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Institutional design propositions for the governance of adaptation to climate change in the water sector

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ABSTRACT

This paper provides an evidence-based contribution to understanding processes of climate change adaptation in water governance systems in the Netherlands, Australia and South Africa. It builds upon the work of Ostrom on institutional design principles for local common pool resources systems. We argue that for dealing with complexities and uncertainties related to climate change impacts (e.g. increased frequency and intensity of floods or droughts) additional or adjusted institutional design propositions are necessary that facilitate learning processes. This is especially the case for dealing with complex, cross-boundary and large-scale resource systems, such as river basins and delta areas in the Netherlands and South Africa or groundwater systems in Western Australia. In this paper we provide empirical support for a set of eight refined and extended institutional design propositions for the governance of adaptation to climate change in the water sector. Together they capture structural, agency and learning dimensions of the adaptation challenge and they provide a strong initial framework to explore key institutional issues in the governance of adaptation to climate change. These institutional design propositions support a "management as learning" approach to dealing with complexity and uncertainty. They do not specify blueprints, but encourage adaptation tuned to the specific features of local geography, ecology, economies and cultures.

1. Introduction

While considerable attention has been paid to the mitigation agenda in recent years, it is increasingly recognized that we also need to be planning to adapt to the challenges and opportunities that a changing climate will bring. Managers and policy makers responsible for water and environment related issues are under pressure to respond to the unprecedented impacts of climate change such as larger floods, more severe droughts, sea level rise, coastal erosion, ecosystem degradation and reduction of ecosystem services, water supply shortages, increase and new forms of pollution and water related diseases. Current institutional arrangements are often insufficient to manage these new challenges adequately and innovative and adaptive ways of governing water are required.

Adaptation to climate change is defined by Adger et al. (2005, p. 78) as: "An adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities. Adaptation can involve both building adaptive capacity thereby increasing the ability of individuals, groups, or organizations to adapt to changes, and implementing adaptation decisions, i.e. transforming that capacity into action. Both dimensions of adaptation can be implemented in preparation for or in response to impacts generated by a changing climate."

We know, as yet, little about the 'politics' of how adaptation processes actually work, e.g. in regard to trust building, conflict resolution and the way in which different interests are weighed against each other. This paper builds on earlier empirical work as well as theoretical notions from the literature in order to develop a framework, which relates the notion of adaptation to institutional design principles. It then develops these notions through drawing on experiences from water users and managers in three very

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different case-studies in the Netherlands, Australia and South Africa. Climate change will test not only the resiliency of ecosystems but also the adaptability of individual cities, villages and societies. This is the reality in the Netherlands, Australia and South Africa, which are all confronted by changing flood and drought regimes (Schulze, 2005; KNMI, 2006; Berti et al., 2004).

The paper focuses on policy changes at the national and/or sub-national level, more specifically, on the initiation and development of climate change adaptation strategies for dealing with floods and droughts in the Netherlands, Australia, and South Africa. It is important to acknowledge that the adaptation strategies may not have achieved their projected outcomes yet, since there normally is time-lag between policy development and actual implementation. Nevertheless, for a governance regime to deal with the current and anticipated impacts of climate change it first needs to have a policy or strategy in place. From this perspective, the output of a governance system is not only defined by its physical interventions, but also by means of its management interventions.

The overall objective of this paper is to develop institutional design propositions for climate change adaptation based on comparative analysis of strategy development.

2. Institutional design principles

Research on institutions has not produced many concrete answers to the crucial challenge of how to facilitate necessary institutional change without imposing external blueprints that ignore the intricacies of local conditions (Evans, 2004). Adaptation to climate change represents specific challenges for institutional dynamics – uncertainties, conditions beyond envelope of historical experience and heterogeneous local impacts and capacities to respond. Instead of trying to search for the single, optimal, set of rules we agree with Ostrom on the importance of studying the underlying designs of those real-world experiments that have proved to be robust over time (Ostrom, 1990; Ostrom et al., 2007). For this work Ostrom received the 2009 Nobel Prize in Economics.

Ostrom's approach was to derive design principles from analyzing the management of local, common-pool resources (CPR) like irrigation water. When one member of a group uses a common pool resource it is not available for others in that group and it is possible for members of the group to stop others getting access to it (Ostrom, 1990). She came up with eight design principles: (1) clearly defined boundaries; (2) proportional equivalence between benefits and costs; (3) collective choice arrangements; (4) monitoring; (5) graduated sanctions; (6) conflict-resolution mechanisms; (7) minimal recognition of rights to organize; and (8) nested enterprises.

However, the design principles for sustaining long-enduring, common pool resource systems on a local scale and those for establishing or sustaining a governance system to deal with the impacts of climate change in a complex, cross-boundary resource system may be expected to be distinct for several reasons (e.g. Healey et al., 2003; Rotmans, 2005; Grin, 2006). First, complexity is substantially increased since larger-scale water resources usually must be managed across different time-frames and at different scales (local, regional, national, international). Second, and in contrast to traditional planning for infrastructure, governments and stakeholders at all levels need to be flexible under changing conditions when determining adaptation policies and measures, especially since climate change and its impacts are uncertain (see also Hallegatte, 2009). Third, knowledge about the effectiveness of alternative interventions is incomplete and knowledge that exists, and is important to management, is often dispersed amongst several different stakeholders.

3. Research methods

Our selection of strategies being analyzed is based on earlier work on the comparison of water governance regimes, their adaptation strategies and levels of policy learning (see Huntjens et al., 2008, 2011a,b). With only three cases it is not expected that major generalizations will suddenly emerge but that the contrasts will help to refine the analyses.

The three case-studies are selected because they all have climate change adaptation strategies in place, not only as response to recent disturbances (i.e. floods and droughts), but also to anticipated future disturbances. In all three case-studies this is based on downscaled climate change scenarios and risk assessments, and the governance systems are confronted by changing flood and drought regimes (Schulze, 2005; KNMI, 2006; Berti et al., 2004). The strategies are outputs of extensive policy processes. These policy processes were explored in this paper using the institutional design principles of Ostrom (1990, 2005). Table 1 provides an overview of the key institutional features of the adaptation strategies and policy processes analyzed in the Netherlands, Western Australia and South Africa.

The primary data sources were documents about the process events, water policies and other project plans, and interviews with participants or conveners involved in their preparation, implementation and follow-up. In all three cases the authors were involved as experts during the adaptation process, although the cases were compiled post hoc. For each case study we undertook 10 extensive interviews with experts representing ministries, water authorities, planners, academic institutions and civil society. The interviewees in each case study were selected because they had been closely involved in the process of developing the selected strategy. An effort was made to select a mixture of experts to provide a fair representation of the perspectives on the processes being analyzed. During the interviews we discussed for each design principle the extent to which that specific aspect was similar or different when talking about (the processes of) climate change adaptation in the countries under considerationusing a standardized set of questions (see Annex 1). We used the original design principles of Ostrom (1990) as point of departure for our analyses.

4. Results and discussion

In this paper we provide empirical support for a set of eight institutional design propositions for climate change adaptation in complex governance systems (see Table 2). Before explaining several design propositions in detail we first note that two of the original design principles of Ostrom (1990) were of low relevance in this study and we will briefly introduce two new design propositions.

Compared to the original design principles of Ostrom (1990) there are two principles which have not been explicitly mentioned in our analyses in this section: (I) Minimal recognition of the rights to organize; and (II) Graduated sanctions (see also Ostrom, 2005, p. 259). This does not mean that they are irrelevant, but in our view they do not explicitly characterize the processes for developing adaptation strategies in our specific case studies. In other geographical areas or sectors these two principles might be more directly relevant to climate change adaptation strategies.

We acknowledge, for example, minimal recognition of the rights to organize as a pre-condition for collective choice arrangements (design principle 3). In case the rights to organize are not recognized it might lead to problems with collective choice, consensus orientation and conflict prevention or conflict resolution (design proposition 5).

