An institutional and socio-cultural perspective on the adaptation pathways approach

Rutger van der Brugge and Ronald Roosjen

ABSTRACT

The uncertainties surrounding climate change are creating challenges for policy makers with regard to investments in water-related infrastructure. A promising new approach is the adaptation pathways approach. This article contributes to this approach by introducing an institutional and socio-cultural perspective. It presents an analytical framework to evaluate the necessary institutional and socio-cultural conditions, uncovering challenges with regard to the governance of adaptation and of keeping options open for the future. The framework has been applied to the case study of fresh water supply in the Netherlands. Based on an institutional and socio-cultural analysis, the feasibility, flexibility and governance of adaptation strategies are discussed. Reflecting on the presented framework, critical issues are addressed with regard to the further development of the adaptation pathways approach.

Key words | adaptation, flexibility, governance, institutional, socio-cultural

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INTRODUCTION

In delta areas across the world, policy makers see themselves confronted with the uncertainties of climate change. For instance, in the Netherlands they are confronted with uncertainties about the speed of sea-level rise, fresh water supply and flood probabilities of the river Rhine. These uncertainties create real challenges for policy makers with regard to investments in water-related infrastructure. On the one hand, they run the risk of adapting too slowly resulting in unsafe situations, while on the other hand they run the risk of wasting public money by over-dimensioning the infrastructure if climate change impacts turn out to be less than expected. Hence, dealing with uncertainty regarding climate change is a real art.

Usually, decision-support studies about the impacts of climate change take climate change scenarios as a starting point, calculate the impacts and develop potential solutions. In a recent study, Kwadijk *et al.* (2010) took another starting point. They asked instead how long present-day water management strategies would continue to be effective under different climate change scenarios. Kwadijk *et al.* (2010) used the term adaption tipping points (ATPs) to indicate those critical values (thresholds) beyond which the current water management policies fail to meet their objectives. These thresholds can be norms or standards (i.e. water safety, water quality norms), financial thresholds (i.e. treasury, funding, cost-benefit) and societal thresholds (i.e. agreements, statistics) (Te Linde & Jeuken 2011). The last type of ATP refers to the acceptance of the public, or what is called social robustness (Offermans *et al.* 2011). Although this approach informs policy makers under what conditions it is necessary to take action, it does not tell them which adaption measures should be taken.

Haasnoot *et al.* (2011) therefore argued to explore a range of possible adaptation pathways after reaching an ATP. The adaptation pathway approach (Haasnoot *et al.* 2012, 2013) generates an array of possible pathways which can be compared on relevant criteria. Figure 1 illustratively shows an adaptation pathways map for fresh water supply in the Netherlands. Each pathway consists of a series of possible measures (y-axis). If an adaptation measure reaches an

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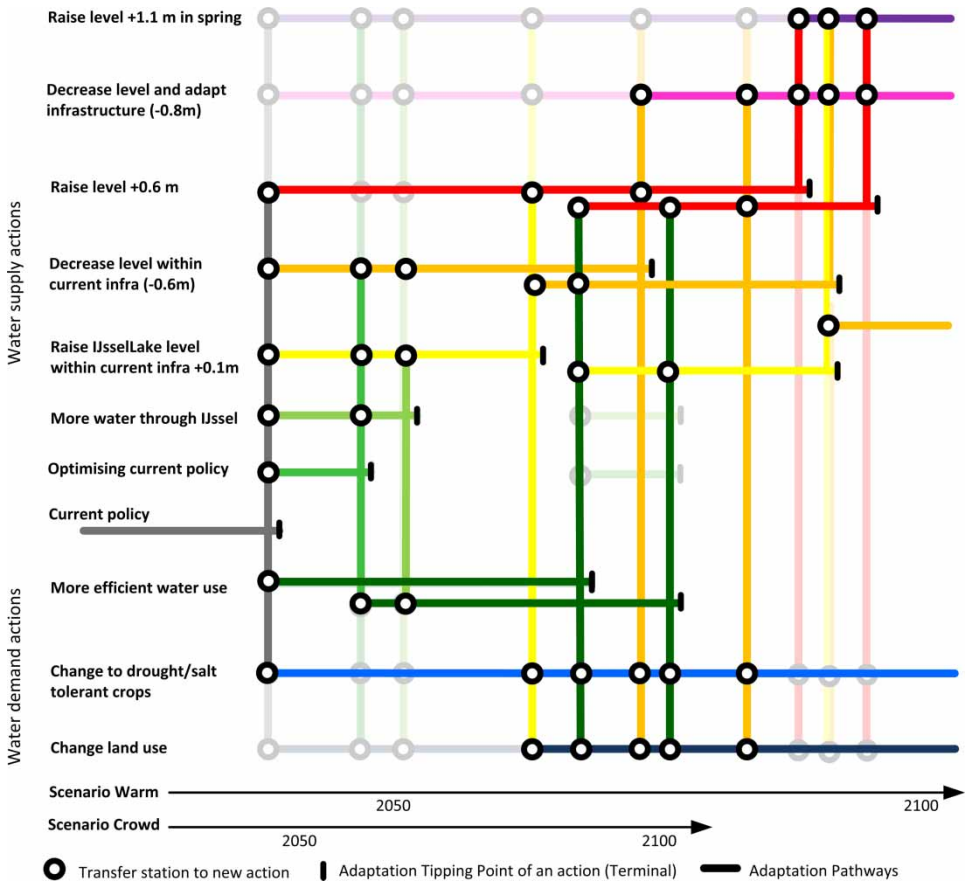

Figure 1 | Adaptation pathways map of Dutch fresh water supply (Haasnoot *et al.* 2012).

ATP, it means that it is no longer effective in meeting (current) objectives or norms and a new adaptation measure is required. The possible pathways can be scored and then compared.

