The first chapter introduces the overall research question and contextualizes it in conjunction with climate adaptation planning. It also introduces the theoretical, empirical and methodological setting of this thesis. The first chapter also provides a succinct overview of the challenges of climate change for water management, putting the research problem in context. The central research problem at the core of this thesis is the fact that climate change has exposed the boundaries of adaptive water management. The need in current water management as we move towards a transformative management style that supports, guides and accelerates long-term, fundamental changes in water systems to make them more resilient to climate change is furthermore justified. Against this backdrop, I propose that backcasting should be a complementary approach to adaptive management in support of transformative adaptation in water management.

The second chapter elaborates the research approach and methodology used to address the knowledge gaps dealt with in Chapter 1. It draws together insights from research approaches within the positivist, critical, constructivist and participatory action research traditions to build a research perspective for backcasting research that is more conducive to participatory research. I consider a participatory action approach to be appropriate for my research, because that enabled me to design my research in such a way that knowledge could be derived from the current practice in water management and backcasting, while acknowledging that the same practice is informed by knowledge in an ongoing process which is what lies at the core of participatory research. This approach provides an adequate framework for examining our present situation/practice in a contemporary, postmodern context. It is also congruent with the complex adaptive systems perspective, which underlies current thinking about the role of adaptive management in environmental and natural resource management. Adaptive management emphasizes the importance of the management process rather than focusing on goals, whilst recognizing that the process is not an end in itself. This is very much in line with the purpose of participatory action research and learning through action that subsequently leads to change and which also applies to backcasting.

The third chapter is an article entitled "Analysing the Role of Visions, Agency, and Niches in Historical Transitions in Watershed Management in the Lower Mississippi River". It contributes to an improved understanding of the role of visions and visioning in water management transitions and was conducted on the basis of a qualitative historical single-case study. It served to learn from historical transitions by investigating complex processes and tracing specific causal-event chains within their own context. This case study facilitated the development of a framework for the analysis of water management transitions and emerging visions and niches. The framework builds on the Multi-level Perspective, an analytical view associated with the transitions approach. The relevance of the Lower Mississippi River lies in its rich history pertaining to major flood disasters and damage in conjunction with a wide array of US Congress enactments and policy developments and the wide availability of secondary historical sources reporting on these events.

The fourth chapter is an article entitled "Combining backcasting and adaptive management for climate adaptation in coastal regions: A methodology and a South African case study", which contributes to the aim of the thesis in terms of clarifying the concept. A single case study was conducted and its aim was to conceptualize backcasting as a complementary approach to adaptive management when developing climate adaptation strategies and policies. It also facilitated the development of the Backcasting Adaptive Management (BCAM) methodology, a design component that has been validated within the context of the case study. The integration of both approaches into a single methodology can be considered a valuable contribution to the backcasting literature. The applicability of the BCAM methodology has been described for the South African Breede-Overberg coastal region, where a Catchment Management Strategy was developed in 2010 through a participatory process. In this descriptive case study analysis, precise details are given on how the methodological method chosen for the Catchment Management Strategy development process deviated from the combined methodology.

The fifth chapter is an article entitled "Envisioning robust climate change adaptation futures for coastal regions: A comparative evaluation of cases in three continents". It presents a qualitative multi-case study on the impact of three backcasting studies. The aim of the study was (i) to evaluate cases on vision development for robust climate change adaptation planning and (ii) to evaluate the outcomes and their potential for the further development of normative approaches in climate change adaptation planning in general and for the BCAM methodology in particular. This chapter develops and applies an evaluation framework to systematically evaluate cases in relation to the development and implementation of visions in three coastal regions in Africa, Europe and North America. This comparative case study helped me to evaluate each backcasting process within its own context, after which it was possible to establish general patterns and conclusions from the comparison of individual cases. To that end, I developed a set of propositions, which were validated against a set of criteria as part of an evaluation framework. In line with my abductive inquiry logic, I argue in favor of propositions because they are considered more appropriate in the early stages of theory development than hypotheses. The validation of these propositions provided further insight into the degree of diversity and general patterns in vision development as part of backcasting.

The sixth chapter is an article entitled "Recent progress in the use of participatory backcasting and visioning approaches for climate change adaptation planning: A comparative study of 10 cases in 3 continents". The aim of the study was to investigate what is needed if we are to apply backcasting to climate adaptation whilst making use of the widely acknowledged strengths of backcasting as well as identifying elements that could add value to the topic of climate adaptation. A framework has been further developed and applied to evaluate 10 cases in Africa, Europe and North America, using four dimensions: (i) inputs and settings; (ii) process and methods (iii) results, and (iv), impact. The comparative evaluation provides key insights into the use and further development of backcasting for climate adaptation and for specifying what is needed to make backcasting fit for transformative adaptation. This chapter zooms in on the potential behind using backcasting to enhance climate change adaptation. The potential of backcasting lies in its capability to support adaptation in a participatory manner so that more resilience can be built into socio-ecological systems in different contexts e.g., water, mobility and forest management. The chapter provides methodological, conceptual and analytical reflections on what is needed to further advance backcasting for transformative climate adaptation.