Table 1
Key institutional features of the adaptation strategies being analyzed in the Netherlands, Western Australia and South Africa.

Key features	Netherlands (NL)	Western Australia (WA)	South Africa (SA)
Key drivers	1993 and 1995: Extreme peak discharges in Rhine and Meuse rivers > Although no dyke breaches have occurred there was a preventive evacuation of 150.000 people; Climate change scenarios predict more extreme peak discharges (WB21 scenarios, KNMI, scenarios) EU policy, in particular the Water Framework Directive (2002)	Perth's Water Future (1995) mentions that WA could move into dryer climate; 1997: Water Corporation decides to use short term instead of long term historical records for planning purposes; Severe droughts in 1998 and winters of 2001–2002	Climate stress, effects of climate change are increasingly noticeable in terms of increasing scarcity and extreme events; International discourse on climate change adaptation; Implementation and capacity are both a problem which is a motivation; Food security is at stake
Focal policy	Room for Rivers policy initiated in 2000, leading towards Spatial Planning Key Decision (PKB) in 2006	Three successive strategies: State Water Strategy (2003); Security through Diversity Strategy (2005); State Water Plan (2007)	SA National Climate Change Response Strategy (2004), including Water Sector Climate Change Strategy (DWA), and National Climate Change R&D Strategy (DST)
Time period	2000–2009	2000–2009	2000–2009
Key objectives	(1) in 2015 the Rhine branches will safely cope with an outlet capacity of 16,000 cubic metres of water per second; (2) the measures implemented to achieve the above will also improve the quality of the environment of the river basin; (3) the extra space the rivers will need throughout the coming decades subsequent to expected climate changes, will remain available	Objective of the State Water Strategy was to ensure a sustainable water future for all Western Australians by: (1) Improving water use efficiency in all sectors; (2) Achieving significant advances in water re-use; (3) Fostering innovation and research; (4) Planning and developing new sources of water in a timely manner; and (5) Protecting the value of water resources	(1) Strategic resource management; (2) Flexibility in water use allocations; (3) Water demand and conservation mechanisms; (4) Contingency planning for extreme events such as floods and droughts; (5) Communication; (6) Optimizing the operation of existing infrastructure and (7) Constructing new infrastructure.
Related policies	Nationaal Bestuursakkoord Water (2003); Vierde Nota Ruimtelijke Ordening Extra (VROM, 1992); National Spatial Strategy ('Nota Ruimte', VROM, 2004); EU Directives (e.g. Water Framework Directive; Habitat Directive; Common Agricultural Policy; Flood Directive)	National Water Initiative (2005); WA Rights in Water and Irrigation Act 1914; WA Planning and Development Act (2005); Environmental Protection Act (1986)	National Water Act (1998); National Water Resources Strategy version 1 (NWRS1) in 2005, and version 2 (NWRS2) in 2009 National Environmental Management Act (1998)
Key responsible authorities	Room for Rivers policy has been initiated by the Ministry of Transport, Public Works and Water Management; Coordinating responsibilities were assigned to provincial level instead of national level	Premier's Office; Department of Water (est. in 2005), formerly known as State Water Department; Water Corporation	Department of Water Affairs and Forestry (DWAF), which is now Department of Water (DWA); Department of Science and Technology (DST)

Table 2
Institutional design propositions for climate change adaptation in complex water governance systems.

Design principle	Explanation
Clearly defined boundaries	Completeness of water-user stakeholders in the adaptation process and clarity about who has rights to use water resources in the case of droughts. In case of floods, clarity about who is affected by this problem and who has the responsibility, capacities, access to resources and information to deal with this problem
Equal and fair (re-)distribution of risks, benefits and costs	Requiring engagement with, and strong representation of, groups likely to be highly affected or especially vulnerable;
Collective choice arrangements	To enhance the participation of those involved in making key decisions about the system, in particular on how to adapt;
Monitoring and evaluation of the process	Providing a basis for reflexive social learning and supporting accountability;
Conflict prevention and resolution mechanisms	Including timing and careful sequencing, transparancy, trust-building, and sharing of (or clarifying)responsibilities;
Nested enterprises/polycentric governance	(In a multi-level context), as functional units to overcome the weakness of relying on either just large-scale or only small-scale units to govern complex resources systems;
Robust and flexible process	Institutions and policy processes that continue to work satisfactorily when confronted with social and physical challenges but which at the same time are capable of changing
Policy learning	Policy and institutional adjustments based on commitment to dealing with uncertainties, deliberating alternatives and reframing problems and solutions

We were unable to identify specific sanctions related to the adaptation processes under consideration. There are two likely reasons. First, exclusion from the process would represent the most severe sanction for a participant, but is avoided by conveners since it would jeopardize the legitimacy of the process itself. Second, graduated sanctions become more important in the phase of implementation rather than in the phase of developing a strategy and plan of measures.

Based on our case studies we propose two additional design propositions that are important for adaptation processes (Table 2): (a) a robust and flexible process; (b) policy learning. Both will be explained in more detail in the section below.

In the following section we will summarize the key observations in each case study; a more detailed description of analyses of individual design propositions in each case study is provided in Huntjens et al. (2011a). Table 3 shows an overview of the key characteristics and examples related to the institutional design propositions for climate change adaptation in the Netherlands, Western Australia and South Africa.

4.1. Design proposition 1 – clearly defined boundaries

For a climate adaptation process Ostrom's first design principle of 'clearly defined boundaries' (1990, p. 259) is slightly different than the originally stipulated presence of well-defined boundaries around a community of users and boundaries around the resource system this community uses (see also Cox et al., 2010). In the case of droughts, it concerns the completeness of water-user stakeholders in the adaptation process and clarity about who has rights to use water resources. In the case of floods, it also concerns completeness of stakeholders, but clarity is more about who is affected by floods and who has the responsibility, capacities, access to resources and information to deal with this problem.

For all case studies the responsibility to deal with flood and drought problems is ultimately vested in government, which can declare a disaster area and through national agencies to allocate resources and delegate responsibilities to provincial and local authorities or agencies. In many cases, regulation and facilitation of bottom-up processes are at least as important for flood prevention, recovery and rehabilitation. From this perspective, the community and resource boundaries are well defined in all case studies. For developing adaptation strategies for both droughts and floods, it is important that tasks, mandates, responsibilities, know-how and capacities, become clearly defined and transparent. However, when dealing with complexity and uncertainty during adaptation it is equally important that these boundaries can be re-negotiated and adjusted if necessary.

At the beginning of adaptation processes in the Netherlands and Australia certain responsibilities and relationships were deliberately left open, allowing boundaries for users, water and other resources to be re-negotiated during the adaptation process (see Table 3). Such situations also illustrate the importance of a robust and flexible process (see proposition 7).

4.2. Design proposition 2 – equal and fair (re-)distribution of risks, benefits and costs

The redistribution of risks amongst rural and urban areas, as well as amongst poor and wealthy people in urban areas, is a central theme of flood politics in many regions. We also know that much of what passes for institutional reform at the basin or State level to reduce risks of disaster might really be about redistributing risk away from central business districts and valuable property, rather than reducing risks to livelihoods of the poorest or most vulnerable (Lebel and Sinh, 2009; Lebel et al., 2011).

As stated by Carr (2008, p. 690): "no adaptation will result in equal outcomes for all", and "the benefits and costs of any particular "adaptation" effort will not be distributed evenly through a social group." However, this does not mean that institutional designs should not strive to achieve a fair and equitable (re-)distribution of risks, benefits and costs. It could prove to be one of the biggest challenges during processes of climate change adaptation.