The approach is promising by virtue of its ability to support the development of robust adaptation policies. An adaptation policy is robust if the desired result can be reached under a variety of circumstances and assumptions (Lempert *et al.* 2003) or scenarios (Van Asselt & Rotmans 1997). We understand flexibility as the relative ease by which a policy can be adapted to changing circumstances (Mens *et al.* 2012). Hence, we see flexibility as a key quality of robust policies in the sense that policies can be adjusted, may be implemented sooner, or postponed, or can be switched to other measures altogether, while the result the policy aimed for will still be achieved. Walker *et al.* (2013) refer to this as dynamic robustness. In the adaptation pathways map flexibility is shown by the so-called transfer points, the points where choices can be made between measures. These options reflect flexibility in the sense that when an ATP is reached, a variety of measures may be implemented (Rosenhead *et al.* 1972) in contrast to the situation in which the only option is to continue along the same path. This is also known as a lock-in, in which it becomes increasingly difficult or expensive to shift to an alternative pathway (Grin *et al.* 2010), often as a result of the existing infrastructure or economic activities.

The adaptation pathways approach builds further on the adaptation tipping points approach of Kwadijk *et al.* (2010) and the Thames Estuary project in England (Reeder & Ranger 2009). Although the adaptation pathways approach requires simulation models and time series scenarios to quantify the ATPs and to generate adaptation pathways (Haasnoot *et al.* 2012, 2013), there is also some experience of applying the approach in a more qualitative way (Van der Brugge *et al.* 2012; Roosjen *et al.* 2012). Jeuken *et al.*

(2015) have reviewed how the approach has been applied up till now in four different deltas.

This article aims to contribute to the further development of the adaptation pathways approach by introducing the institutional and socio-cultural dimension, since these two dimensions have not yet been addressed sufficiently in the approach. They are however important with regard to the actual feasibility and flexibility of an adaptation strategy. Institutional conditions, such as legislation and responsibilities, or socio-cultural conditions, like belief systems, economic activities or the state of knowledge (see section two) enable certain adaptation measures while hampering others. To a considerable extent, they guide the actions and interactions of the actors involved in climate change adaptation, but are also shaped and reshaped by them (Termeer *et al.* 2011). As such, these conditions are enablers or barriers for climate change adaptation (Lawrence *et al.* 2013). Especially in the case of transfer options that require larger, transitional changes, the institutional and socio-cultural conditions are important constraining factors (Grin *et al.* 2010). The point is that they may reduce the number of feasible pathways and the flexibility that is seemingly present in the adaptation pathways map of Figure 1.

With this is in mind, the main research aim in this study was: how can we incorporate the institutional and socio-cultural dimension in the adaptation pathway approach? To this end, a case study of fresh water distribution in the Netherlands (Haasnoot *et al.* 2012) has been re-examined with regard to the institutional and socio-cultural conditions of the proposed adaptation strategies. We have used the framework of Van der Brugge (2009) for this analysis because of its useful starting point, namely the identification of socio-cultural structures (i.e. structure elements) that need to change along a transition path. The research question addressed in the case study was: which institutional and socio-cultural structures should have to change in order to realise the adaptation strategies?

A second aim of the study was concerned with the question of governance of adaptation strategies and specifically that of keeping options open to switch to another strategy to ensure flexibility in the future (Rosenhead *et al.* 1972). Long-term adaptation strategies transcend single policy cycles. While Moser & Ekstrom (2010) identified numerous barriers for governance in each phase of climate adaption policy development, their framework considers too much detail for our purpose here. Instead, we will discriminate between different levels of governance complexity, indicating the degree of control that actors have over the implementation of an adaptation strategy, in other words, the 'governability' of a strategy. To this end, the second research question addressed in the case study was: which actors are able to change these structures, to what extent can they manage implementation of the adaptation strategies and keep open transfer options in the future to ensure flexibility?

The next section outlines the framework that has been developed in order to incorporate an institutional and socio-cultural perspective, including governance, in the adaptation pathways approach. Subsequent sections cover presentation of the case study results, the conclusions drawn and discussions on how this study contributes to the adaptation pathway approach and the way forward.

ANALYTICAL FRAMEWORK

Institutional and socio-cultural structures

The institutional and socio-cultural framework (ISA-framework) presented here is developed to support the analysis of adaptation with regard to institutional and socio-cultural conditions, building further on the work done by Haasnoot *et al.* (2012). Application of the framework contributes to our understanding about how social structures should change in order to realize a particular pathway.

The ISA-framework is based on the framework presented in Van der Brugge (2009), in which institutional and socio-cultural structures in the Dutch water sector were identified. The framework was originally developed to analyse retrospectively how the institutional and socio-cultural structures in the Dutch water management sector had changed over the past thirty years. The framework however, can also be applied to adaptation pathways in a prospective way, that is, the analysis of which institutional and socio-cultural structures are implied by, or rather required by, different strategies. Existing social structures create institutional and socio-cultural conditions that either support of hamper measures (Giddens, 1984). Hence, for the realisation of an adaptation strategy, it might be necessary to change social structures.

Among the myriad of social structures three main types can be identified: institutions, culture and infrastructure (Van der Brugge 2009). Institutions are generally thought of as 'values solidified into rules' (March & Olsen 1989; Klijn 1996). Scharpf (1997) understands institutional structures as a system of rules guiding actions of actors. Hence, institutions are organizing principles. For instance, they structure local responses, mediate between the collective and the individuals and deliver resources to facilitate adaptation (Agrawal *et al.* 2009). The difference between culture and institutions is not so clear. Originally, culture was used by Edward Barret Tylor (1874) as a synonym for civilization, but after that it referred to the implicit and explicit patterns of behaviour (Kroeber & Kluckhohn 1952). Behind these patterns of behaviour are sets of values, beliefs, ideas, knowledge and skills. Where institutions may be understood more or less as 'formal' structures, culture is associated with 'soft' or 'mental' structures. Infrastructure, as the third type of structure, refers to physical structures, such as roads, bridges, dykes, storm barriers and the like. Since the adaptation pathway approach already includes the infrastructure, we focus here on the institutional and socio-cultural structures.

