Chapter 1
Addressing Water Governance Challenges in the Anthropocene

Abstract Water governance, negotiation between actors and institutions for the effective implementation of acceptable water allocation and regulation, faces a plethora of challenges over the coming decades. The challenges arising from population growth, development, climate variability as well as climate change impacts. Concurrently, a crisis of governance has been recognised as one of the major issues facing global water resources over the past decades. The duality of essential role water governance plays in responding to these challenges and the recognised limitations and failures of governance regimes to adequately manage legacy issues predicates the value of closer investigation of both water governance challenges and solutions in the context of climate change and uncertainty. This chapter provides an introduction to the developments in both the challenges to and solutions from water governance over the past few decades.

Keyword Water governance challenges • Climate change uncertainty • Hydro-climatic pressures • Water governance solutions • Adaptive and integrative water management

1.1 Climate Change and Uncertainty: The Great Acceleration

The crisis of governance in the challenges facing global water resources is now well recognised (Gleick 2009; UNESCO 2006; WEF 2009). Governance reflects the negotiation between society and government for effectively implementing socially acceptable allocation and regulation by mediating behaviour through values, social norms and laws (Rogers and Hall 2003). Water governance therefore encompasses the laws, regulations, property rights, institutions, policies and actions, which manage and negotiate water resources as well as networks of influence, such as international market forces, the private sector and civil society (UNDP 1997). Population growth, development, and diminishing water supply from current climate variability

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are already stressing the availability of high-quality water resources. Water governance is essential to managing variability in water supply and delivery (due to seasonality and local variability), in part through the construction and management of regulating infrastructure, but also through the rules (permits, ownership rights, laws, regulations) that administer valuable water resources.

Even if greenhouse gas emissions cease tomorrow, the inertia of the climate system is committed to a likely increase in global temperatures of at least 2°C by the end of the century (IPCC 2007). The associated shifts in climatological patterns will require us all, but water managers in particular, to adapt in a timely and effective manner. The physical and environmental changes pose significant challenges to water infrastructure and management systems, despite the fact that water stakeholders have long dealt with changes and stresses relating to climate variability. The projected speed and magnitude of anthropogenic climate change is set to exacerbate underlying variation and stresses, rendering future situations less manageable (IISD 2006) unless our current institutional arrangements can become adaptive to the realities of future environmental situations.

The release of the fourth assessment report by the Intergovernmental Panel on Climate Change (2007) could have been seen as a tipping point for an increasing awareness of the linkage between climate change and related resource management issues, including water management. Significant progress was made, yet the subsequent years have seen a number of setbacks to significant traction being made by the scientific community on a number of resource related issues. Climate and water cannot be separated as independent issues, especially as water is the primary medium through which climate impacts will be experienced, through changes in local hydrological patterns (Parry et al. 2007). The significance of the water, energy, food nexus is so fundamental to economic development globally, that the intensification of hydrological cycle will impact on both rich and poor, whether through too much water, or too little. Moreover, mountainous areas, commonly considered 'Water Towers' of the world are at the forefront of these warming patterns (Häberli and Beniston 1998). Climate impacts on glacier retreat, precipitation patterns (seasonality and snow line) and associated changes in run off regimes are already observed in Alpine and Andean regions, and model projections suggest a continuation if not heightening of current trends (Viviroli et al. 2011).

In 2002, a Nature paper (Crutzen 2002) suggested that the advent of a new geological period was upon us, one defined by the fact that human actions were playing a dominant role in shaping biospheric processes. This period was called the 'anthropocene', and has fundamentally challenged our perception of human interaction with bio-physical processes. Humans can no longer view themselves as an observer of bio-physical or bio-chemical processes, but instead have become a major contributor and actor in them. This has significant consequences for how human actors should view their part in the 'management' of bio-spherical process and natural resources. Moreover, it prescribes a shift in how actors evaluate and design the management processes to cope in a less stable climatological period, and the increasing need to be aware of the planetary boundaries that we are rapidly approaching (Rockström et al. 2009). The Nature article on planetary boundaries suggested that the regulatory capacities of the earth maintained a safe operating space of natural environmental change within which humanity could thrive and develop (Rockström et al. 2009). It goes on to define a set of interlinked biophysical thresholds, or planetary boundaries, which if crossed, could lead to irreversible and abrupt environmental change with disastrous consequences for human development. These planetary boundaries are: climate change; rate of biodiversity loss; interference with the nitrogen and phosphorus cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; change in land use; chemical pollution; and atmospheric aerosol loading.