Both in the Netherlands and Western Australia we have seen examples where stakeholders at risk were given opportunities to participate in reshaping and reducing the risks to which they are projected to be exposed, e.g. in the Noordwaard (in September 2003) and IJsseldelta (in April 2005) in the Netherlands and the local water forums in 2002 in Western Australia. Important decision support tools in the Netherlands and Western Australia where scenario-based approaches, including environmental impact, risk or vulnerability assessments and cost-benefit analyses, which proved to be helpful, amongst others, in handling risks, vulnerabilities and uncertainties. In South Africa equal and fair (re-)distribution of risks, benefits and costs is seen as very much a "first world concept" to be answered in a developing country context, e.g. in a dual economy such as South Africa's, there will always be cross-subsidization from the "haves" to the "have nots". In any case, based on our observations in the Netherlands, Australia and South Africa we argue that reducing the risks of exposure requires engagement (of process owners) with, and strong representation of, groups likely to be highly affected or especially vulnerable. This relates directly to the next paragraphs on collective choice arrangements.

Table 3
Overview of key characteristics and examples related to the institutional design propositions for the governance of climate change adaptation in the water sector in the Netherlands, Western Australia and South Africa.

Principle	Netherlands	Western Australia	South Africa
Clearly defined boundaries	For dealing with floods and droughts (i.e. disaster management) community and resource boundaries are well defined For adaptation processes (including anticipation to perceived disturbances) certain responsibilities and relationships were deliberately left open	For dealing with floods and droughts (i.e. disaster management) community and resource boundaries are well defined For adaptation processes (including anticipation to perceived disturbances) certain responsibilities and relationships were deliberately left open	Community and resources boundaries are not always well defined, amongst others because governance capacity by CMAs is relatively limited Drafting of strategy started within very clearly defined boundaries (by DWAF), but no input from other governmental stakeholders and water sector as a whole
Equal and fair (re-)distribution of risks, benefits and costs	Stakeholders at risk were given opportunities to participate in reshaping and reducing the risks to which they are projected to be exposed Scenario-based approaches proved to be helpful in handling risks and uncertainties, e.g. EIA and CBA	Similar as NL, e.g. in the local water forums in 2002 Extensive groundwater and environmental studies, e.g. to identify the likely impacts of utilizing the Gnangara Groundwater System or South West Yarragadee aquifer > finally decided for climate independent option (=desalinization plant)	Principle seen as a "first world concept" >in a dual economy such as South Africa's, there will always be cross-subsidization from the "haves" to the "have nots" Total cost recovery is unlikely
	Transboundary cooperation: sharing upstream-downstream costs and benefits, e.g. in RHWAP		Strong moral component in NWA (1998) to redress past inequities for the previously disadvantaged groups > main- streamed into the system of water allocation
Collective choice arrangements	Multi-stakeholder dialogues, e.g. stakeholder design sessions in IJsseldelta (in April 2005); Organizational set-up integrated national, regional and local interests, supervised by provincial authorities Formal management track was supported by consultative groups Strong influence of civil society reflected in the key spatial planning decision (PKB, 2006)	Multi-stakeholder dialogues, e.g. 17 public water forums in the Perth metropolitan area and southwest regional areas; Above forums informed the preparation of the State Water Strategy, published by the Government in February 2003; Also the State Water Plan (2007) involved consultation at all levels in the community	Process of stakeholder participation is strongly embedded in the National Water Act + CMAs; However, the CMAs have been slow to evolve and it remains to be seen at what level genuine stakeholder participation will be; Emergent influence of shadow networks on the subject of climate change
Monitoring and evaluation of the process	External evaluation of the Room for Rivers process in 2007; Ministerial statement ensuring that lessons and experiences from evaluation are used for further steps in policy-making and implementation	Monitoring and evaluation processes are embedded in various types of water management plans NWI Implementation Plan is monitored and evaluated by the National Water Commission Irrigation Review informed the governance review, as well as later commitments from the Government, e.g. to sign the NWI	Monitoring and evaluation is more problematic owing to capacity problems and information gaps Some pilots on active involvement of citizens in the local monitoring of water and sanitation services
Conflict prevention and resolution mechanisms	Programmatic approach, including 'decisions for exchange', was important tool for time sequencing; Early and transparent information sharing and communication of uncertainties; Sharing of responsibilities > majority decided to co-operate instead of protest	Forums supported community awareness and knowledge transfer > trust base for State Water Strategy; Centralization of responsibilities; In a later stage, these responsibilities were shared again (but without overlap!); Climate-independent option to deal with droughts removed part of the conflict	Water Tribunal for water conflicts at all levels > its use, however, is relatively limited; Water sharing agreements between countries > but need to be revisited in light of projected changes in flow regimes; Necessity for 'out of the box'- thinking as regards upstream-downstream conflicts
Nested enterprises/polycentric governance	Polycentric governance system was deliberately introduced by means of the National Spatial Planning Strategy (2004);	General purpose jurisdictions at multiple levels with specific departments focusing on water and climate;	Catchment Management Agencies (CMAs) are embedded in general purpose jurisdictions at multiple levels;

Table 3 (*Continued*)

Principle	Netherlands	Western Australia	South Africa
	Shift from a centralized towards a decentralized mode of governance; Water boards (task-specific jurisdictions) are embedded in general purpose jurisdictions at multiple levels	All seven water regions of WA have developed their own regional water plans	Governance capacity by CMAs is relatively limited compared to Netherlands and WA due to capacity problems
Robust and flexible process	Organizational redundancy > facilitating bottom up initiatives and flexibility; Programmatic approach, including pilot projects and 'decisions for exchange'; Integration of national, regional and local interests, being supervised by provincial authorities; Cross-sectoral policy integration Tailormade masterplans for the IJsseldelta, Noordwaard, Overdiepsche Polder, HoekscheWaard, Waalweelde, etc.	Water reform agenda since 1994; WRM separated from water supply functions in 1996; National Water Act 2007 clarified roles in water management; Cross-sectoral policy integration Tailor-made strategies for the Gnangara groundwater system and for the Perth-Peel region	Drafting of strategy started within very clearly defined boundaries (by DWAF), but no input from other governmental stakeholders and water sector as a whole; Opening up of process was crucial for dealing with complexity; Limited sectoral integration Development of (tailormade) adaptation strategies at regional level has just started, but capacity is relatively limited
Policy learning	Dominated by double loop learning, with elements of triple loop learning, e.g. change in regulatory framework + paradigm shift from 'fight against water' to 'living with water' Commitment to dealing with uncertainties Broad and horizontal stakeholder participation Mutual relation between science and policy Policy experiments (e.g. in Avelingen, IJsseldelta Zuid and Overdiepsche Polder)	Dominated by double loop learning, with elements of triple loop learning Commitment to dealing with uncertainties Broad and horizontal stakeholder participation Mutual relation between science and policy Some examples of policy experimentation in the water sector, but not directly related to climate change adaptation	Dominated by double loop learning, with elements of single loop learning (ad-hoc problem solving) Uncertainties are recognized but not translated into policy-making yet. Pilot projects on bottom-up approaches to water services regulation ("Citizens' Voice"), and because of its success being up-scaled to other regions in SA

As a refinement of this design proposition, especially relevant for river basin management and deltaic regions, it is important to consider the sharing of upstream-downstream costs and benefits. Downstream areas in a river basin are being influenced by physical interventions in the upstream areas of the same basin, which may shift the distribution of benefits or involuntary risks from one group to another. Adaptation may even exacerbate injustice, such as when actions in the logic of protecting national assets and interests render some disadvantaged groups even more vulnerable than they were previously (Lebel et al., 2009a). In the Netherlands, Germany and Switzerland the design proposition of sharing upstream-downstream costs and benefits is taking shape under the umbrella of the Rhine High Water Action Plan, in which countries in the discharge basin are implementing appropriate measures, including those described in the SPKD Room for the River. It might also proof an important, but challenging, proposition in the case of South Africa, where hydropower schemes in the highlands of Lesotho (upstream) might be adjusted in order to provide more water to downstream areas (mainly in South Africa) in return for food or other goods.