Table 1 shows the structure elements in the institutional and socio-cultural domain that are used in the ISA-framework. The institutional domain encompasses the following structure elements: responsibilities (of actors), legal norms, legislation, policy plans and budgets. These are typically formal structures, which can be traced back to official documents. They organize formal social interaction. The socio-cultural domain is divided into three subdomains: the social, the economic and the knowledge subdomains. In the social subdomain, belief systems and awareness are considered. Belief systems refer to the underlying values, paradigms and discourses that are dominant in the sector. These beliefs determine to a large extent how problems and solutions are understood and framed (Van der Brugge 2009). Belief systems are powerful, because they might lead to the exclusion of new approaches that are outside the dominant perspective. Awareness refers to the familiarity of the local residential community with regard to water related issues. Public awareness influences the acceptance of solutions, but also the exposure to risks. The economic subdomain considers the 'economic identity' of a region. An important structuring element is land use (exploitation), which supports and constrains the economic activities and possibilities in a region. A second structure element to be considered is what we refer to as 'water logistic', referring to the role and meaning of water management in a region, for instance, agricultural areas have huge fresh water requirements, while urbanized areas may require water management for shipping and safety. The knowledge domain considers the type of knowledge produced by research programs, available simulation software and the technological capabilities. These structure elements are related to what we know and how people are trained and

Table 1 | Types of structures in the institutional and socio-cultural domains, illustrated with examples of the Dutch water sector

Domain	Structures	Examples from the Dutch water sector
Institutional	Responsibilities	Flood protection, water quality, freshwater distribution
	Norms	Flood protection norms, water quality
	Legislation	Water Management Act, permits
	Policy plans	National water plan, local water management plan, local water level agreements
	Budget	National budget, regional budget, investment funds
	Procurement	Regulations, contracts
Social	Belief systems	Paradigms, values, discourses
	Awareness	Preferences, awareness, behavior, commitment, compliance
Economic	Economic activity	Farming, recreation, shipping, industry, etc.
	Logistic	Supply and demand, transport, transfer nodes
Knowledge	Research programs	Hydrology, civil engineering, governance, impact assessment, etc.
	Simulation/forecasting software	Hydrological models, decision support tools, cost benefit, etc.
	Technology	Machines, techniques, materials, constructions

thus indicate what we technically can or cannot do with regard to water management.

Hence, all the above described elements of institutional and socio-cultural structure influence in their own manner the way in which we shape our climate adaptation strategies. Application of the ISA-framework supports a more specific analysis of how these structures enable or constrain specific adaptation strategies.

Governance

In order to address the issue of the governance of adaptation strategies, we are interested in the question whether these structures indeed can be changed and how difficult that is. Hence, we are interested in the actors that are connected to these structures, whether they have the resources and the power to change these structures and if they are indeed willing to change them. In order to assess to what extent adaptation strategies can be governed and transfer options can be held open, the following four factors should be taken into account: (a) is a single actor individually capable of changing the institutional or socio-cultural structure, or does it require multiple, interdependent actors; (b) are all the actors willing to cooperate or do they have strong opposing (conflicting) stakes; (c) do the actors (together) have the resources (financial, power, knowledge) to change the institutional or socio-cultural structure, or is the structure changing as a consequence of mere autonomous processes; and (d) is the structure itself critically dependent on the changing of other institutional and socio-cultural structures (which means that (a)–(d) should be addressed for all the dependent structures)?

Based on these four factors, different levels of governance complexity can be distinguished to indicate the governability of adaptation strategies. The lowest level of complexity is when an organization is singlehandedly capable of changing a particular institutional or socio-cultural structure, thus, governability is relative high. The governance becomes more complex when multiple organisations are involved. We refer to this as level 2 when the actors have non-conflicting stakes and are willing to cooperate. Level 3 complexity corresponds to the situation in which multiple actors have opposing stakes. In this case, the governability of the strategy becomes more difficult. The next level of complexity is reached when the resources that are needed to change a structure are not sufficient. Governability decreases even more, then. The highest level of complexity (level 5) considered is that of multiple actors, with opposing stakes, who do not have enough resources to change a number of interdependent structures simultaneously.

Application of the ISA-framework in this way helps to evaluate to what extent adaptation strategies and transfer options can be governed. In the next section we will show how we applied the ISA-framework to the case of fresh water supply in the Netherlands.

METHOD

In order to illustrate how the ISA-framework enables the analysis of institutional and socio-cultural conditions of climate adaptation, we have applied it to a case study in which already three possible adaptation strategies had been identified. The ISA-framework will be used in two different ways in the case study. The first is an analytical exploration of three adaptation strategies with regard to the institutional and socio-cultural conditions. It helps answering the question: which institutional and socio-cultural structures should have to change in order to realise the adaptation strategies? The second way is analytical exploration into the governability of the strategies and transfer options. The framework helps to answer the question: which actors are able to change these structures, to what extent can they manage these strategies and keep open the transfer options in the future to ensure flexibility?

The approach consists of four steps in which various analytical exercises have been carried out. These exercises were carried out by the authors, who both have a professional history in the water management sector and were reviewed by two colleague experts. During the first step, the authors carried out an exercise to assess the socio-cultural changes implied by three different adaptation strategies. The institutional and socio-cultural structures were coded in terms of 'needing to change' for realisation of the path or 'not needing to change'. Then, an assessment was made on how these structures should change so that they would support the pathway. The second step was

concerned with an exercise to identify the actors that have the power to change the structures that were coded as 'needing to change' during step one. Actors were coded as 'supporting' or 'hampering' the required change by assessing whether the strategy would or would not benefit their stakes. In addition, the authors assessed whether the actors' resources were sufficient. Step three was an exercise concerning the evaluation of the four governance factors to indicate the governance complexity on the five-point scale. During the fourth step the strategies were analysed in terms of their robustness and subsequently their need for flexibility. To this end, the four delta-scenarios developed by Bruggeman *et al.* (2013) were used. First, the scenarios were decomposed into the structures used in the ISA-framework and described what these structures would look like in these particular scenarios. Then, the structures implied by the strategies were compared to the structures implied by the delta-scenarios and the differences were recorded. The robustness of the strategy was indicated by the degree of differences between the structures of the strategy and the structures of the four scenarios and reflects the need for keeping options open (i.e. if a strategy is robust with regard to the four scenarios, there is no need to keep options open). The next step involved an exercise in which the authors assessed which structures should change to support a switch to another strategy similar to the procedure during step two and identified possible actions that could be taken in anticipation of such a switch.