The 15th Conference of the Parties meeting (COP15) in Copenhagen was seen as a major disappointment for the global change science research community on many fronts. The water community was one of many that came out of Copenhagen severely disenchanted, since all references to water were dropped entirely from the final text on adaptation, which represented a widening of the gap between the climate and water contingents when many had hoped a connection would be further fused.[1] COP15 showed that many were still not making the link between the climate and water agendas, or even the wider environmental issues at stake. It also raises the issue that many governance regimes focus on separate aspects of the social or ecological systems (e.g. climate, or forests, freshwater fisheries, marine fisheries, or even less coherently across sector specific legislation or different institutional combinations at ministerial level). However, there is an increasing focus from the global change community on the need for human society and the governance systems that moderate our actions and decisions to operate within multiple inter-connected earth systems. Since the climate negotiations centred purely on the climate system, those involved in carving out the climate regime fell short in recognising the need for human society to operate within the other earth systems (Rockström et al. 2009).

The link between tipping points in these planetary boundaries has been reflected in theories of environmental resource management and governance, as well as in the water disciplines, but has not yet been widely adopted by those outside of the research and scientific community (Rockstrom et al. 2009). The retreat of mountain glaciers is one of the indications that certain sub systems of the earth are moving out of their relatively stable Holocene state, and into the anthropocene (Crutzen 2002; Rockström et al. 2009). Global freshwater consumption has moved from a pre-industrial value of 415 km^3 per year to 2,600 km^3 per year, which while it may fall under its proposed planetary boundary, is tightly coupled with other boundaries in the system. Our ability to stay within the climate boundary may depend on stopping the transgression of the freshwater boundary and vice versa, since all of them are conceived as 'bio-physical preconditions for human development…and well-being' (Rockström et al. 2009, p 474).

[1] Co-operative Programme on Water and Climate (CPWC); Netherlands Commission for Environmental Assessment (MER); Institute for Environmental Studies (IVM); Netherlands Environmental Assessment Agency (PBL).

Additionally, it should be noted that uncertainty does not stem only from the increasing risks and hazards for a potentially warmer world, but also from the very nature of the knowledge system used to map out climate impacts. Despite significant advances in climate change science and modelling techniques, the uncertainty associated with such projections (rather than predictions) at either global or regional levels is likely to continue for the foreseeable future (Carter et al. 2007). Yet, decisions about how to adapt the governance and management of complex water resource systems to climate change impacts cannot just wait until climate model projections are more precise.[2] While models can project a range of futures or alternative scenarios of change, the complex nature of the bio-spherical processes that drive water hydrological patterns means that in the conceivable future short and long term management decisions about future water quality, security and availability will still be subject to a large range of uncertainty in both projected and unanticipated changes.

Social systems have tended to have rules or tools to cope with normal ranges of uncertainties, or moderate deviations from the norm (what Mathews et al. (2011) term 'predictable certainty'), such as wet years followed by dry years on an inter-annual or decadal timescale (Smit and Wandel 2006; Yohe and Tol 2002). For example, from a governance perspective, prioritisation rules may kick in when indicators suggest a dry year is underway. From a management perspective, reservoir storage could tie over water provision during dry years, or flood management strategies such as dykes and early warning systems might protect against high precipitation events (Herrfahrdt-Pähle 2010; Huntjens et al. 2010; Smit and Wandel 2006). However, climate change embodies a more unpredictable and indeterminate form of uncertainty (Matthews et al. 2011) or irreversible changes in state (reduced run off contribution from glacier and snow melt, shifts in seasonality, increasingly consecutive dry years) that may lie outside or beyond the boundaries of past and present coping ranges of water management and governance regimes[3] (Smit and Wandel 2006; Yohe and Tol 2002).