A recurrent question about climate change is how much time and money does an agency spend preparing for it compared to other pressing and proven needs. In all case-studies concerns with climate change have reinforced and helped drive ongoing work on water resources management. In all case studies there is a focus is on no-regret measures (e.g. dyke reinforcements on weak spots or controlling leakages in water pipes) – actions that yield benefits even if climate were not to change further. In line with the different types of strategies identified by Hallegatte (2009) our case-studies show that safety margin strategies (e.g. raising dikes based on flood risks in the Netherlands) are relatively easy to develop, making infrastructures (preferably in the design phase) able to cope with more water than we currently expect. With relatively low investment costs it makes adaptation measures more robust (Hallegatte, 2009). The "institutionalization" of a long-term planning horizon in the strategies being studied illustrates soft strategies which help to anticipate problems and implement adequate responses (Hallegatte, 2009). The current management and resources systems in all case studies are vulnerable and climate change triggers action that should have been done already in past. This is moving from looking at strategies to deal with individual impacts to more holistic approaches like increasing the adaptive capacity of the system.

4.3. Design proposition 3 – collective choice arrangements

Ostrom (1990) convincingly shows that user communities of a common pool resource have the capacity for self-organization and self-governance and that there are many different viable combinations between the public and private sectors. Involving actors in the design of formal institutions is expected to increase compliance and long-term effectiveness, but this may come at the expense of decreased short-term efficiency since participatory processes are resource consuming (Pahl-Wostl, 2009). Nevertheless, while something is inefficient in the short term the reasons for that inefficiency (e.g. capacity building) may create a more efficient system in the longer term. Social learning processes often take considerable time and money of both water managers and other stakeholders. Hence, social learning processes are more likely to be beneficial when they deal with issues: (1) that are important for (and decided by) stakeholders; (2) different stakeholders depend on each other to reach their goals; (3) when knowledge is incomplete or dispersed amongst different stakeholders; (4) there is little agreement on the problems at stake.

Stakeholder participation and processes of learning do not imply that "everyone" is included but all who are concerned. The same applies to the local level where those who are concerned need to be involved. Given the fact that climate change adaptation is a multi-level process where local measures may provide benefits at other places (e.g. calamity polders, or up-stream–down-stream relations) there is a role for governmental intervention in guaranteeing a transparent and fair process and possibly also to implement benefit transfer schemes.

In South Africa the process of stakeholder participation is strongly imbedded in the *National Water Act*, as it is within the Catchment Management Agencies (CMAs), but collective choice arrangements are just recently becoming introduced in the process of climate change adaptation at multiple levels. In the Netherlands and Western Australia, collective choice arrangements, in particular multi-stakeholder dialogues have been at the center for developing climate change adaptation strategies. Multi-stakeholder dialogues, including social learning processes, negotiation and co-production of knowledge are crucial for adaptation processes and are cross-cutting many of the design propositions discussed in this article. In Lebel et al. (2009b) multi-stakeholder dialogues are defined as "events at which different stakeholders openly engage in facilitated, informed, deliberations". The dialogues in the local adaptation programmes such as IJsseldelta Zuid (The Netherlands) and the 2002 Water Forums (Western Australia) are typical examples of such multi-stakeholder dialogues.[1] The purposes (and values) of these dialogues were: (1) to reduce conflicts and explore synergies; (2) explore alternatives, and; (3) shape and inform negotiations and decisions. The water governance regime in the Netherlands is particularly sensitive for conflicting debates, amongst others by its experience on the "calamity" polders (issued by the Luteijn Committee in 2002), where stakeholder groups were not involved at an early stage and uncertainties were not sufficiently acknowledged. This resulted in persistent controversies in the scientific community and civil society and eventually to a decision by parliament to abandon the idea of "calamity" polders and to find other solutions in providing more room for rivers.

As discussed in design proposition 7 the science-policy interface is an important element of a robust and flexible process, and multi-stakeholder dialogues provide an important tool for facilitating this. During these dialogues it is important to produce outcomes that are directly relevant for planning and decision making. Stakeholders should therefore be involved in analyzing and synthesizing project and process outcomes as well as identifying best practices for governance and implementation.

4.4. Design proposition 4 – monitoring and evaluation of the process

Our case studies in the Netherlands and Australia highlight the importance of monitoring and evaluation as a key institutional practice in interactive governance to provide the basis for reflexive social learning (see also Sanderson, 2002). In reflexive monitoring, agents consciously reflect on the intended and unintended consequences of their own actions, and reflexive monitoring thus may inform strategic action (Grin, 2006, 2010). In the Netherlands (e.g. the external audit by Berenschot and Delft Technical University in 2007) and Western Australia (e.g. the Irrigation Review and Water Governance Review in 2005) monitoring and evaluation has clearly contributed to an improved understanding and in some instances to an adjustment of the course of action, for example in the water reform process in Western Australia. While the Irrigation Review (2005) produced 59 overall recommendations, it also outlined nine key directions

[1] For a more detailed analysis of the multi-stakeholder dialogues in IJsseldelta-Zuid (Netherlands) and the 2002 Water Forums in Western Australia, see Lebel et al. (2009a,b).

which the State Government has supported. The Government Response (Government of Western Australia, 2005) formed the basis for the Water Reform Program and included the establishment of a Water Reform Implementation Committee to provide advice to Government on the implementation of key directions. Monitoring and evaluation in South Africa is more problematic owing to capacity problems and information gaps.

The process of evaluation and monitoring serves to adjust the course of action and motivate those driving the processes. During the process of climate change adaptation, actions and objectives can then be adjusted based on reliable feedback from the monitoring programmes and improved understanding (Nyberg, 1999). An entirely new element of monitoring, in both the Netherlands and Western Australia, refers to the quality of the communication process in actor networks, and the appropriateness of a chosen institutional setting (see the Berenschot evaluation (2007) in the Netherlands and the Governance Review (2005) in Western Australia).

4.5. Design proposition 5 – conflict prevention and resolution mechanisms

Based on our empirical analysis we found that both conflict prevention as well as resolution mechanisms were being used. The latter is illustrated in Western Australia where the roles of water service providers were separated from water resource managers (on 1-1-1996). The objective of this change was to ensure that water resource management took into account all water needs and that allocations were not subjectively biased towards public water supply. This was a fundamental change to organization and human relationships which took some time to resolve during the late 1990s and early 2002. A series of water forums and Premier's Water Symposium in 2002, the State Water Strategy, the establishment of a Ministerial Water Council, a new Office of Water Strategy in the Department of Premier and Cabinet and the Premier taking responsibility for water were all important steps in resolving the institutional issues in water management in Western Australia. Besides these examples, it was difficult to identify specific conflict resolution mechanisms, a design principle mentioned by Ostrom (2005), possibly because measures are not yet implemented or serious conflicts were prevented by means of effective conflict prevention mechanisms. Based on our observations we can state that conflict prevention and resolution mechanisms can take many forms, often more implicitly than explicitly. In some cases a reframing of (initially conflicting) interests was often necessary to identify solutions, such as the climate-independent option of desalinization in Western Australia. It is also interesting to note that investing in conflict prevention during policy development (e.g. by means of time-sequencing (see proposition 7 for a more detailed discussion), transparency and trust-building in the Netherlands) might be more cost- and time-efficient than investing in conflict resolution mechanisms. The latter might be especially expensive when it comes to litigation or lawsuits (often resulting in costly delays) during policy implementation.