The case study deals with freshwater distribution as part of the Dutch Delta Program (2011), a national policy program on climate adaption. The main objectives of the program are guaranteeing flood protection and freshwater supply taking into account the uncertainties with regard to climate change and socio-economic developments. Uncertainties surrounding climate change on the one hand, but the need to invest in the water infrastructure on the other, created a need for an adaptive approach. The result was the launch of a research program on Adaptive Delta Management in which both academics as well as policy makers contributed (Van Rhee 2012). The word 'delta' was added to point out that the concept applied to the Dutch delta and in a more general sense to all delta areas in the world. Delta areas require specific attention, since these areas are generally threatened by sea level rise and extreme river discharges due to climate change. Often these areas are densely urbanized areas with complex infrastructure and have high demands for fresh water.

The main source of fresh water for the Netherlands is the River Rhine, which enters the country near Lobith in the Province of Gelderland (Figure 2). Rhine water is distributed across the land through three Rhine branches – the Waal, Nederrijn, and IJssel. The first two branches eventually drain their water into the North Sea. The IJssel supplies Lake IJsselmeer and Lake Markermeer. Lake IJsselmeer was created by damming the former inland sea called the Zuiderzee. The lake is approximately 1,100 km^2 and on average 5–6 m deep, with a maximum of 9.5 m. Lake IJsselmeer and Lake Markermeer are important water reservoirs and play an important role in fresh water supply to the surrounding areas for agriculture (e.g. the Provinces of Friesland and Groningen in the North). According to the current policy the water level is set −20 cm NAP during summer when demand is high and −40 cm NAP during winter when demand is low. During dry spells in summertime, water from the lake is used to flush the regional water systems in the Western part of Holland to prevent salt intrusion from the North Sea.

The analysis of Haasnoot *et al.* (2012) focuses on fresh water supply, in which the lake IJsselmeer plays a decisive role. The lake can be used to temporarily store run off water from the Ijssel river in case of higher discharges due to climate change. The stored fresh water can be used in times of drought, which are expected to occur more often in the future due to climate change. In response to climate change, we consider three main strategies. The first is to increase the water storage capacity of Lake IJsselmeer by raising the water level and using the surplus during summer. This strategy requires raising the dikes, wharfs, seafronts, sluices and harbours. The same strategy can be repeated when climate change continues and more storage capacity is needed. The second strategy would be to reduce fresh water demand through efficient water use, especially of farmers, and eventually adopting the production of drought-tolerant crops, or salt-tolerant crops near the sea (a considerable amount of fresh water is currently used to counter salinization in these areas). The third strategy would be to reduce fresh water demand by more efficient use of water and transforming non-profitable

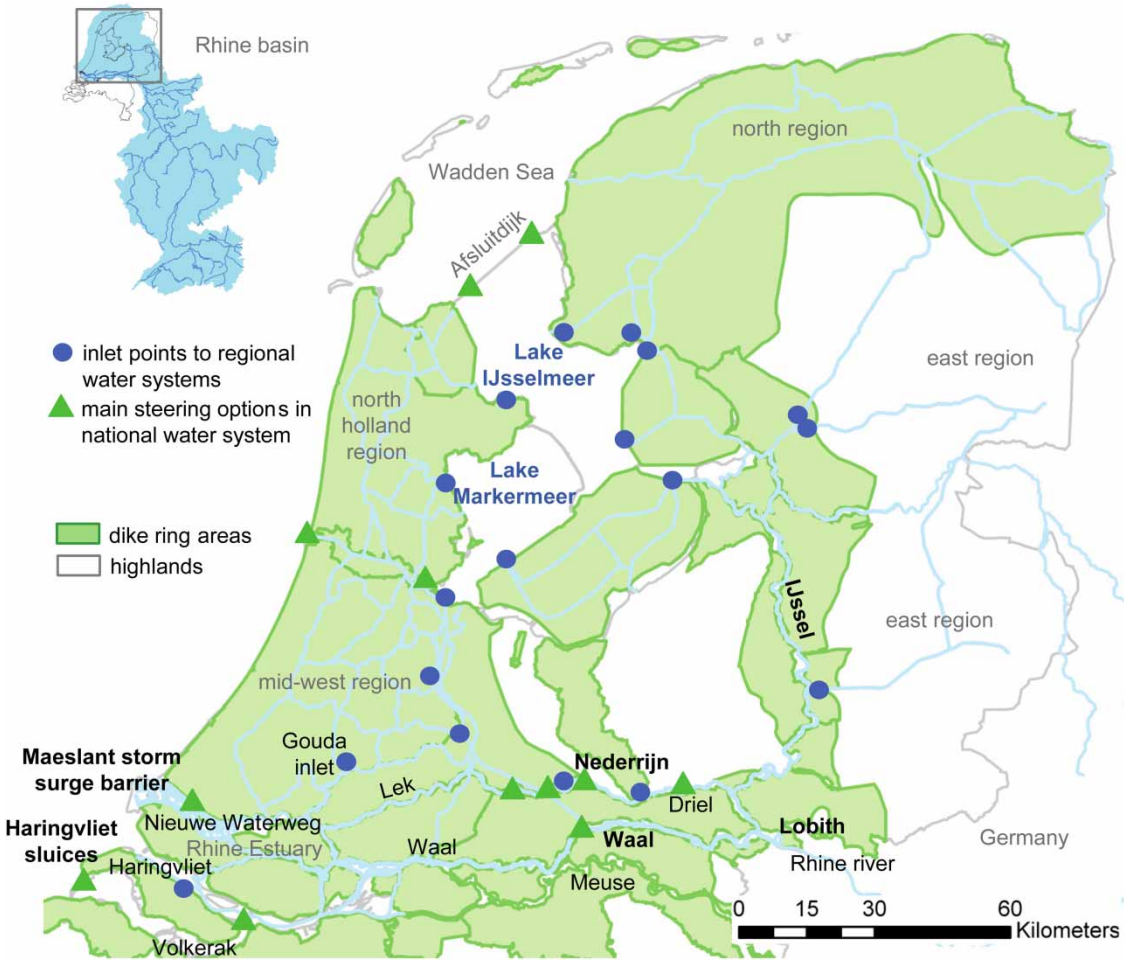

Figure 2 | The IJsselmeer area in the Netherlands and its role in fresh water supply.

agricultural lands into areas with functions less dependent on fresh water supply.