The concluding chapter provides answers to all the research questions, highlights the theoretical, empirical and methodological contributions to the field of backcasting and climate adaptation and the emerging sustainability transition field and it supplies critical reflections. It also takes stock of key insights and lessons learned from the use of backcasting for climate adaptation, together with the implications for transformative adaptation. Finally, it provides recommendations for future research and outlines a future research agenda.

SAMENVATTING

Klimaatverandering is één van de grootste uitdagingen waar de wereld momenteel voor staat. De gevolgen van klimaatverandering: temperatuurstijgingen, verschuivingen in neerslagpatronen en in sneeuwbedekking en -val leiden tot meer frequente en intensere extreme weersomstandigheden, zoals overstromingen en droogtes. Deze gevolgen manifesteren zich in veel delen van de wereld, met name in kust- en deltagebieden. De toename van weer- en klimaatextremen veroorzaakt onomkeerbare gevolgen voor het aanpassingsvermogen van ecologische en sociale systemen. In alle sectoren in relevante regio's worden de meest kwetsbare mensen en sociaalecologische systemen onevenredig zwaar getroffen door deze extremen. Aanpassing aan deze extremen vereist kennis van de risico's die worden veroorzaakt door klimaatverandering en de uitvoering van alle maatregelen die op tijd moeten worden genomen om deze risico's te verminderen. Deze risico's maken klimaatrobuust waterbeheer noodzakelijk, zodat kan worden geanticipeerd op de gevolgen van een veranderend klimaat.

Het is duidelijk dat klimaatverandering het waterbeheer op verschillende manieren beïnvloedt. In de afgelopen twee decennia is adaptief waterbeheer leidend geweest in de aanpak van klimaatverandering. Deze aanpak kenmerkt zich door incrementele aanpassingen om de veerkracht van mens en natuur te vergroten. Klimaatverandering heeft echter de beperkingen van adaptief waterbeheer blootgelegd, dat gericht is op het verminderen van de gevolgen van klimaatverandering. Deze responsieve aanpak, die gebaseerd is op incrementele aanpassingen, is ontoereikend of contraproductief gebleken bij extremere weersomstandigheden. De toenemende complexiteit van watersystemen, die niet alleen zelforganiserende complexe adaptieve systemen zijn, maar ook onvoorspelbaar en niet-lineair in hun reactie op interventie en klimaatverandering, brengt onzekerheden met zich mee voor het beheer ervan. Hierdoor vindt er een verschuiving plaats in de dominante opvattingen, die ten grondslag liggen aan het huidig waterbeheer. Waterbeheerstrategieën moeten verder gaan dan incrementalisme – meer transformatief te worden – om het welzijn van de samenleving op de lange termijn te behouden.

Tegen deze achtergrond beoogt dit onderzoek naar backcasting voor klimaatadaptatie bij te dragen aan een beter begrip van het potentieel van backcasting voor klimaat adaptatie en hoe het kan worden toegepast in waterbeheer. Backcasting is een methode die ideeën genereert voor een wenselijke toekomst om vervolgens vanuit die toekomst terug te redeneren naar het heden hoe die toekomst kan worden bereikt. Door de normatieve, reflexieve en iteratieve aard kan backcasting waterbeheerders ondersteunen bij het zoeken naar mogelijkheden om te investeren in langetermijnoplossingen die de risico's van klimaatverandering effectief verminderen. Backcasting stelt hen in staat om klimaatadaptatiestrategieën te kunnen ontwikkelen onder onzekerheid. Het stelt hen ook in staat om zich gewenste toekomstbeelden van klimaatadaptatie voor te stellen en robuuste adaptatiepaden die tot dergelijke toekomstbeelden kunnen leiden.

Ondanks een toename in het gebruik van backcasting, zijn er beperkte inspanningen geleverd om de impact van backcastingstudies systematisch te evalueren om de huidige en toekomstige backcastingpraktijk te verbeteren. Deze dissertatie richt zich op backcastingbenaderingen en hun potentieel voor gebruik bij klimaatadaptatie, omdat er tot nu toe beperkt onderzoek is gedaan naar backcasting in combinatie met klimaatadaptatie. Vergeleken met voorspellende en exploratieve toekomstbenaderingen zijn participatieve backcasting en aanverwante visiegerichte normatieve benaderingen het minst vaak toegepast voor klimaatadaptatie. Het doel van dit onderzoek is dan ook om meer inzicht te krijgen in de relevantie van normatieve benaderingen van klimaatadaptatie, met name waar het gaat om visievorming en backcasting, en om vast te stellen wat er nodig is om backcasting verder te ontwikkelen ten behoeve van transformatieve klimaatadaptatie.