Climate change is therefore seen as exacerbating these broader challenges affecting water governance, acting as an overarching pressure that causes these underlying stresses on water institutions to become even more pronounced as impacts intensify (Lettenmaier et al. 2008). Since climate change is a systemic threat that will have significant interactions with other drivers of change (as discussed above), it will require fundamental shifts in how water governance regimes operate, and how they interact and coordinate across local, regional, national, and trans-boundary scales. More specifically, increasing uncertainty of future conditions, or 'non stationarity'

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[2] Also refer to http://www.newater.info/index.php?pid=1045

[3] *Adaptive capacity has been analyzed in various ways, including via thresholds and "coping ranges", defined by the conditions that a system can deal with, accommodate, adapt to, and recover from (de Loe and Kreutzwiser 2000; Jones 2001; Smit et al. 2000; Smit and Pilifosova 2001, 2003). Most communities and sectors can cope with (or adapt to) normal climatic conditions and moderate deviations from the norm, but exposures involving extreme events that may lie outside the coping range, or may exceed the adaptive capacity of the community.* (Smit and Wandel 2006, p 287).

(Kiang et al. 2011; Milly et al. 2008) and possible bifurcations ("thresholds") in the climate system implies that water governance cannot approach the future based on the assumption that it will replicate the relatively stable conditions of the past. The resulting implication is that a shift is required in how we plan and manage water resources, which respects non stationary conditions and embraces (rather than seeks to remove) increased levels of uncertainty, transforming how water governance relates to ecosystems and communities over climate-relevant timescales.

Climate change impacts on hydrological resources and patterns will affect water governance and management primarily through alterations in the timing of hydrological patterns (seasonality), quantity of water resources (floods and droughts) and quality (suitability for consumption or use) (Matthews and Le Quesne 2009; Cook et al. 2011). Impacts include alterations in seasonality, a rise in the frequency or intensity of extreme hydrological events (increased drought and flood recurrence and duration), higher variability of precipitation patterns, increased hurricane intensity, changing trends in snow pack, and generally accelerating rates of glacier melt leading to changes in run-off (first increasing then decreasing) (IPCC 2007). These changes imply both a shift in the alteration (shifts in timing and averages) and intensification (increasing number and severity of extreme events) of the hydrological cycle. Changing seasonality, water temperatures and alterations in precipitation patterns affect water quality, in terms of dissolved oxygen levels, concentration of pollutants, as well as levels of toxic algae and sedimentation impacting aquatic species (Matthews and Le Quesne 2009) and infrastructure such as dams.

Therefore, governance processes that were designed in a context of 'stationarity' may not be equipped to address accelerated changes to the hydrological cycle and more unpredictable uncertainties in relation to future climate. Water rights, regulatory and policy contexts that do not take into account the ecological requirements for maintaining healthy, productive and protective waterways threaten to undermine the resilience of the socio-ecological system, at a time when it is needed most (i.e. as climate impacts mount). Likewise rights, plans, policies and regulation that do not acknowledge inherent uncertainties by allowing for revision if the bio-physical parameters, upon which they are based, change, are likely to become increasingly ineffective in managing the rivalries and negative impacts arising from climate change. Legislation and rules set now or in the past may impact decisions on investment and management paths for the next 10, 20 or 30 years, over which time these impacts will intensify. Simply scaling up past solutions to environmental challenges to tackle climate related issues may not be adequate to manage future challenges, because rules may not have taken unpredictable uncertainty into account, or solutions have been focussed primarily on enabling technical 'hard' adaptations that do not address the social reality in which they must be implemented, or because the timelines for re-assessment and the integration of new knowledge do not match increasing speeds of change.

However, water governance, and the institutions it effects, do not just experience climate change, but play a crucial role in developing an enabling environment for successful adaptation (Tompkins and Adger 2004), to anticipate and respond to a changing climate. Governance regimes define the context within which adaptation takes place (Adger et al. 2005), requiring the institutions these regimes define to be simultaneously both climate adaptive and yet able to drive sustainable adaptation efforts. To respond to this dual challenge, the water resources and research community have in recent years focussed more heavily on better understanding adaptive governance processes for sustainable water resources management.

The recognition of an anthropocene requires the water research community to focus more heavily on strategies that would effectively manage water resources in the context of a new epoch. Thus it signals the need to shift attention from assessing and shaping responses in order to avoid over-exploitation of resources to also include dealing with uncertainty under changing climatic conditions. Therefore, when investigating water resource issues, it is vital to recognise and take into account the complex inter-connected and multi-functional role that water resources serve for healthy ecosystems, societies and economies, and thus the ability for humankind to stay within the bio-physical preconditions that are necessary for our own development and well-being (Rockstrom et al. 2009).