In the original analysis, Haasnoot *et al.* (2012) developed a number of possible adaptation pathways for each strategy (Figure 1). In this analysis, however, we focused on the level of the three main strategies. We did so in order to illustrate the point more clearly as the required socio-cultural changes are more profound and not to be distracted by the complexity of the adaptation pathways map. Subsequently, the ISA-framework has been applied to the three strategies: strategy 1 refers to a path from the current policy towards a policy of elevating water levels in Lake IJsselmeer and in a later phase raising the level a second time; strategy 2 is a path from current policy to more efficient use to switching to salt water tolerant crops; strategy 3 is a path from current policy to more efficient use to changing land use. In addition, we used the ISA-framework to analyse the possibilities of switching from one strategy to another.

RESULTS

Socio-cultural analysis of the adaptation pathways

In this section, we present the results of the various analytical explorations that have been carried out. Table 2 shows the results of the analytical exploration of strategy 1. According to the authors, strategy 1 implies a number of structure changes in each of the considered domains. In the institutional domain, the most profound structure that seems

Table 2 | Institutional and socio-cultural analysis of strategy 1 (Current policy → Raising water level IJssel lake → Raising water level IJssel lake)

Domain	Structure	Structure elements of strategy 1	Actors	Governance level of complexity
Institutional	Responsibilities	Adjust Water level agreement	Parliament, Ministry, Rijkswaterstaat,	3
	Norms	Adjust National water plan, local water	Waterboards, Provinces, Municipalities	3
	Legislation	management plan, spatial plan	Parliament, Ministry, Rijkswaterstaat,	
	Policy plans	Create Investment fund	Waterboards, Provinces, Municipalities	4
	Budget		Parliament	
	Procurement			
Social	Belief systems	Change discourse that raising water	Knowledge institutes, Officials	
	Awareness	level is necessary for freshwater	Parliament, Ministry, Rijkswaterstaat,	5
		supply	Waterboards, Provinces, Municipalities	4
		Raise awareness	Parliament, Ministry, Rijkswaterstaat,	4
		Create local support	Waterboards, Provinces, Municipalities	
Economic	Economic activity	Adjust recreational facilities,	Entrepreneurs	2
	Logistic	restaurants, etc.		
Knowledge	Research programs	Set up research program for raising	Knowledge institutes	2
	Simulation/ forecasting software tech.	water level of Lake Ijsselmeer		

necessary to change is the water level agreement of Lake IJsselmeer when the water level is allowed to rise. Raising the level also implies water level adjustments in nearby regional water systems (also in response to altering groundwater tables). This should be regulated in local water level agreements and maybe even in national water policy plans as well, since the implications are profound. Financially, in order to fund the large scale dike raising program implied by this strategy, the authors point out that substantial budgets would have to be reserved. With regard to the cultural domain, the authors assess that the current discourse is momentarily not quite creating the right condition for this strategy. Policy reports and other documentation written within the Delta Program show that the current discourse is tending strongly to maintain the current water level. So, instead of raising the level considerably, a flexible water level will be introduced first. Although one could argue that this might still lead to raising the level in the future, regional authorities are currently opposing that option. Supported by research on the effectiveness and cost-benefit analysis, current belief with regard to raising the level structurally seems to be inclined towards 'not necessary and too expensive'. Support from the local community for raising dikes, harbours and other infrastructure seems unlikely according to the authors. Although they do not know this for a fact, raising the dikes and the water level affects recreational activities and the 'experience' related to living or working near the IJsselmeer negatively. On the other hand, farmers depending on fresh water from the lake would probably welcome the additional water buffer during dry summers. In the economic domain, the authors could not clearly identify necessary structural changes. They see no reason why existing economic activities in the region (i.e. harbours and private companies near the shore) could not continue after they have adjusted their infrastructure (new wharfs etc.). In the knowledge domain, it seems that there is no clear need for a fundamental different knowledge development or training programmes either. There is already a great deal of experience with this kind of engineering work in the Netherlands. It would, however, be sensible to set up a research program to study effects and specific solutions.

With regard to the governance of strategy 1, the authors are inclined to see the water level agreements, the discourse and the local support for raising the water level as the most profound socio-cultural conditions needing to change. At the same time, they argue that these changes cannot be simply managed. Though principally national government

is entitled to impose the strategy, the question is whether this could be achieved politically against the will of local communities, probably not without clear scientific evidence about the profitability to raise the water level. Top-down regulation at the expense of resistance of local authorities and the public is politically dangerous.

Table 3 shows the analysis of strategy 2. This strategy critically depends on a change in the economic activity of farmers from growing traditional crops to growing crops that are drought or salt tolerant. The authors suspect that strategy 2 implies the embracement of a new discourse as well. The current discourse is still that the public water management authorities (Rijkswaterstaat and the water boards) are considered responsible for fresh water supply, although discussions are raised more and more if this remains justifiable in the future. The authors argue that this is still in contradiction to a discourse of farmers being self supportive with regard to fresh water supply. From an economic point of view, strategy 2 also implies the emergence of a consumer market for drought or salt tolerant crops. The authors emphasize that the successful emergence of such a market is highly uncertain and cannot be depended on. It implies that consumers will have to change their dietary habits in the future and that farmers will alter their production processes without having the certainty of receiving (higher) revenues.