Dit onderzoeksdoel heeft geleid tot de volgende hoofdonderzoeksvraag: ***Hoe kunnen visies, visioning en backcasting transformatieve adaptatie in waterbeheer versterken?***

Deze dissertatie beantwoordt deze vraag door middel van een aantal bijdragen:

- **Theoretische bijdrage**: Het proefschrift integreert verschillende hoofdconcepten uit duurzaamheidstransities, toekomststudies en onderzoek naar watermanagement om tot een interdisciplinair en transdisciplinair gebied te komen. Een overzicht is gemaakt om de belangrijkste termen en concepten voor elk onderzoeksgebied samen te vatten. Van bijzonder belang zijn degenen die voorkomen in alle gebieden, omdat ze ook verweven zijn in de empirische delen van dit proefschrift. Dit overzicht stelde mij in staat om dit onderzoek te positioneren in backcasting met betrekking tot duurzaamheidstransities, toekomststudies en onderzoek naar watermanagement. Backcasting en transitiemanagement delen dezelfde kernbegrippen en concepten vanuit duurzaamheidstransities en toekomststudies. Beide benaderingen zijn sterk gericht op het betrekken van belanghebbenden, het leren van belanghebbenden en het ontwikkelen en beoordelen van wenselijke toekomstvisies, inclusief het omzetten van langetermijnvisies in acties en actieagenda's. Ondanks deze overeenkomsten is transitiemanagement geworteld in transitietheorieën zoals bijvoorbeeld het Multi Level Perspectief dat benadrukt dat vernieuwing begint in niches, die het dominante regime of paradigma kan vervangen of aanpassen. Ter vergelijking, backcasting is niet geworteld in een bepaalde sociale systeemtheorie en wordt minder relevant als er vernieuwing begint in een niche of in het regime zelf. Voortbouwend op de bestaande literatuur over transitiemanagement en backcasting, wil dit proefschrift meer inzicht verschaffen in de relevantie van visies en visievorming voor transities in waterbeheer in het algemeen en voor de transitie naar transformatief waterbeheer in het bijzonder.

- **Empirische bijdrage**: Dit proefschrift bevordert het huidige begrip van participatieve backcastingbenaderingen en hun potentieel voor gebruik in klimaatadaptatieonderzoek. Dit wordt gedaan door backcasting te onderscheiden van andere benaderingen van toekomstverkenning voor klimaatadaptatie, en de relevantie en potentie van verschillende backcasting toepassingen voor klimaatadaptatie in waterbeheer te duiden. De empirische resultaten van dit onderzoek geven meer inzicht in hoe backcasting kan worden toegepast op klimaatadaptatie en hoe het systematisch kan worden geëvalueerd om backcasting voor klimaatadaptatie verder te ontwikkelen. Deze inzichten bieden tevens input voor kritische reflectie over wat nodig is om backcasting toe te passen op klimaatadaptatie, waarbij gebruik wordt gemaakt van de algemeen erkende sterke punten van backcasting en kernelementen worden geïdentificeerd die waarde kunnen toevoegen aan het onderwerp klimaatadaptatie. Het empirische deel van dit onderzoek richt zich op wat nodig is om backcasting voor transformatieve adaptatie in waterbeheer te bevorderen. In tegenstelling tot de impact van visiestudies, is relatief beperkt onderzoek gedaan om de impact van backcasting studies systematisch te evalueren. Dit proefschrift draagt bij aan een beter begrip van de belangrijkste aspecten van backcastingstudies om de huidige en toekomstige backcastingpraktijk te verbeteren.

- **Methodologische bijdrage**: Deze dissertatie benadrukt de relevantie van een mixed-methods onderzoeksstrategie, die een doelgerichte mix van methoden omvat voor gegevensverzameling, gegevensanalyse en de interpretatie van het empirisch bewijsmateriaal. De toegepaste mixed-method onderzoeksaanpak bestaat uit drie hoofdstappen: (i) de ontwikkeling van een conceptueel kader door het gebruik van theorie; (ii) analyse van overgangen op basis van één historische gevalstudie en (iii) een vergelijkende evaluatie van tien casussen. Een mixed-method onderzoeksbenadering draagt bij aan een beter begrip van verbanden tussen de kwalitatieve en kwantitatieve gegevens die geconstrueerd moeten worden. Het biedt deelnemers aan het onderzoek de kans om invloed uit te oefenen en hun ervaringen te delen tijdens het onderzoeksproces. Het ondersteunt ook verschillende manieren van onderzoek die het empirisch bewijsmateriaal kunnen verrijken en ruimte bieden voor kritische reflecties. Een mixed-method approach is daarom congruent met procesgerichte benaderingen zoals visievorming en backcasting, die zijn toegepast in het empirisch onderzoek. Het empirisch onderzoek omvat de vergelijkende evaluatie van backcastingstudies die verschillende gradaties van actieonderzoek laten zien. Daarin heb ik verschillende rollen vervuld, die overeenkomen met de ideaaltypische rollen in actieonderzoek. Dit proefschrift beoogt een bijdrage te leveren aan de verdere ontwikkeling van backcasting benaderingen voor klimaatadaptatieonderzoek, waarin nog steeds een systematisch begrip ontbreekt van wat nodig is om backcasting geschikt te maken voor transformatieve adaptatie.

Deze dissertatie is gebaseerd op vier tijdschriftartikelen, gekaderd in een algemene inleiding, methodologie en conclusie.