4.6. Design proposition 6 – nested enterprises/polycentric governance

When common-pool resources are larger and more dynamic, as in the case of (transboundary) river basins or groundwater systems, and involve multiple stakeholders, an additional design principle tends to characterize robust systems, viz. the presence of governance activities organized in multiple layers of nested enterprises (Ostrom, 2005, p. 269). By doing so, these systems have tried to overcome the weakness of relying on either just large-scale or only small-scale units to govern complex resources systems (Choe, 2004; Ostrom, 2005; Swallow et al., 2005; Kerr, 2007). According to Ostrom (2001, p. 2) "polycentric systems are the organization of small-, medium-, and large-scale democratic units that each may exercise considerable independence to make and enforce rules within a circumscribed scope of authority for a specific geographical area". Adaptive management suggests that there should not be one single center of power, but a system dividing power to multiple centers, or a polycentric governance system (Lebel et al., 2006).

Based on our empirical analyses we can conclude that adaptation in water governance systems in our case studies involved polycentric institutional arrangements (see Table 3 for examples). In the Netherlands and South Africa there are nested quasi-autonomous decision-making units (water boards and catchment management authorities respectively) operating at multiple levels, while Western Australia shows general purpose jurisdictions at multiple levels with specific departments focusing on water and climate. In the process of developing adaptation strategies the responsible decision-making units in all case studies involve local, as well as higher, organizational levels and aim at finding a balance between decentralized and centralized control (Imperial, 1999; Huntjens et al., 2010). Hence, multi-level systems, cross-scale interactions and networks that connect individuals, organizations, agencies, and institutions at multiple organizational levels seem to be crucial for climate change adaptation (see also Adger et al., 2005; Olsson et al., 2006; Kok and de Coninck, 2007).

4.7. Design proposition 7 – a robust and flexible process

Ostrom's design principles do not refer to changing rules and adapting to new circumstances but rather to the characteristics of system in place. We propose that a robust and flexible adaptation process is an important, additional, requirement for climate change adaptation based on our observations in the case studies and wider considerations (Hallegatte, 2009; Palmer et al., 2008). By robust and flexible we mean institutions and policy processes that continue to work satisfactorily when confronted with social and physical challenges but which at the same time are capable of changing (Anderies et al., 2004; Lebel et al., 2006; Janssen et al., 2007; Dovers and Hezri, 2010)

One of our key observations is that during adaptation processes in the Netherlands and Australia certain responsibilities and relationships were deliberately left open, resulting in a robust and flexible process. This was apparent in overlapping mandates. Miranda et al. (1995) provide evidence that the deliberate introduction of redundancy can improve organizational and system performance. In our case studies, this organizational redundancy provided stakeholders more room to find their appropriate position and role during the process, and at the same time allowed for these positions and roles to change when necessary (see also Berenschot, 2007). This flexibility resulted, for example, in bottom-up initiatives for establishing national and regional committees, representing important local stakeholders.

Another important element which supported the robustness and flexibility of the process in the Netherlands was a programmatic approach, including pilot projects and so-called 'decisions for exchange' ('*inwisselbesluiten*' in Dutch). These 'decisions for exchange' means that specific projects might be adjusted or replaced by better alternatives in a later stage of the process. In other words, the Room for River process offers the flexibility to include new initiatives when they apply to the boundary conditions. This approach provided 'more leverage for decision-making' (Berenschot, 2007), and was a crucial instrument for avoiding delays in the decision-making process and for realizing the program's objectives.

Building trust is an important element of a robust and flexible process. In the Netherlands this included proper expectation management by providing participants (including citizens and farmers) a clearly defined and realistic scope of what to expect during the adaptation process, for example in the Noordwaard, one of the focus areas in the Room for Rivers process. Inhabitants of the Noordwaard expected clarity on the settlement of damages, since it was likely that a substantial number of houses and farms would need to be removed, and the owners would need to build a life elsewhere. When process owners were promising more than they could deliver then as a direct result the support from citizens and farmers would diminish drastically. At the same time, it was crucial that inhabitants of the area still had something to choose during the process. This is the big challenge of stakeholder participation: providing enough room for ideas and wishes from the local stakeholders, while at the same time providing them with a realistic and politically defined scope. Looking forward, trust is also likely to be important to further evolution of strategies and taking alternative actions as new knowledge becomes available.

The Noordwaard example illustrates a key challenge for policy-makers, that is, how to best integrate important 'bottom-up' processes with 'top-down' high-level policy strategies and visions. It is clear that a 'one-size-fits-all' approach for adaptation is not appropriate for the complexities of climate change (McEvoy et al., 2010). Strategies should stimulate and support pro-active adaptation responses, while retaining the flexibility and robustness necessary for enabling the development, testing and implementation of measures at the local scale (McEvoy et al., 2010). In the Netherlands the integration of national, regional and local interests, being supervised by provincial authorities, was a direct result of a decision by the Dutch Parliament in 2000 to establish an organizational set-up called ''central-decentral interwoveness'' (Berenschot, 2007), and according to an external evaluation it was one of the success factors of the Room for Rivers policy (Berenschot, 2007).

Robustness may be enhanced by cross-sectoral policy integration or 'mainstreaming adaptation' because it reduces the incidence of large adverse side-effects and feedbacks or 'maladaptation' (Dovers and Hezri, 2010). The multi-level complexities of climate change adaptation make integration challenging. In South Africa the sectoral integration is limited by lack of cooperation and coordination amongst government agencies even though the National Environmental Management Act is supposed to guide such integration. In the Netherland and Western Australia we noted a substantial effort to mainstream climate change adaptation by means of cross-sectoral policy integration, requiring the consideration of adaptation through existing institutional mechanisms. This is not easy: for example, innovative flood management in the Netherlands requires a strong coordination with spatial planning and agricultural policy.

The projected impacts from climate change can differ significantly amongst adjacent areas for many reasons, including water resources, socio-economic circumstances, specific institutional arrangements, and local capacities. In our case studies we have seen that adaptation processes involved the development of tailor-made arrangements (e.g. the IJsseldelta Masterplan in the Netherlands, the Perth-Peel Regional Water Plan in Western Australia and the Western Cape Climate Change Strategy and Action Plan in South Africa) which, inter alia, take into account situational conditions regarding the content of the issues, relationships with other sectors, and commitments. A flexible institutional framework avoids 'one-size-fits-all' prescriptions allowing solutions to be developed appropriate for local contexts.

One of the key challenges of adaptation processes is related to the timing and sequencing dilemma (Pierson, 2000; Haug et al., 2009), including questions concerning whether to act early or to postpone action, but also the timescale over which policy should be introduced, and the dangers of becoming 'locked in' to inappropriate policy pathways. All case studies in this research are confronted with timing and sequencing dilemmas since their climate change adaptation policies (no matter in which stage of development) are characterized by long time horizons and great uncertainty over potential costs and benefits of different courses of action. Any adaptation action can create unintended impacts on other natural and social systems. In practice, there may be considerable uncertainty over the impact of an adaptation action. In some cases the impact may be clear and immediate, and past experience may be a very useful guide. In other cases, for example where the action is innovative, the consequences may not be known (Adger et al., 2005).

A programmatic or portfolio approach might be an important tool for time sequencing, by including proxies for longer-term objectives whose achievements are contingent on more immediate objectives being met (Wilson and McDaniels, 2007). In the context of the Room for Rivers process, for example, a programmatic approach involved near-term objectives for adaptation alongside objectives which characterize an improved capacity or ability to address adaptation in the long-term (see also Keeney and McDaniels, 2001). This avoided biasing the selection of alternatives towards those that provide immediate gains. Indeed, an important lesson of successful and adaptive management strategies is the importance of avoiding low-probability but high-consequence outcomes in the long term, even though immediate outcomes may be suboptimal (Gunderson and Holling, 2002). In the Netherlands it meant that spatial requirements for the long-term accommodation of major floods, as a result of expected climate changes, will remain available. All measures to be implemented in the short term need to be consistent with this long-term view. The type of solutions sought are those which can work in a range of future conditions, or ones which can be successively adjusted and corrected as new knowledge is gained. Such a flexible framework is necessary since various alternatives are, or will become available at a later stage.