In terms of governance, strategy 2 – according to the authors' assessment – is probably even more difficult than strategy 1, as it implies this emergence of a new consumer market which is a highly uncertain and uncontrollable dynamic. Evidently, this particular part of the strategy is not easily managed. Maybe through public awareness campaigns, successful marketing and stimulation regulations for farmers this could be facilitated to some extent, but above all it seems to be an autonomous development depending on consumer behaviour.

Table 4 shows the structural changes in strategy 3 in which growing traditional crops will no longer be profitable. In this strategy, farmers ultimately sell their business and the land will be economically exploited in other ways. According to the authors, this strategy only differs from strategy 2 with regard to the necessary socio-cultural changes in the economic domain in the sense that it does not imply a new consumer market. It does however imply a same discourse change as in strategy 2, namely that farmers themselves are responsible for the way they deal with a lack of fresh water instead of the government.

Table 3 | Institutional and socio-cultural analysis of strategy 2 (Current policy → Efficient water use → Drought/salinity tolerant crops)

Domain	Structure	Structure elements of strategy 2	Actors	Governance level of complexity
Institutional	Responsibilities Norms	Shift from government to self-supportive users	Waterboards, Provinces, Municipalities, end users	3
	Legislation Policy plans Budget Procurement	Adjust local Water level agreements	Waterboards, Provinces, Municipalities, end users	3
Social	Belief systems Awareness	Change discourse that government is responsible for freshwater supply	Waterboards, Provinces, Municipalities	5
		Farmers should be more self-supportive in (fresh)water supply	Waterboards, Provinces, Municipalities	4
		Consumer adjust to salt tolerant products	Consumers	5
Economic	Economic activity	Switch to growing drought/salt tolerant crops	Entrepreneurs	1
	Logistic	Emergent new market for drought /salt tolerant crops	Consumers	5
Knowledge	Research programs Simulation/forecasting software tech	Optimization drought/salt tolerant crops	Famers, Knowledge institutes	2

Table 4 | Institutional and socio-cultural analysis of strategy 3 (Current policy → Efficient water use → Land use change)

Domain	Structure	Structure elements of strategy 3	Actors	Governance level of complexity
Institutional	Responsibilities Norms	Shift from government to self-supportive users	Waterboards, Provinces, Municipalities, end users	3
	Legislation Policy plans Budget Procurement	Adjust local Water level agreements	Waterboards, Provinces, Municipalities, end users	3
Social	Belief systems Awareness	Change discourse that government is responsible for freshwater supply	Waterboards, Provinces, Municipalities	5
		Famers should be more self-supportive in (fresh)water supply	Waterboards, Provinces, Municipalities	4
Economic	Economic activity Logistic	Switch to other exploitation of land	Entrepreneurs	1
Knowledge	Research programs Simulation/ forecasting software tech			

In terms of governance, the authors note that strategy 3 may in some way be seen as a *laissez-faire* strategy, but in fact, is based on a rational consideration of costs and benefits. If the costs of fresh water distribution rise up to a point that the costs no longer outweigh the benefits, the discourse might change. In some locations where hydrological conditions are bad and become only worse, this debate is already going on. It is also a matter of justifying tax money. A considerable part of the general water tax is now used to maintain water levels for agricultural purposes only.

Robustness and flexibility

The robustness of the three strategies has been analysed by comparing the structures implied by the strategies with those implied by the four delta-scenarios (Bruggeman *et al.* 2013). These four scenarios (called Steam, Busy, Warm and Quiet) combine climate change with socio-economic changes, in particular possible demographic, economic and spatial trends focusing on the years 2050 and 2100. The authors have analysed how the institutional and socio-cultural structures would change in the four delta-scenarios (Table 5) and where tensions would arise between the institutional and socio-cultural conditions implied by the strategies and those implied by the delta-scenarios. Tension means that the required conditions in the strategy are different from those in the scenario. If tensions were identified, the authors argued that the institutional and socio-cultural robustness decreased. Switching to another strategy might in that case be necessary. Therefore, the authors argued that in those cases the need to keep transfer options open, increased and proceeded with examining how these transfer options could be kept open.

According to the authors' assessment, strategy 1 appears to be quite robust with regard to the scenarios Steam and Busy. Characterized by high economic growth, growing population and heavy urbanization, both scenarios imply having strong needs and sufficient budgets available to invest in the water infrastructure required by strategy 1. In scenario Steam, the government and private parties are willing to invest in water infrastructure in order to safeguard economic activity. In scenario Busy, the underlying motivation is not economically driven, but safety and water supply are seen as a public responsibility. Strategy 1 seemed less robust with regard to the scenarios Warm and Quiet, according to the authors' assessment. These two scenarios have a declining economy. It could well be that in these two scenarios there is insufficient budget available for the costly water infrastructure of strategy 1. However, these scenarios rely strongly on agriculture, which on the other hand implies that investments in fresh water supply are supported. In scenario Quiet, however, there is a shift towards self-supportive communities and away from the

Table 5 | Changes in the institutional and socio-cultural structures implied by the four delta-scenarios

Structure elements		Steam	Busy	Warm	Quiet
Infrastructural	Land use	Urbanization, less agriculture, more nature	Urbanization, less agriculture, more nature	More nature, less agriculture, less urbanization	More nature, less agriculture, less urbanization
	Water	More extremes Less room for water	Less room for water More infrastructure	More extremes More room for water	More room for water
	Infrastructure artefacts	More infrastructure and stronger		Stronger infrastructure	Less infrastructure
Institutional	Responsibilities	Public Private Partnerships	Public authorities	Public Private Partnerships	Public authorities, self-supportive
	Norms	Higher safety norms	Higher safety norms Higher water quality norms	Same norms	Same norms –
	Legislation	–	–	–	–
	Policy plans	–	–	–	
	Budget	Large budget for water management	Large budget for water management	Small budget for water management	Small budget for water management
	Procurement	–	–	–	–
Social	Belief systems	Economy first Government and private parties are responsible for water safety and supply	Sustainability first Government is responsible for water safety and supply	Climate Adaptation first Government and private parties are responsible for water safety and supply	Self-supporting region first Community and Government are responsible for water safety and supply
	Awareness	Support for large investments in water infrastructure	Support for large investments in sustainable water infrastructure	Low support for large investments in water infrastructure	Low support for large investments in water infrastructure. Adaption on local scale
Economic	Economic activity	High, urban	High, urban	Low, agriculture	Low, agriculture
	Logistic	High water demand	High water demand	High water demand	Self-supportive
Knowledge	Research programs	–	–	–	–
	Simulation/ forecasting software	–	–	–	–
	Technology	High tech	High tech	Low tech	Low tech

government as responsible actor for fresh water supply. In such a context, support for the large national investments of strategy 1 seems unlikely.