Het eerste hoofdstuk introduceert de algemene onderzoeksvraag en plaatst deze in de context van klimaatadaptatie. Het introduceert ook de theoretische, empirische en methodologische achtergrond van dit proefschrift. Het eerste hoofdstuk geeft ook een beknopt overzicht van de uitdagingen van klimaatverandering voor waterbeheer, waarbij het onderzoeksprobleem in context wordt geplaatst. Het centrale onderzoeksprobleem in dit proefschrift is het feit dat klimaatverandering de grenzen van adaptief waterbeheer heeft blootgelegd. Klimaatverandering benadrukt de noodzaak dat fundamentele veranderingen in watersystemen op de lange termijn ondersteunt, begeleidt en versnelt. Tegen deze achtergrond beschouw ik backcasting als een aanvullende benadering op adaptief beheer ter ondersteuning van transformatieve klimaatadaptatie in waterbeheer.

In het tweede hoofdstuk worden de onderzoeksaanpak en -methodologie uitgewerkt die zijn gebruikt om de in hoofdstuk 1 beschreven kennishiaten te adresseren. Het combineert inzichten vanuit onderzoeksbenaderingen binnen de positivistische, kritische, constructivistische en participatieve actieonderzoekstradities om een onderzoeksperspectief voor backcasting te ontwikkelen dat gebruikelijk is voor participatief onderzoek. Participatief actieonderzoek als onderzoeksbenadering maakt een onderzoeksopzet mogelijk waarbij kennis kon worden afgeleid uit de huidige praktijk van waterbeheer en backcasting, terwijl diezelfde praktijk wordt geïnformeerd door kennis in een voortdurend proces, wat de kern is van participatief onderzoek. Deze benadering biedt een adequaat kader voor het onderzoeken van de huidige situatie/praktijk in een hedendaagse, postmoderne context. Actieonderzoek is vereenigbaar met het perspectief van complexe adaptieve waterbeheer systemen, dat ten grondslag ligt aan het huidige denken over de rol van adaptief beheer van milieu en natuurlijke hulpbronnen. Adaptief waterbeheer benadrukt het belang van het managementproces in plaats van te focussen op doelen, maar erkent tevens dat het proces geen doel op zichzelf is. Dit sluit goed aan bij het doel van participatief actieonderzoek en leren door acties die vervolgens tot verandering leidt en dat ook van toepassing is op backcasting.

Het derde hoofdstuk is een artikel getiteld "Analysing the Role of Visions, Agency, and Niches in Historical Transitions in Watershed Management in the Lower Mississippi River". Dit hoofdstuk draagt bij aan een beter begrip van de rol van visies en visievorming in waterbeheertransities op basis van een kwalitatieve historische gevalstudie. Daarin staat centraal het leren van historische overgangen door complexe processen te onderzoeken en specifieke causale gebeurtenisketens te traceren binnen hun eigen context. Deze gevalstudie maakte de ontwikkeling mogelijk van een kader voor de analyse van opkomende visies en niches in waterbeheertransities. Het raamwerk bouwt voort op het Multi-level Perspectief, een analytische perspectief dat geassocieerd wordt met de transitiebenadering. De relevantie van het stroomgebied van de Mississippi Rivier ligt in de rijke geschiedenis van grote overstromingsrampen en -schade in combinatie met een breed scala aan regulering en beleidsontwikkelingen van het Amerikaanse Congres en de ruime beschikbaarheid van secundaire historische bronnen die deze gebeurtenissen hebben vastgelegd.

Het vierde hoofdstuk is een artikel getiteld "Combining backcasting and adaptive management for climate adaptation in coastal regions: A methodology and a South African case study". Dit hoofdstuk draagt bij aan het doel van het proefschrift om de meerwaarde van backcasting voor klimaatadaptatie te verduidelijken. Er is één gevalstudie uitgevoerd met als doel backcasting te conceptualiseren als een aanvullende benadering op adaptief waterbeheer bij het ontwikkelen van strategieën en beleid voor klimaatadaptatie. Het maakte ook de ontwikkeling van de Backcasting Adaptive Management (BCAM) methodologie mogelijk, een ontwerpcomponent die gevalideerd is aan de hand van een gevalstudie. De integratie van beide benaderingen in één enkele methodologie kan worden beschouwd als een waardevolle bijdrage aan de backcastingliteratuur. De toepasbaarheid van de BCAM-methodologie is beschreven in de context van de Zuid-Afrikaanse kustregio Breede-Overberg, waar in 2010 via een participatief proces een beheerstrategie voor het stroomgebied is ontwikkeld. In deze beschrijvende casusanalyse worden precieze details beschreven over hoe de methode die werd gekozen voor het ontwikkelingsproces van de waterbeheerstrategie afweek van de BCAM methodologie.

Het vijfde hoofdstuk is een artikel getiteld "Envisioning robust climate change adaptation futures for coastal regions: A comparative evaluation of cases in three continents". Dit hoofdstuk presenteert een kwalitatieve comparatieve studie naar de impact van drie backcastingstudies. Het doel van het onderzoek was (i) het evalueren van casussen op het gebied van visieontwikkeling voor robuuste planning van aanpassing aan klimaatverandering en (ii) het evalueren van de uitkomsten en hun potentieel voor de verdere ontwikkeling van normatieve benaderingen voor klimaatadaptatie in het algemeen en voor de BCAM methodologie in het bijzonder. In dit hoofdstuk wordt een evaluatiekader ontwikkeld en toegepast om op systematische wijze de geselecteerde casussen te evalueren met betrekking tot de ontwikkeling en implementatie van visies in drie kustregio's in Afrika, Europa en Noord-Amerika. Deze vergelijkende casusanalyse stelde mij in staat om elk backcastingproces binnen zijn eigen context te evalueren, waarna het mogelijk was om algemene patronen en conclusies te trekken uit de vergelijking van individuele gevallen. Daarvoor heb ik een aantal proposities geformuleerd die gevalideerd zijn aan de hand van relevante criteria die onderdeel zijn van een evaluatiekader. Verwijzend naar mijn abductieve onderzoekslogica pleit ik voor proposities, omdat deze geschikter worden geacht in vroege stadia van theorieontwikkeling dan hypothesen. De validatie van deze proposities biedt meer inzicht in de mate van diversiteit en algemene patronen in visieontwikkeling als onderdeel van backcasting.