1.2 Shifting Lens: Sustainability to Adaptability

In his seminal book 'On the Origin of Species', Darwin famously noted that "It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change" (Darwin 1859). This observation perfectly elucidates how humans have always had to adapt to change, including climatic and meteorological variation. So what is different now? Why do we worry so much about society's ability to adapt to future variation in the twenty-first century? The answer to this can be found by looking at the speed of current climatic change, and the complex geo-political-environmental context within which it is and will take place. Current rates of change and the increasing global, rather than local, drivers of concatenating shocks (Biggs et al. 2011) have meant that a more concerted effort must be placed on creating an enabling environment for adaptive capacity to accelerating rates of change in today's more complex and interconnected world.

Discussions around resource based institutions have held prominent place since Hardin argued in his seminal paper 'The Tragedy of the Commons' (Hardin 1968), that resource users in shared resource extraction and use systems, are inevitably locked into the trap of destroying the resource on which they depend. In the preceding 40 years, much of the debate around institutional arrangements for resource management has been pinned on whether or not this 'tragedy of the commons' prophesy is universally true, or if enough examples can be found to counter argue the proposition (Ostrom et al. 1999), identifying favourable institutional processes that resolved these shared resource problems. While Hardin proposed polarised solutions of either socialism or privatisation of free enterprise, Ostrom continues to chart a number of alternative methods of restricting access and creating incentives that resolve over-exploitation issues related to shared resources that are open to public consumption (e.g., fisheries catchment quotas, local forest management practices, and water allocation agreements to name a few).

Ostrom herself has noted that accelerating rates of change are a major challenge in establishing sustainable institutions to manage such shared resources that are open to public consumption (Ostrom et al. 1999). While this in part points to the historic exclusion of ecological requirements in the governance system leading to negative environmental impacts it also shows that the convergence of human induced global change processes, such as climate change, with diverse governance challenges (i.e. lack of clarity around existing water use rights and over-exploitation), is pushing institutions and humanity in general, past those environmental thresholds beyond which it becomes increasingly difficult to apply previous practices to future problems (Kane and Yohe 2000). This calls for a new lens through which to assess the appropriateness of governance frameworks in a rapidly changing environment of increasingly indeterminate risks. It also calls for suitably robust criteria to be established with which to shape fitting responses.

In response to these increasing stresses on global hydrological resources, increasing attention has been paid to the failure of governance in the water sector in the preceding two decades. Investigations of different governance regimes and outcomes have sought to pinpoint elements in a system which may produce more effective results in creating 'good governance' (Rieu-Clarke et al. 2008). Normatively the concept appeals to the democratic advantages of broadening the participation base and the durability of solutions which evolve through negotiation and cooperation by a greater number of stakeholders. The frameworks which have arisen out of these studies and research programmes have primarily centred on goal-specific approaches such as integrated water resources management (IWRM), as inspired by the Dublin Principles (Solanes and Gonzalez-Villareal 1999). While the focus on good governance and IWRM has provided a vital goal on which water managers could frame solutions (UNECE 2009), a better understanding is needed of how relevant these frameworks are in relation to the challenges induced by climate change.

Scholars and practitioners have therefore become increasingly critical of traditional command and control approaches for their rigidity and impracticable goal of decreasing uncertainty (Johnson 1999). Instead, approaches that focus on governance and management that is adaptive as well as integrative have been posited as being more suitable to managing uncertainty (Engle et al. 2011). This has led in recent years to a number of the water resources and research community to focus more heavily on better understanding adaptive processes, either in relation to how systems have coped with past variability as well as shocks outside past and present coping ranges (Engle 2010; Herrfahrdt-Pähle 2010; Huntjens et al. 2011; Pahl-Wostl 2007; Pahl-Wostl and Sendzimir 2005). In the past decade, there have been many more studies from the governance, adaptation and resilience discourses that have sought to improve the baseline understanding of adaptation and adaptive capacity in water governance regimes. Case evidence has been used to suggest an increasingly converging set of criteria required to foster adaptive processes (Dovers and Hezri 2010). Within the context of river basins, it has been noted that more attention needs to be devoted to understanding and managing the transition to more adaptive regimes that 'take into account environmental, technological, economic, institutional and cultural characteristics of the basin' (Pahl-Wostl et al. 2007, p 49).