4.8. Design proposition 8 – policy learning through exploring uncertainties, deliberating alternatives and reframing problems and solutions

In addition to the working hypotheses of Ostrom we have assessed the level of policy learning in the case studies. Huntjens et al. (2011b) shows that higher levels of policy learning lead to more advanced adaptation strategies. Policy learning is defined by Hall and Peter (1988, p. 6) as a 'deliberate attempt to adjust the goals or techniques of policy in the light of the consequences of past policy and new information so as to better attain the ultimate objects of governance'. It is important to take into account that learning takes place at different levels beyond just refining established actions or single-loop learning (Fig. 1; see also Argyris, 1999; Hargrove, 2002).

Table 4 presents an overview of key variables and qualitative assessment of policy learning in our case studies. Our key objective was to determine the dominant level of policy learning observed during development of climate change adaptation strategies in the Netherlands, Western Australia and South Africa (see also Huntjens et al., 2011b). Our assessment shows that adaptation processes in the Netherlands and Western Australia were predominantly characterized by double loop learning, although elements of triple loop learning have been observed as well. Climate change adaptation in South Africa is characterized by a combination of single loop and double loop learning (Huntjens et al., 2008, 2011b). The Room for Rivers-policy clearly shows some elements of triple loop learning, such as a change in the regulatory framework (i.e. the Spatial Planning Key Decision in 2006), strong

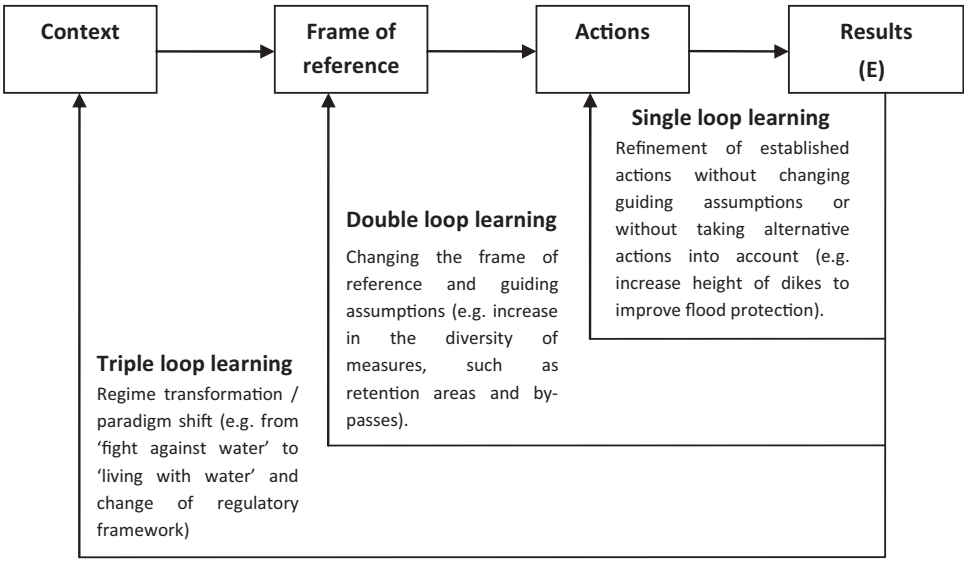

Fig. 1. Triple loop learning concept derived from Hargrove (2002), and adjusted by Huntjens et al. (2011b). Reproduced by permission of Hargrove (2011).

involvement of civil society, taking into account uncertainties, and last but not least, a change in paradigm from "fighting against water" towards "living with water". The clear influence from civil society on policy making is being reflected, amongst others, in the "Advice to the parliament as regard the PKB Room for Rivers by nine civil society organisations" (LIRR, 2003). This advice was for a large part incorporated in the final plan. Moreover, the Room for Rivers-policy involves entirely new management measures and new physical interventions (see Table 4).

In general, we can state that during processes of climate change adaptation policy learning is achieved by exploring uncertainties, deliberating alternatives and reframing problems and solutions. These elements of policy learning will be briefly discussed in below paragraphs.

An important element of policy learning in our case studies is a commitment to dealing with uncertainties, which is often related to trust as well (Isendahl et al., 2009, 2010). For example, transparent and early communication of uncertainties contributed to trustworthiness and learning processes in the Netherlands and Western Australia specifically. Also the sharing of responsibilities in the Netherlands (see design proposition 5) was an important way of dealing with uncertainties, but also for building trust. Dealing with uncertainty means that uncertainty is addressed openly in a transparent and accountable manner. For example, in our case studies in the Netherlands and Western Australia an important step was to acknowledge the major uncertainties related to climate change, and to describe the uncertainty in quantitative or qualitative terms, for example by developing climate change scenarios leading to 'possible futures', not 'probable futures' as in statistical analysis. These scenarios have to be downscaled to the level of the system that has to be adapted to climate change. Future climate uncertainty was recognized early in Western Australia and included in the Perth Water Future Plan in 1995. Water supply sources were derated through the 1990s in response to real reductions in availability and anticipation that these reductions were likely or could continue. There was a conscious shift from using the long term (100 years) average rainfall and streamflow data for planning purposes towards an acceptance of shorter term data (firstly the last 30 years and then the last 8 years) as the basis for planning.

For deliberating alternatives and reframing problems and solutions three specific mechanisms stand out: (a) horizontal and broad stakeholder participation; (b) mutual relation between science and policy; (c) policy experimentation. The first element has already been discussed under design proposition 3 (Collective choice arrangements). As regards the science-policy interface, the adaptation processes in our case-studies were characterized by a twofold ambition of developing practically relevant and scientifically sound knowledge. In our case-studies this was facilitated amongst others by the Indian Ocean Climate Initiative in Western Australia, the Water Resources Commission in South Africa and several science-policy commissions in the Netherlands. Transdisciplinarity (involving academic AND non-academic participants) as a science-policy approach was an important contributor to the learning processes in the Netherlands and Western Australia, as it was to a lesser extent in South Africa by means of interdisciplinarity (only involving academic participants).[2]

Policy experimentation in our case studies played a supportive role in expanding horizons to find solutions and for adapting to new circumstances (for examples see Table 3). In most cases it was a coordinated activity, involving experts, stakeholders, ordinary citizens and policy makers in a process of collective discovery. Policy experimentation is not equivalent to freewheeling trial and error or spontaneous policy diffusion; it is a purposeful and coordinated activity geared to producing novel policy options that are injected into official policymaking and then replicated on a larger scale, or even formally incorporated into national law (see Heilmann, 2008). However, policy experiments can be difficult to initiate since the results of experiments do not always lend themselves to clear-cut policy choices, and results may appear when the policy makers who initially asked for them have disappeared from the political scene (Sanderson, 2002). However, experiments can be an effective way of loosening up policy systems, so creating space for innovations (Huitema and Meijerink, 2009). Policy experimentation is a relatively new concept in all case studies. In the Netherlands it has been used specifically for management experiments in climate change adaptation. For example, near Avelingen a management experiment was initiated in 2007 to test how decision-making on flood management might be accelerated by means of timely involvement of stakeholders

[2] For a more detailed discussion of concepts such as multidisciplinarity, interdisciplinarity and transdisciplinarity we refer to Hinkel (2008) and Balsiger (2004).

Table 4
Overview of key variables to determine the dominant level op policy learning during the development of climate change adaptation strategies in the Netherlands, Australia, and South Africa. The outcomes of these adaptation strategies are largely unknown at present. Most of them have only recently been introduced and there has not been enough time to test their appropriateness and effectiveness.