Het zesde hoofdstuk is een artikel getiteld "Advancing participatory backcasting for climate change adaptation planning using 10 cases from 3 continents". In dit hoofdstuk ligt de focus op wat nodig is om backcasting toe te passen op klimaatadaptatie, door gebruik te maken van de algemeen erkende sterke punten van backcasting en elementen te identificeren die waarde kunnen toevoegen aan het onderwerp klimaatadaptatie. Er is een kader ontwikkeld en toegepast om 10 cases in Afrika, Europa en Noord-Amerika te evalueren, waarbij vier dimensies zijn gebruikt: (i) input en setting; (ii) proces en methoden; (iii) resultaten en (iv) impact. De vergelijkende evaluatie biedt belangrijke inzichten in het gebruik en de verdere ontwikkeling van backcasting voor klimaatadaptatie en voor het specificeren van wat nodig is om backcasting geschikt te maken voor transformatieve adaptatie. In dit hoofdstuk wordt ingezoomd op de mogelijkheden van backcasting voor klimaatadaptatie te verbeteren. Het potentieel van backcasting ligt in de mogelijkheid om klimaatadaptatie op een participatieve manier te ondersteunen, zodat er meer veerkracht kan worden ingebouwd in sociaalecologische systemen in verschillende contexten, zoals water-, mobiliteits- en bosbeheer. Het hoofdstuk biedt methodologische, conceptuele en analytische reflecties op wat nodig is om backcasting voor transformatieve klimaatadaptatie verder te ontwikkelen.

Het afsluitende hoofdstuk geeft antwoorden op alle onderzoeksvragen, belicht de theoretische, empirische en methodologische bijdragen aan het veld van backcasting, klimaatadaptatie en duurzaamheidstransitie en geeft kritische reflecties. Het inventariseert ook de belangrijkste inzichten en lessen die zijn geleerd vanuit het gebruik van backcasting voor klimaatadaptatie, samen met de implicaties voor transformatieve klimaat. Tot slot worden aanbevelingen gepresenteerd voor toekomstig onderzoek en een onderzoeksagenda voorgesteld.

APPENDICES

APPENDIX A

APPENDIX B

ACKNOWLEDGMENT

CURRICULUM VITAE

APPENDIX A: SUPPLEMENTARY MATERIAL ON VISIONS AND GOALS (MITI-PAPER)

Table A1 Vision statement and goals (BOCMA, 2010).

Vision statement 1: Sustain a healthy state of ecosystem goods and services and biodiversity Goals and guiding targets: • Protect 60% of freshwater ecosystems at a 'B eco category' level (orthophosphate < 0.015 mg/l; total nitrogen < 0.63 mg/l) • Achieve groundwater stress index below 65% (highly stresses) in all quaternary catchments
Vision statement 2: Sharing water resources for equitable development in changing world Goals and guiding targets: • Improve economic efficiency of water use and allocation continually over the next 5 years • Allocate 15% of agricultural water use to emerging farmers by 2015
Vision statement 3: Cooperation for compliance and resilience Goals and guiding targets: • Improve compliance with water use regulations • Develop sustained and innovative financing of the CMS implementation

Table A2 Selected studies for water management in New Orleans.

Visions and goals
Vision statement of Dutch Dialogues: Living with water[21]. Goal: • Secure water safety and amenity from water in New Orleans
Vision statement of Master Plan – "New Orleans 2030: By 2030, New Orleans is a liveable and sustainable city of equal opportunity for all (NOLA, 2010) Goals: • Enhance the quality of life for everyone to preserve the City's character • Expand opportunity and ensure equitable chance to share the benefits for everyone. • Create a more resilient city with shared environmental responsibility at every level.
Vision statement of Green Collaborative[22]: New Orleans rebuilding green. Goals: • Manage Water Resources to Protect Against Flooding • Restore Coastal Wetlands • Create Green Local Government
Vision statement of Mayor Landrieu's Transition Team - Flood Protection and Coastal Restoration Task Force: Coastline protection and restoration and engineered flood protection for a safe New Orleans (TNOTF, 2010) Goals: • Enhance the security of Louisiana's coastline and structural defences • Protect the City from floods • Establish World Class Urban Water Management

21. http://dutchdialogues.com (2014)
22. http://globalgreen.org (2014)