Flexibility in governance systems is one key criterion in building adaptive capacity to react to the unanticipated conditions that may result from climate impacts (Hurlbert 2009). Empirical studies have also suggested that designs that focus on participatory, collaborative, and learning-based approaches can increase adaptive capacity and support the sustainability of water systems (Folke et al. 2005; Kallis et al. 2006; Pahl-Wostl et al. 2007; Tompkins and Adger 2004). Other studies have identified the important role that leadership plays in championing innovative approaches and strategies for adapting to climate change (Engle 2010) as well as steering social systems through transformative processes (Olsson et al. 2004). Better understanding how to identify and assess these governance mechanisms that foster adaptive capacity is an integral part of transitioning to more sustainable water governance regimes.

1.3 Converging Threats

Chile and Switzerland both face an interesting set of converging challenges. Both countries have OECD status and possess high levels of the classic determinants of adaptive capacity. Their citizens enjoy democratically elected legitimate governments, strong economies (even through current economic woes of the financial crash) and educated populations, despite recent events in Chile that have elucidated the disproportionate levels of education between economic elite and lower socio-economic levels. However, both case areas within the countries face multiple challenges driven by climate, economic, socio-political and ecological factors. In Chile, the neoliberal model implemented by the Pinochet regime validates strong deregulation, privatisation and market liberalisation in the interests of improving economic efficiency. While the particular market model pursued has been seen to be effective so far for the development of supply and sanitation[4] and export based economic growth, its limitations concerning effective protection of ecosystems, climate change and upstream-downstream rivalries have gradually been recognised (Vergara-Blanco 2004). The water rights market and Water Code do not take into account the diverse nature of the different sectoral stakeholders, yet assumes agriculture, mining, energy and industry could all compete for the same resource on equal terms. Carl Bauer has discussed at length the social and environmental consequences of the Chilean water model, and presented a detailed description of the major political challenges in reforming the 1981 Water Code to take better account of environmental and social externalities (Bauer 1997, 1998, 2004).

In March 2010, President Piñera took over the presidency from the Bachelet government, heralding the first *Alianza* government after 20 years of the *Concertacion* coalition. For the first time since the Pinochet regime fell, the right wing neo-liberal

[4] However, a recent UN-ECLAC study (Lentini 2011) has presented evidence that shows rising costs for domestic consumers due to increasing water losses because utilities have allowed infrastructure to deplete.

coalition is in power, with potential consequences for the development and direction of water governance. Field work in Chile took place about 7 months after the change of government, with many of the civil servants from the previous government recently out of their positions. The strong political influences of the neo-liberal dogma for water resources management in Chile, defines not just the new government, but also left its mark on policies followed during the period of the left wing Concertacion. For example, in the northern areas of Chile, in response to growing stresses from mining use and population growth, the previous government had attempted to pressure, unsuccessfully, the Superintendencia into forcing the regional utility to move to desalination.

As central and northern areas become drier, this policy could potentially imply a transference of the costs of industrial over-consumption onto the domestic customer, as the cost of moving to a desalination system would have increased water prices three- or four-fold. Similar levels of worry persist with regards to the hydropower sector, where concerns exist that Italian owned ENEL control 80% of non-consumptive water rights in Chile and 96% of non-consumptive rights in the Aysen area, which is the most water rich in Chile and one of the richest in the world (Patagonia 2011). The challenges in the case area Aconcagua Basin are presently not as highly contentious as northern or Patagonian areas of Chile, but increasingly recurring drought, changes in glacier and snow coverage, mounting pressures from mining and expanding agricultural coverage are all exerting mounting pressure on water resources.

In Switzerland, a very different set of drivers frame the challenges, particularly within the Alpine context of the Canton Valais. Traditional socio-economic structures in the alpine zone have undergone large upheavals over the last 50 years (Hill et al. 2010), with consequent challenges for resource management. Not only have alpine farmers played an important role in the governance of water through common property resource regimes, but they have been crucial in the development and maintenance of water infrastructure in the upper watersheds of the Rhône. As there are fewer full time and part time farmers, these traditional structures have suffered, with consequences for water management in crucial periods.