	Room for rivers, Netherlands	Western Australian drought strategies	South African strategies
Most important driver(s) to initiate strategy development	1993 and 1995: Extreme peak discharges in Rhine and Meuse rivers	Perth's Water Future (1995) mentions that WA could move into dryer climate	Climate stress; effects of climate change are increasingly noticeable in terms of increasing scarcity and extreme events – international discourse on climate change adaptation
		1997: Water Corporation decides to use short term instead of long term historical records for planning purposes Severe droughts in 1998 and winters of 2001–2002	
Entirely new management measures	Central/decentral co-management (State as facilitator/controller > objectives and terms of references; Regional/local authorities > advice and development of measures)	A portfolio-style approach, being less reliant on engineering solutions to water supply and more reliant on community participation and contribution than previous approaches	A range of management options, old and new is currently being discussed – their implementation has not yet been decided
	Fall-back option of traditional protection caused positive pressure to search for innovative approaches	Reuse targets	
	Pilot projects, programmatic approach and decisions for exchange	Water trading (is an important tool, but just a tool)	
	Informal process included translating knowledge to decision makers/trust building/consensus orientation	Generating shared visions of a desired future for inter-jurisdictional water management	
	Robust and flexible process by: organizational redundancy, bottom up governance, linkages with other issues, flexibility, commitment of decision makers	Rebate Program (e.g. 3A washing machine, dual flush toilets)	
		Guidelines for saving water for all sectors	
Entirely new physical interventions	Retention areas	Government built a 45 GL/year seawater desalination plant to provide a major climate independent water source for the integrated water supply system	Mostly independent from a climate change adaptation strategy, further upgrading and expansion of dams to allow further development of water-intensiveindustries is on the way
	Green by-passes/High water channels Numerous dyke replacements Dwelling mounds ("*Terpen*") in *Overd. Polder*		
Structural constraints being addressed	Financial constraints addressed by ad-hoc Financial Commission (FiKa) to tackle financial constraints, but also by *Van Lith/Boelhouwer* motion to Parliament to re-allocate money from the rejected plan for emergency polders to the budget for Room for Rivers	Water reform agenda by formation of Department of Water (2005). Other commitments were the first State Water Plan (2007) and a framework of Strategic Regional Water Plans (on-going)	Lack of skills to effectively address climate change in South Africa is probably the most relevant constraint, however only addressed to a limited extent at the moment
		1996: Separation of the roles of water service providers from water resource managers	Former regulatory framework will most likely be maintained, however more emphasis will be placed on implementation of already existing policies
	Political constraints addressed by building commitment and trust of decision makers by translating knowledge; building trust between local stakeholders and decision makers	Improving institutional and human relationships by Water Forums in 2002, State Water Strategy, Ministerial Water Council, a new Office of Water Strategy in the Dept. of Premier and Cabinet and the Premier taking responsibility for water	
	Institutional/legal framework: Key Decision Spatial Planning (2006) > creating a legal mandate for climate change adaptation in Dutch river basins	Strong political response resulting in institutional reform, funding for water resource management and commitments to legislative reform	
Uncertainties being recognized/addressed	Strategy based on climate change scenarios	Future climate uncertainty was recognized early in Western Australia and included in the Perth Water Future Plan in 1995	Detailed downscaling of the IPCC scenarios
	Uncertainties in transboundary collaboration recognized and addressed by *Arbeitsgruppe*		

Table 4 (*Continued*)

	Room for rivers, Netherlands	Western Australian drought strategies	South African strategies
	Technical experimentation to reduce incomplete knowledge (e.g. impacts of lowering groynes near Beuningen)	Conscious shift from using the long term (100 years) average rainfall and streamflow data for planning purposes and an acceptance of shorter term data (firstly the last 30 years and then the last 8 years) as the basis for planning	Uncertainties are being recognized in the framework of several studies; more and more precise models of the impact on climate change on water resources are currently being developed
	Policy experimentation on different management styles (e.g. *Avelingen*, *IJsseldelta* and *Overdiepsche Polder*)		
Changes in the actor network	Coordinating responsibilities were assigned to provincial level instead of national level	Consultation at all levels in the community: Public forums are now an integral part of the process: a whole program to keep the public involved. Understanding that demand-management only could be done by more public involvement	Rather than fundamental changes in the actor network, the networking of responsible actor, i.e. government departments at different levels is currently undertaken
	Civil society organizations were involved more explicitly, e.g. LTO, ANWB and environmental NGOs	Local government (councils) shifted positions, became bigger player (their constituency is demanding it; not only planner, but also a major water user)	
	Private parties for sand exploitation and for housing and infrastructure development have become more involved	Mining sector, commerce and industry, irrigators, and social services all became more active in response to community concern about water issues	
	More public involvement, e.g. by citizens, farmers, but also by media		
How does new information enter the policy-making process	By formal Commissions, e.g. on emergency polders (Luteyn, 2002), finances (FiKa, 2005)	By formal committees, e.g. Indian Ocean Climate Initiative	By formal committees, e.g. Water Resources Commission
	Environmental Impact Assessments (2005) and Cost-Benefit Analyses (2005)	In 2005 there was a major science-policy forum, including climate change adaptation	Efforts are under way and funded to enhance research efforts to better understand the impact on climate change in South Africa – the DST has launched considerable research efforts in this regard
	Informal network (translation of knowledge to policy- and decisionmakers), and strong civil society involvement, e.g. ''Meer waarden met eenrobuusterivierruimte'' (LIRR, 2003)	The State Water Plan (2007) involved consultation at all levels in the community to ensure that stakeholders and water users throughout Western Australia	
	National Research Programmes, e.g. Living with Water, Knowledge for Climate, Room for Climate, etc.	Regional Strategic Water Planning, Water Allocation Planning and Water Supply Planning processes all provide opportunities for community and stakeholder participation	
New norms and values	Paradigm shift from ''fight against water'' towards ''living with water''/''room for rivers''	First health, economy, and crime were the major political issues, suddenly water came in (2000/2001). Nowadays it means losing an election when politicians don't take care of water problems.	South African water policy in principle based on the paradigm of IWRM; additional changes will be integrated to foster a more adaptive water management approach
	EU norms have become more dominant, e.g. river basin management planning, good ecological status of water bodies, public participation requirements, etc.	However, some people are (still) expecting one single solution as longterm planning, instead of portfolio approach. Strong recognition in all water organizations of the importance of community participation to immediate water decisions and to capacity building for the long term.	
Dominant type of learning	Double loop learning + some elements of triple loop learning	Double loop learning, including elements of triple loop learning	Combination of single loop and double loop learning

'The State's primary water legislation is the Rights in Water and Irrigation Act 1912. A legislative reform process which aimed to update and consolidate the numerous pieces of water resources legislation into one Bill, and numerous pieces of water service legislation into one other Bill was commenced but has not yet been completed. There was a change in Government in September 2008 and the legislation is now on hold awaiting policy direction.

(Ministerie van Verkeer en Waterstaat, 2008); In South Africa examples of policy experimentation were only within the context of water services regulation and in Western Australia for sustainable urban development (see Table 3). An important measure is at least to have agencies at least review impacts of their policies and other interventions even if they were not designed as formal experiments.

5. Discussion and conclusion

Based on our observations we argue that there is a need to distinguish between design principles for sustaining long-enduring, common pool resource systems on a local scale (based on Ostrom, 1990, 2005) and design principles for adaptation to climate change in complex, cross-boundary and large-scale resource systems. In our case studies the jurisdictional and geographical scale, complexity and uncertainty related to the policy problem were large. In these situations more attention is needed to institutions that facilitate systemic learning processes. Our argument is supported by our empirical analyses in the Netherlands, Western Australia and South Africa.

In this paper we proposed and found empirical support for a set of eight institutional design propositions for climate change adaptation in complex water governance systems (see Table 2). The propositions provide useful support for a "management as learning" approach when dealing with complexities and uncertainties. Management as learning is an important notion in this respect, since Huntjens et al. (2011b) shows that higher levels of policy learning lead to more advanced adaptation strategies. These strategies are characterized by: (1) a robust and flexible process; (2) polycentric, broad and horizontal stakeholder participation; (3) climate change scenario analyses; (4) risk assessments; (5) high diversity in management and physical interventions; (6) dealing with structural constraints of the management system itself. The propositions supporting this management as learning approach do not foster a narrow blue-print style but rather the opposite, namely locally-appropriate institutions treated as experiments.