Vision statement of Flood Protection Alliance: A flood proof metropolitan New Orleans area[23]. Goals: • Build inner Levees • Create inner peace through construction of polders
Vision statement of Lake Pontchartrain Basin Foundation and Coalition to Restore Coastal Louisiana: A multiple lines of defense strategy for sustaining coastal Louisiana (LPBF, 2008) Goals • Restore environmental habitat restoration • Create vital engineered flood protection
Vision statement of LACPRA Master Plan: A sustainable long-term solution for coastal protection and restoration (CPRA, 2012) Goals: • Increase flood protection for all communities. • Use an integrated and synergistic approach for a sustainable and resilient coastal landscape.
Vision statement of GreeNOLA: A green strategy for a sustainable New Orleans (GreeNOLA, 2008). Goals: • Revive environmental programs, policies and conservation practices. • Support city government to effectively implement new initiatives on energy, development and environment. • Establish specific, measurable, and attainable short, medium, long-term sustainability goals.

Table A3 Vision statements and climate-relevant goals for the Rhine-Meuse region.

Visions and goals
Vision statement of Rotterdam Climate Proof: Rotterdam 100% climate proof by 2025 (RCP, 2009, 2010) Goals and guiding targets: • Reduce CO2 emissions in 2025 by 50% compared to 1990. • Investment in climate solutions to enhance the attractiveness of the city and port. • Rotterdam is to become a leading centre for water knowledge and climate change expertise.
Vision statement of Port Vision 2030: Rotterdam is Europe's most important port and industry complex in 2030 (PoR, 2011). Goals and guiding targets: • Acquire a strong position in the handling & storage of new types of cargo such as CO2, LNG and biomass. • Reduce transportation of containers to & from the Maasvlakte by road to 35% • Reduce CO2 emissions by 50% in 2025 compared to 1990 levels, and by 60% in 2030. • Increase the share of sustainable energy in Rotterdam's energy mix from 10% now to 30% in 2030. • Reduce the share of fossil energy carrier to roughly 40% of Rotterdam's energy mix • Reduce the share of coal to about 30% of Rotterdam's energy mix
Vision statement of Delta Programme: 'A safe and liveable Delta' (Deltaprogramme, 2011c) Goals and guiding targets: • Develop a longterm strategy for flood risk management and freshwater supplies • Support a sustainable and vital spatial development of the Rhine EstuaryDrechtsteden region.

23. http://www.slfpae.com (2014)

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APPENDIX B: SUPPLEMENTARY MATERIAL ON CASE RESULTS (CLRM-PAPER)

Table S1 Inputs & project settings.

Criteria	Case 1: SA	Case 2: US	Case 3: NL1	Case 4: SE1	Case 5: SE2	Case 6: UK	Case 7: NL2	Case 8: EU1	Case 9: EU2	Case 10: CA
Level of financial resources*	0,67	0	0,67	0,33	0,33	0,67	0,67	1	1	0,67
Availability of knowledge & expertise	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Types of knowledge used**	S, C, I	C, I	S, C, I	S, C, I	S	S, C, I	S, C, I	S, C, I	S, C, I	S, C, I
Presence of commissioner	Yes	No	Yes	Yes	No	No	No	No	No	No
project duration	0,67	0,33	0,67	0,33	0,33	0,67	0,67	0,67	0,67	0,67
Project goals***	C, P, M	C	C, P, M	C	C, P, M	C, P, M	C, P, M	C, P, M	C, P, M	C, P, M

* 0 = none; 0,33 = <10k€; 0,67 = 100k€-500k€; 1 = >1M€
** 0,33 = < 1 yr; 0,67 = 2- 5 yr; 1 = > 5 yr
*** S =Scientific knowledge; C = contextual knowledge; I = Interdisciplinary knowledge
*** C= Content; P = process; M = methodological impact

Table S2 Stakeholder engagement.

Criteria	Case 1: SA	Case 2: US	Case 3: NL1	Case 4: SE1	Case 5: SE2	Case 6: UK	Case 7: NL2	Case 8: EU1	Case 9: EU2	Case 10: CA
Degree of stake-holder diversity*	H	L	M	L	M	L	M	M	M	M
Degree of Stake-holder influence	H	L	H	M	M	L	M	M	M	M
Presence of stakeholder involvement	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of stakeholder com-mitment to results	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Scores: L = Low; M = medium; H = high

Table S3 Methods.

Criteria	Case 1: SA	Case 2: US	Case 3: NL1	Case 4: SE1	Case 5: SE2	Case 6: UK	Case 7: NL2	Case 8: EU1	Case 9: EU2	Case 10: CA
Inclusion of analytical tools & methods*	CA, DAT	DAT	CA, DAT	DAT	DAT	CA, DAT, DPT	CA, DAT, DPT	CA, DAT, DPT	(CA, DAT, DPT	CA, DAT, DPT
Inclusion of design tools & methods**	SDT & RD	RD	SDT & RD	RD	RD	SDT RD, M	SDT RD, M	SDT RD, M	SDT RD, M	SDT RD, M
Inclusion of modelling & simulation tools & methods***			WM, SM, SEM			TSM, TC-SIM	GM, SM	LUM, WM	SD, WM	SEM, 3DM
Inclusion of stakeholder tools & methods ****	SW, CB	RT	SW, FGM	SW & BS	SW & BS	EW, I, SG, EC	SI, SW & OS	SW, EW	SW, EW	SW & 1
Inclusion of communication / dissemination tools & methods*****	PW, R	R, N, P	PW, R	R	R	PW, R	PW, R	PW, R	PW, R	PW, R