Strategy 2 seems, according to the authors' considerations, robust with regard to the scenarios Warm and Quiet, but much less robust with regard to scenarios Steam and Busy. In scenarios Warm and Quiet the small budgets imply that farmers have to be highly efficient. In cases where salinization cannot be prevented anymore, farmers are more or less forced to switch to salt tolerant crops. In scenario Warm, where fresh water supply is seen as public service, small investments might be done, but based on cost-effectiveness this would mean that some areas would not be supported. The authors argue that strategy 2 appears to be less robust with regard to scenarios Steam and Busy because of the strong urbanization that pressurizes agricultural land. Farmers will therefore be more tempted to sell their site for a good price than go experimenting with growing new crops and uncertain revenues. On the other hand, the authors point out that in

scenario Busy, with its emphasis on sustainability, new markets for sustainable products could arise quickly.

Strategy 3 seems most robust with regard to all delta-scenarios. According to the authors, more efficient use of fresh water is stimulated in all scenarios and specific sites where problems arise with fresh water supply will undergo land use changes. In Steam and Busy, these sites will be transformed into urbanized areas and in scenarios Warm and Quiet into nature sites.

Based on this particular exercise, the authors argue that since strategy 1 seems to score lowest on robustness, it has the greatest need of keeping options open to switch to one of the other strategies. Switching however, might be very costly. Strategy 1 requires large investments. Once this path is taken, it would be a waste of money switching to other strategies that do not require these investments. The other way around seems to be less expensive. Along strategy 2 or 3 it seems still possible to transfer to strategy 1, which suggests starting out with either strategy 2 or 3. Based on the exercise, strategy 3 seems to be the most robust strategy from the socio-economic perspective of the delta-scenarios. Hence the need to keep options open to switch to the strategies might be smaller here.

Following this, the authors have looked into the governance of keeping open the options to switch from one strategy to another. In Tables 6 and 7 the authors have attempted to identify actions that could be undertaken in the institutional and socio-cultural domain in anticipation of a possible switch from strategy 1 to strategy 2 and from strategy 1 to strategy 3, respectively. The switch from enlarging the water storage capacity in Lake IJsselmeer to reducing water demand implies a shift from water management authorities taking responsibility for fresh water supply towards famers being responsible themselves. Self evidently, such a shift cannot be governed easily to the extent that it is a rather autonomous societal process. Anticipating actions are limited to raising awareness and communication, and preparing the community that responsibilities might change in the future.

Table 8 shows possible anticipative actions to keep open options for a shift from strategy 2 or 3 to strategy 1. According to the authors, one of the anticipative actions could be a regulation to guarantee that new infrastructure, like harbours and wharfs, have dimensions that can cope with the higher water levels of Lake IJssel. Anticipative actions such as making spatial reservations for dike broadening to prevent housing or other economic activity from blocking a switch would be useful as well. In addition, creating awareness by the public that elevating the water level in the future is still an option is another action that could be done in order to prepare the public for a possible switch. Finally, the authors were not able to identify clear anticipatory actions in order to keep the options open for transferring from strategy 2 to 3 and vice versa. This is probably due to

Table 6 | Anticipative actions to keep the option open to transfer from strategy 1 to strategy 2

Domain	Anticipative actions to keep option open to transfer to strategy 2	Actors	Governance level of complexity
Institutional	–	–	–
Social	Creating awareness by the famers that water supply in the future might no longer be the responsibility of the water management authorities	Water management authorities	5
Economic	Prevent investments that take a long time to pay off	Farmers, private companies, banks	1
Knowledge	–	–	–

Table 7 | Anticipative actions to keep the option open to transfer from strategy 1 to strategy 3

Domain	Anticipative actions to keep option open to transfer to strategy 3	Governance level of complexity	Governance level of complexity
Institutional	–	–	–
Social	Creating awareness by the public that other land use is a real option	Local community	5
Economic	Prevent investments that take a long time to pay off	Private companies, Banks	1
Knowledge	–	–	–

Table 8 | Anticipative actions to keep the option open to transfer from strategy 2 or strategy 3 to strategy 1

Domain	Anticipative actions to keep option open to transfer to strategy 1	Actors	Governance level of complexity
Institutional	Make spatial reservations for dike broadening	Municipalities, Ministry of Water Management	2
	Guarantee that new infrastructure (harbors, wharfs can cope with higher water levels)	Municipalities, Ministry of Water Management	3
Social	Creating awareness by the public that elevating water level is a real option		5
	Creating awareness of the crucial role of the IJssel lake in fresh water supply		
Economic	Prevent adverse effects for related economic sectors	–	3
Knowledge	–	–	–

the fact that these two strategies are not too far apart as both already focused on reducing fresh water demand.

DISCUSSION

With this study we have aimed to contribute to the further development of the adaptation pathways approach by introducing the institutional and socio-cultural dimension. These two dimensions have not yet been addressed sufficiently in the approach. Furthermore, we aimed to address the question of governance of adaptation strategies, including actions in anticipation of switching from one strategy to another. In this section we will discuss the results from the case-study analysis. We will try to show how the analysis can contribute to the discussion on robustness and flexibility and to adaptive governance, and how to proceed.