The design propositions have several potential uses in practice. First, decision-exploring, decision-making and evaluating steps at different levels of governance can be made more adaptive. In this type of application the design propositions can be seen as diagnostic tools rather than blueprints for institutional reform. The specific solutions are almost always very highly context dependent.

Second, the propositions should be useful for exploring new, and refining existing adaptation strategies, by focusing more attention on their governance – in particular how decisions about particular strategies are reached and not just their technical content. This can help overcome the frequent neglect of power relations and interests in the making of "adaptation" policy. Hence, the institutional design propositions are not meant to establish individual adaptation decisions, but to develop a coherent adaptation strategy, i.e. a portfolio approach in which a range of different physical and management interventions are deliberated upon.

Third, the propositions may be useful to not just planning agencies and processes of governments but also community-based organizations and the private sector interested in working with other stakeholders in pro-active approaches to adaptation. Several of the roles implied by the design propositions may be taken up effectively in some situations by non-state actors and multi-stakeholder bodies.

The initial set of design propositions suggested need further testing and elaboration. In particular issues of generalizability and trust building deserve further exploration. The design propositions presented here arose from explicit consideration of water management challenges in the context of a changing climate. It is not yet clear to what extent these findings are generalizable to adaptation in the water sector in less developed country contexts or to other sectors.

5.1. Trust building

Trust building is clearly important to collective action and thus an important component of several design propositions. More work is needed on how trust is built starting with areas that this paper suggests, such as: early communication of uncertainties, joint/participative knowledge production, open access to, and shared information sources, transparency about the decision-making process, and sharing of responsibilities. Transparency and trust-building are closely related (Abrams et al., 2003) and special attention is given to the role of leaders who are able to provide key functions for adaptive governance such as "building trust, making sense, managing conflict, linking actors, initiating partnership among actor groups, compiling and generating knowledge, and mobilizing broad support for change" (Folke et al., 2005, p. 451).

It is obvious that building trust becomes more challenging when the number and intensity of stakeholders participating becomes higher, and when complexity and uncertainty increases. In this case sources of legitimacy become more important to maintaining trust as not everything can be done through individual connections and interactions. Trust building and legitimacy are therefore major issues during climate change adaptation, especially since it could make the difference between stakeholders opting for confrontation or cooperation.

When comparing the case studies the element of trust building was found, often implicitly, in a variety of ways. For example, in the Netherlands the sharing of information at the right time during the process supported trust between stakeholders and trust regarding the process itself. Also transparency, by providing stakeholders with a clearly defined scope of what to expect during the process, was an important way of building trust about the process. In Western Australia the public water forums supported community awareness raising and knowledge transfer. As participants developed their understanding of the issues, complexity and environmental footprint, they became more supportive of Government action. These forums built considerable trust on which to first develop and then implement the State Water Strategy actions. Furthermore, monitoring and evaluation (design proposition 4) are considered important for increasing accountability, and thus building the trust that those who are responsible are also held accountable.

5.2. Interdependency of design propositions

Interdependence amongst institutional design features covered by the propositions was common. For example, when a case study is characterized by a polycentric governance system, including horizontal and broad stakeholder participation, design propositions such as a robust and flexible process, collective choice arrangements and conflict resolution mechanisms will be based on a high level of stakeholder participation (see also Huntjens, 2011). However, one cannot expect that design and implementation of adaptation strategies will be based on a full understanding of the interaction between institutional design features. Some of them are emergent and path-dependent, and will unfold during the adaptation process. Hence, the whole process of adaptation has to be regarded as a systemic learning process as well. From this perspective, the design proposition on policy learning is related to all design propositions which facilitate learning processes, in particular design propositions 3, 4, and 7. This is again directly related to a high level of stakeholder participation in a polycentric

governance system. Interdependence between different elements of a water governance system has been mentioned as a stabilizing factor of current governance systems and also a reason for lack of innovation (Pahl-Wostl, 2007; Huntjens et al., 2010, 2011b). One cannot, for example, move easily from top-down to participatory management practices without changing the whole approach to information and risk management and collaboration structures. On the other hand, the significance of interdependence is that one coordinated action may have multiple benefits, that is, be able to deal with several different types of challenges simultaneously.

5.3. Concluding comments

Successful governance of adaptation to climate change depends on enabling and supporting adaptive institutions that are able to cope with complexity and uncertainty in the face of new challenges and possible surprises (Pahl-Wostl, 2002; Huntjens et al., 2011b; Pahl-Wostl, 2009). In order to adapt to new situations institutional arrangements are required that are flexible and encourage reflection, learning and innovative responses to often very specific local capabilities and needs. A certain degree of redundancy and experimentation also appears to be important. Learning processes and trust building are critical to exploring uncertainties, deliberating alternatives and reframing problems and solutions. If one was to identify an overarching frame for institutional design propositions for climate change adaptation it might be called '*mechanisms for facilitating social learning and policy learning*' (Huntjens et al., 2011b).

Such learning mechanisms include collective choice arrangements, policy experimentation, conflict resolution mechanisms, monitoring and evaluation of the process, and nested enterprises. All of them are important institutional arrangements for facilitating multi-level learning processes (Huntjens et al., 2011b; Pahl-Wostl, 2009). Huntjens et al. (2011b) has labeled the totality of such learning environments as the socio-cognitive dimension of a governance system. In particular, better integrated cooperation structures and advanced information management are structural conditions leading towards higher levels of policy learning in river basin management (Huntjens et al., 2011b). Hence, in order to achieve institutional adaptation, certain elements need to be focused on, including adequate access and distribution of information, collaboration in terms of public participation and sectoral integration, flexibility and openness for experimentation (Huitema et al., 2009; Huntjens, 2011).

Our research has shown that one important element of climate change adaptation is the governance structure, and specifically the manner in which institutional design propositions support adaptation processes at different levels. However, further research is needed to assess the capacity of institutions to adapt to climate change and the way in which institutional arrangements can enhance that capacity. Furthermore, it is important to identify and assess the capacities of these institutional arrangements in diverse settings, since adaptation must be finely tuned not only to the specific features of local geography and ecology, but also to local economies and cultures.

Our comparative study had several important limitations. Only three cases were examined. The cases were compiled post hoc. For simplicity we selected as units of analysis one or a tight cluster of closely related events as a focus of our analysis of the processes. In practice all of these 'cases' were part of a much larger and less coherent collection of activities, meetings and networking that might constitute a process for strategy development. A more historical, long-term, analysis of individual cases was beyond the scope of this analysis but undoubtedly would reveal further insights about the building of trust and dynamics of relations, and changing understanding of actors involved. Another important limitation was that effectiveness was not systematically assessed. In other words, to what extent the design propositions contribute to climate change adaptation is not entirely clear yet, since the outcomes of the adaptation strategies being studied are largely unknown at present. Most of these strategies have only recently been introduced and there has not been enough time to test their long-term appropriateness and effectiveness in relation to their institutional arrangements. It does not mean however that there are no tangible outputs for the governance systems being studied. For a governance regime to deal with the current and anticipated impacts of climate change it first needs to have a policy or strategy in place, either for flood protection or drought resilience, or for both. From this perspective, the output of a governance system is not only defined by its physical interventions, but also by means of its management interventions. The three case-studies are selected because they all have climate change adaptation strategies in place, being defined as outputs of extensive policy processes.

The set of 8 refined and extended institutional design principles proposed here provide a strong initial framework to explore key institutional issues in the governance of adaptation to climate change. Together they capture structural, agency and learning dimensions of the adaptation challenge. Further testing and refinement of these propositions should lead to improved diagnostic capacity to design policy processes that lead to better climate change adaptation strategies and actions in many common water resource management situations.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.gloenvcha.2011.09.015.

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