* CA = Climate impact assessment; DAT = Data analysis tools; DPT = Data processing tools

** SDT = Scenario design tools; RD = research design tools; M = Mapping tools

*** TS = Transport simulation modelling tools; TC-SIM = Transport and CO_2 simulation game; GM = Global models; SM = Spatial modelling; LUM = Land-use modelling; SD = Systems Dynamics modelling; WM = Water models; SEM = Socio-economic modelling tools; 3DM = 3D modelling

**** SW = Stakeholder workshop tools; RT = Round table; Focus group meeting; BS = Brainstorm sessions; EW = Expert workshops; I = interviews; OS = Online survey

***** PW = Project website; R = Reporting, N = Networking; P = Partnerships

Table S4 Visions in backcasting studies.

Criteria	Case 1: SA	Case 2: US	Case 3: NL1	Case 4: SE1	Case 5: SE2	Case 6: UK	Case 7: NL2	Case 8: EU1	Case 9: EU2	Case 10: CA
Presence of multiple visions	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Presence of transformative elements	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	No
Presence of goals & guiding targets	Yes	Partly	Yes	No	Yes	Partly	Partly	Yes	Yes	Partly

Table S5 Scenarios in backcasting studies.

Criteria	Case 1: SA	Case 2: US	Case 3: NL1	Case 4: SE1	Case 5: SE2	Case 6: UK	Case 7: NL2	Case 8: EU1	Case 9: EU2	Case 10: CA
Inclusion of uncertainties**	C, S, P	P	C, S, P	C	C	C, P	C, S, P	C, S, P	C, S, P	C
Types of scenarios*	QUAN	None	QUAN	None	None	QUAN	QUAN	QUAN	QUAN	QUAN
Scenario approach	EXPLOR	None	EXPLOR	None	None	COM	COM	COM	COM	COM

* C = climate uncertainties; S = social uncertainties; P = political uncertainties

** QUAN = Quantitative; COM = Combinatory; EXPLOR = Explorative

Table S6 Pathways in backcasting studies.

Criteria	Case 1: SA	Case 2: US	Case 3: NL1	Case 4: SE1	Case 5: SE2	Case 6: UK	Case 7: NL2	Case 8: EU1	Case 9: EU2	Case 10: CA
Addressing uncer-tainty	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Inclusion of actors & measures*	STP	No	LTP	STP	STP	LTP	LTP	LTP	LTP	LTP
Inclusion of robust elements	No	No	Yes	No	No	No	Yes	Yes,	Yes,	No

* STP = Short-term pathways; LTP = Long-term pathways

Table S7 Impact.

Criteria	Case 1: SA	Case 2: US	Case 3: NL1	Case 4: SE1	Case 5: SE2	Case 6: UK	Case 7: NL2	Case 8: EU1	Case 9: EU2	Case 10: CA
Inclusion by formal decision making	Yes	No	Yes	Yes	No	No	No	No	No	No
Examples of f ollow-up activities for implementation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Examples of broader spin-off*	S, SO, PP	SO, PP	S, SO, PP	S, SO	S, PP	S, PP	S	S	S, PP	S, SO, PP

*S = Science; SO = Society; PP = Practice & policy

ACKNOWLEDGEMENTS

When I embarked on my PhD journey 14 years ago, little did I know how many profound experiences and challenges lay ahead. Fulfilling my long-held dream of pursuing a PhD research, time seemed to pass swiftly as I immersed myself in the world of academia. This journey was not a straightforward process, but rather a bumpy road that thoroughly put my perseverance to the test in a way that can best be summarized in the following quote of Nelson Mandela (1918-2013):

"The greatest glory in living lies not in never falling, but in rising every time we fall" .

This quote has always resonated with me, but the more I approached the end of my PhD research, the more its profound meaning took on new significance in my life.

Like with any other journey, I did not undertake the PhD journey alone: many people supported and accompanied me along the way. They inspired me with ideas, motivated me, provided me with feedback, facilitated my writing in countless ways or simply stimulated me to sometimes take a break and focus on something completely different.

First and foremost, I would like to thank Derk Loorbach, my promotor and the director at DRIFT, for providing me with this once in a lifetime opportunity to complete the PhD research I started in Osnabrück, for having faith in my work and for challenging and inspiring me to become 'bolder'. My gratitude goes also to Martin de Jong, my second promotor, for his enormous support, guidance, and encouragement, which have been invaluable throughout the entire process. Your peptalks got me going when the going was tough. Furthermore, I cannot imagine a better co-promotor than Jaco Quist. His endless feedback and unconditional support and guidance have played a pivotal role in helping me to refine my academic writing and research skills and sharpening my arguments. Your unwavering presence and wealth of wisdom and knowledge have been instrumental in shaping my academic growth. It is impossible to truly express how grateful I am to you.