First conclusion we draw is that the ISA-framework is promising in incorporating the institutional and socio-cultural dimensions in the adaptation pathway approach. It shows that the institutional and socio-cultural conditions are indeed important factors to take into account. The analytical exercises described here indicate that each of the three strategies has serious institutional and socio-cultural challenges. Strategy 1 requires local support from the numerous actors that are active near Lake IJsselmeer, though currently local authorities are opposing this. The complexity of the governance in this strategy is high, since many opposing stakes are present and extensive resources are required. Strategy 2 also requires quite some significant socio-cultural changes, which too, cannot be governed easily. The most profound one appears to be the supposed emergence of a consumer market for new agro-food products. Strategy 2, as well as strategy 3, requires a quite fundamental socio-cultural shift with regard to the responsibilities of fresh water supply from government to the users (farmers). Hence, this indicative analysis already reveals some important aspects of these strategies, which so far remained implicit in the original adaptation pathways map (Figure 1). Nonetheless, these are crucial conditions with regard to the actual realisation and governance of these strategies. We conclude, therefore, that this type of analysis does provide us with an enriched and improved representation of the strategies, including the flexibility of switching from one strategy to another, and that it is worthwhile to pursue this strain of research.

The analytical exercises were carried out primarily to illustrate the need to incorporate the institutional and socio-cultural dimension. For the sake of argument, we purposely reduced some of the complexity. The original adaptation pathways map of Haasnoot *et al.* (2012) shows that there are many different adaptation pathways possible within one single strategy, which we deliberately neglected. So the question is to what extent this simplification influences the results. First of all, in the original map there are many more transfer options than we have analysed, which implies a greater flexibility within each strategy than was suggested here. Increased flexibility in turn might lead to a

greater robustness of the strategy itself. It might be so that if we had considered all the different adaptation pathways within one strategy, we might have overestimated the need to switch to other strategies. A second consequence of reducing the actual complexity was that we did not focus on flexible planning or individual adaptation measures. The possibility of accelerating or postponing investments creates flexibility. Due to this, we might have underestimated the flexibility of the three strategies. Since flexible planning is of much interest to policy makers, we specifically suggest in the further development of this approach to include multiple adaptation pathways within one strategy.

Reflecting on the approach, we conclude that the ISA-framework was quite helpful in guiding the analytical exercises with regard to the identification of how specific structures should change. However, we also remark that the elicitation of the required changes remains a matter of subjective interpretation and that the number of experts included in the case is too small to actually draw strong conclusions with regard to the case study. Despite this shortcoming, we do recommend to apply the approach. More specifically, we urge ourselves and others to refine the approach by further objectifying the approach. This could be done though conducting the analysis with a larger number of experts and practitioners with different occupational backgrounds and comparing the various interpretations. We also point out that framework can be used in two distinct ways depending on what is aimed for. The first way in which the ISA-framework can be used is to support participatory (policy) processes by exploring socio-cultural conditions and trigger discussion and raise awareness by stakeholders. The second way in which the framework can be used is to support decision making. Clearly this requires more scientific rigor in the evaluation of the strategies than performed here. Much of the data can be found easily in the law, policy documents, geographic information system (GIS) maps, or spatial planning documents. For some of the cultural structures it may be more difficult. A survey among people working in the field could help to reveal the dominant paradigms and discourses. Further applications in the future should also point out whether some important structures are missing or some could be left out.

On a more fundamental note, the future institutional and socio-cultural conditions are inherently uncertain themselves and therefore pose fundamental limitations to drawing conclusions regarding the feasibility of future pathways based on such exploratory exercises. The exercises performed in this study should therefore not be misunderstood as an assessment of the feasibility of adaptation strategies. Rather, they point out that, from this point of view, different adaptation strategies require different levels of proactive governance to change institutional and social-cultural conditions. Indirectly, we are saying that if we are not aware of that, the feasibility of successfully implementing a strategy is indeed less likely. Hence, it would be helpful to consider these conditions more explicitly when such strategies are being developed.

This research emphasizes that we should not overlook the institutional and socio-cultural structures in the adaptation pathways approach. It also warns us that we should not underestimate the resistance to change in the existing socio-technical regimes. Literature on Transition theory is explicitly concerned with this regime issue (Rotmans *et al.* 2001; Loorbach 2007; Van der Brugge & Van Raak 2007). Regimes are understood as clusters interrelated institutional, cultural and infrastructural structures that 'imply and refer to each other', meaning that adjusting one structure requires the adjustment of interdependent structures. We experience resistance and lack of flexibility if this synchronization does not work (Van der Brugge 2009). The reasons may vary, from opposing stakes and lack of resources to structures operating on different time and spatial scales. The approach presented here is promising in capturing and unraveling this resistance to change.

Another conclusion we draw from this study is that the ISA framework is able to reveal some of the governance challenges that up till now remained implicit in the adaptation pathway approach. Application of the framework increased our understanding of what is required of actors executing the strategy. The governance complexity scale is especially helpful for a quick indication of how difficult it is to change socio-cultural structures. Socio-cultural structures are rarely 'changed' by a single actor, suggesting that we should focus on governance arrangements. By governance arrangement we mean the set of actors, the actions each actor will carry out, the policy instruments that can be used, the available resources and the agreements that are made between them.

We see a great challenge in how to organize adaptive governance arrangements. An adaptive governance arrangement should have the capacity to adequately respond to signals that might require adjustment of the strategy or pathway. An adaptive governance arrangement should feature a continuous feedback loop between external signals and adjustment of the strategy through monitoring system operationalizing 'signposts' and responsive actions as put forward by Walker *et al.* (2001). Literature on adaptive capacity provides us with important clues how to increase this adaptive capacity, such as creating diversity and stimulating learning (for an overview, see Gupta *et al.* 2010). Interestingly, it is quite easy to derive the critical developments and the innovation and knowledge challenges that come with a specific adaptation pathway. In anticipation of future decisions, experimentation with possible innovative solutions should be stimulated much more to ensure adaptive capacity. In this respect there is much to learn from the transition management emphasis on learning and evaluation through experimentation with multiple innovative approaches simultaneously.

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