These transitions have also brought new rivalries for water resources. The convergent expanse in tourism in the major Valais ski resorts, with increasing requirements of water for artificial snow production as snow coverage becomes less predictable intensifies existing rivalries on the tributaries to the Rhone in the Valais. The on-going inclusion of environmental flows as a new ‘user’ of water resources adds further tension to water governance across multiple sectors. Despite the image of Switzerland, and in particular the Valais, as the Water Tower of Europe, the abundance of water resources are highly spatially dependant, and periodic rivalries exist not just during peak winter periods, but are increasing in the later periods of summer (e.g. La Reche; Saviése; Conthey).

Both regions represent mountain watershed nivo-glacial regimes, where climate change (as experienced through glacier melt and snow pack changes) will correspond with changes in the seasonality of river flows. In both areas impacts of climate change have already been observed on glacial melt and elevation of the snow line with associated impacts on the timing and amount of run off (Häberli and Beniston 1998; Pellicciotti et al. 2007) projected to increase (Christensen et al. 2007). As mountainous areas, climate change impacts will be keenly felt in both cases, mainly through alterations in seasonality (Viviroli et al. 2011). However, shifts in seasonality and decreases in glacier melt take on particular significance in the Andean region where dependence on glacier and snow melt run off is high for water availability during the dry summer months (Pellicciotti et al. 2007; Souvignet et al. 2008).

Global climate models show that warming and drying trends have already been observed and can be projected to intensify for the Andean region (Christensen et al. 2007). Temperature increases in the Alps have exceeded 1–1.5 °C since 1900 (about three times the global-average temperature rise), with corresponding implications for increased glacial melt and changes in snow pack (OcCC 2008; Solomon et al. 2007). Furthermore, in combination with the strong El Nino Southern Oscillation (ENSO) event currently occurring, the central-northern regions of Chile have been experiencing one of the worst drought periods in memory (DGA 2010). The convergence of climate change impacts with the complex political and economic issues poses significant challenges across the two case areas that will need to be navigated through effective water governance frameworks.

1.4 Summary

Effective adaptation and building adaptive capacity should therefore be seen as crucial to the sustainable management of water resources in the Anthropocene. Governance is recognised as being an issue at the heart of water resource challenges, and therefore strengthening adaptive capacity through governance frameworks is essential for responding effectively to future climatic uncertainty and stress (Folke et al. 2005; UNECE 2009) and shifting to means of managing freshwater in a way that incorporates climate change associated changes in timing, quantity and quality. Moreover, higher uncertainties and the increasingly indeterminate nature of water risks (e.g. years of drought followed by extreme flooding) from climate change challenge the fixed rules and regulations that define many water institutions, and may lie beyond current planning practices (Matthews and Le Quesne 2009).

As attention has shifted to better understanding adaptive processes, a set of assumptions and panaceas (single solution applied to wide range of problems) have arisen in the literature that address how to foster governance arrangements that are more adaptive, integrative and flexible. However, despite an upsurge in research into governance and adaptation and the water sector over the past decade, a lack of comparative analyses of the application of these approaches in river basins persists (Huntjens et al. 2011). Furthermore, there remain considerable gaps in the empirical exploration and understanding of the complex dynamics that effect the stimulation and mobilisation of adaptive capacity at different scales as well as the role of different governance regimes in building adaptive capacity.

This calls for a better understanding of how governance systems adapt to climatic stimuli. Other studies have shown that investigating how these systems have adapted (or not) to recent past stresses from extreme events may allow us to draw lessons about adaptive capacity to future climate change (Adger et al. 2007; Engle 2011; IISD 2006); allowing managers to learn from what has already been done, successfully or unsuccessfully, to inform their decisions about what should be done. The research presented in this book aims to contribute to the conceptualisation and operationalisation of adaptive capacity in order to help bridge these conceptual gaps. In so doing, it hopes to contribute a more nuanced conceptualisation and operationalisation of adaptive capacity, through better understanding how the governance context and mechanisms within those frameworks contribute to an enabling environment for adaptive capacity. It also seeks to better understand the challenges in generating adaptive capacity across temporal and spatial scales and in so doing, generate a framing of adaptive capacity that better serves policy and decision makers.

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