Throughout my PhD journey, I have been fortunate enough to have had the chance to explore various places and experiences. I would like to thank my former colleagues – Bjorn Fokken, Lea Kammermeier, Christian Husmann, Jeanette Hanseroth, Nina Wernsing, Patrick Huntjens, Jorg Krykow, Caroline van Bers and Georg Holtz - at the Institute of Environmental Systems Research, Osnabrück, where my journey started.

My academic journey has also taken me to South Africa and New Orleans, which marked my first backcasting workshops overseas. Beyond the intellectually stimulating discussions, these trips have provided unforgettable adventures and experiences. I would like to thank Lucinda Fairhurst, Priscilla De Comarmond and Louisa Nauda for providing me with the opportunity to work with you at ICLEI South Africa. My stay in Cape Town would not have been so enjoyable without Paul Robertson – many thanks for having me as your guest.

My case study research in New Orleans would not have been successful without the support of the Horizon Initiative Water Management Committee members. I would like to express my deep gratitude to Grasshopper Mendoza (the Committee Chair), Billy Marchal (Horizon Initiative Executive Committee), Steve Picou (LSU AgCenter) and Rachel Heiligman (New Orleans City Planning Commission). I would also like to express my gratitude to David Waggoner, Don Blancher, John Moore, Matthew Fraser, and Harvey Stern for their contributions to the workshops that significantly benefited my research. In addition, I would also like to thank Shirley Laska and Monica Farris for providing desk space at the CHART Department of the University of New Orleans. Last but not least, this study could not have been completed without the valuable contribution of the other Committee members of the workshops. My stay in New Orleans would not have been so pleasant without Michael Manuselis – many thanks for having me as a guest and being my personal guide. I have good memories of our crawfish boils at the Maple Leaf bar.

Furthermore, I would like to thank Marjolijn Haasnoot for giving me the opportunity to conduct my Dutch case study research within the context of the Deltaprogramma Rijnmond Drechtsteden.

My journey also led me to TNO and the HZ University of Applied Sciences. I would like to thank my former colleagues at TNO: Ingo Bousema, Celine Brus, Han van der Steen, Geiske Bouma, Roald Suurs, and Frans van der Zee. To my former colleagues at HZ University of Applied Sciences: thanks Jean-Marie Buijs and Teun Terpstra for allowing me to share my struggles with you. To my former fellow PhD colleagues: thanks Immy and Emiel for your support.

During my journey, three special persons - Prosun Bhattacharya from KTH Stockholm, Meine Pieter van Dijk from the UNESCO-IHE Water Institute, and Caroline van den Berg from the World Bank - crossed my path. They played a pivotal role in shaping my academic growth. I am very grateful to you for inspiring and supporting me.

Writing a PhD thesis can be quite challenging. Therefore, I would also like to thank Diane Butterman-Dorey for proofreading the thesis, from which it has significantly benefited.

On a personal note, I would like to thank my close friends and relatives for listening to all my PhD stories over the years for just taking me out or putting my struggles in perspective – thanks for being in my life: Yerrol and Said, Timo and Sharon, Wijnand and Jeanette, Wouter and Yr, Bas, Etienne, Herman, Dave, and Ivan. This also applies to my friends overseas: Reggie, Vivek, Heiko and Kajol. During one's journey, there are some people who are meant to cross one's path in life but they are not meant to accompany us to the final destination. This applies to an old friend of mine, Jordy Bouwman. Although we went our separate ways at some point in time, I cherish the philosophical moments when we shared our PhD struggles and jokes and views on the meaning of life. I wish you all the best in your future endeavors.

Equally importantly, I would like to express my deepest gratitude to my family, including my brother and sisters, uncles, Pieter and Jacques, aunt, Maaike, and, "father-law", Theo, and Paco, whose belief in my abilities and support got me going. To my brother from another mother: thanks Wouter, I could not have done the job without your emotional support when times got tough. I cherish our moments in Osnabrück and beyond. Furthermore, I feel obliged to dedicate some special words of gratitude to my mother: dear mom, thank you for your unconditional love and care and for the support that enabled me to undertake this journey. You have let me walk down my own path and follow my dreams since childhood. Your encouragement played a vital role in my personal and professional accomplishments. Therefore, I dedicate this PhD thesis to you.

Last but not least, I would like to thank my partner in crime, Nynke. I am lucky to have your unconditional love and support, which gave me the strength to keep going while you always had faith that it would all work out. With this dissertation, the scientific foundation has been laid for Spiritual Backcasting. I look forward to what is yet to come.

CURRICULUM VITAE

Tom van der Voorn is a climate change adaptation researcher at the Dutch Research Institute for Transitions, Erasmus University Rotterdam. He joined DRIFT in October 2022 to complete his PhD research that started in Osnabruck. Prior to this, he worked at the Netherlands Organization for Applied Scientific Research (TNO), KWR Watercycle Research Institute, HZ University of Applied Sciences and the Millennium Institute, based in Washington D.C., United States. His research interests and topics include the use of participatory backcasting for climate change adaptation planning and water management, transitions in water management, and community-based drinking water supply in developing countries. He is currently an associate editor of the Journal of Groundwater for Sustainable Development. He published and lectured on these topics at various universities, including the University of Cape Town, KTH Royal Institute of Technology, UNESCO-IHE Institute for Water Education, Free University of Brussels, Delft University of Technology, University of New Orleans.