Research

Exploring institutional adaptive capacity in practice: examining water governance adaptation in Australia

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ABSTRACT. Adaptive capacity is widely held as a key property of resilient and transformative social-ecological systems. However, current knowledge of the term does not yet address key questions of how to operationalize this system condition to address sustainability challenges through research and policy. This paper explores temporal and agency dimensions of adaptive capacity in practice to better understand how system conditions and attributes enable adaptation. An institutional dynamics lens is employed to systemically examine empirical cases of change in urban water management. Comparative analysis of two Australian cities' drought response is conducted using institutional analysis and qualitative system dynamics mapping techniques. The study finds that three forms of adaptive capacity appear critical: the ability to learn, decide, and act. The analytical approach developed provides insight into change dynamics and the agency mechanisms that generate them. The paper proposes a typology of adaptive capacity by characterizing these change dynamics and mechanisms for locked-in, crisis, reorganizing, and stabilizing systems. This set of propositions on institutional conditions and forms of adaptive capacity is offered to further advance research on the topic and help to operationalize adaptive capacity in practice.

Key Words: *adaptive capacity; institutions; resilience; transformation; water governance*

INTRODUCTION

The ability of a system to anticipate and respond to various stressors, its adaptability, is considered a central tenet for aligning complex social and ecological systems in the face of uncertain futures (Smit et al. 2001, Walker et al. 2004). Engle (2011) highlights that this concept of adaptive capacity has connotations of being a property that can be harnessed, making the term relevant and attractive to policy makers. Others see potential in the term to engage in a more action-oriented understanding of adaptation (Eisenack and Stecker 2012), thus lending support to the need for more flexible decision making (Polasky et al. 2011). Some scholars have argued, with its mixed heritage from organizational theory, ecology, and anthropology (Gupta et al. 2010, Engle 2011) that the concept of adaptive capacity can connect new disciplinary perspectives to better understand the complexity of sustainability problems (Janssen and Ostrom 2006, Brown and Westaway 2011). As such, adaptive capacity is an underlying ingredient for dealing with some of the fundamental challenges to aligning complex adaptive social and ecological systems, including questions of agency and intervention, governance and decision making, and complexity and uncertainty.

Identifying system conditions and qualities that produce adaptive capacity and understanding how they enable adaptation have become a growing research area in the last decade (Hill and Engle 2013). Current research has critiqued earlier approaches that focused on adaptive capacity determinants and indicators, arguing it is more important to understand the dynamics of adaptive capacity in the relationships between common determinants in different contexts and across scales (Gallopin 2006, Smit and Wandel 2006, Nelson et al. 2007). Recent research following this agenda have: identified empirically and theoretically based institutional prescriptions for enhancing system potential for adaptive capacity (Huntjens et al. 2012); developed heuristic frameworks to assess adaptive capacity in a dynamic system context (Pahl-Wostl 2009, Huntjens et al. 2010, Hill and Engle 2013); and empirically identified activities and strategies that have contributed to the ability to respond to climate extremes of drought and flood (Engle 2011, 2012, Huntjens et al. 2010).

Despite these advances, there remain significant gaps in the conceptualization of adaptive capacity. Recent work noted that the mixed heritage and broad application of the concept has led to crossover and confusion with other terms (Gallopin 2006, Hinkel 2011). Some scholars see this diversity able to offer broad research insights (Janssen and Ostrom 2006), whereas others argue the conceptual confusion poses a barrier to further development and application of adaptive capacity (Eisenack and Stecker 2012, Keskitalo 2013). Hill and Engle (2013:190) note that the discourses on adaptive governance and management "are facing similar challenges in attempts to offer recommendations for improving adaptability and adaptive capacity." Huntjens and collaborators support this observation, suggesting that "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" (Huntjens et al. 2012:80). Thus, what is missing from current scholarship are explanations of how system attributes are combined under particular conditions and within particular contexts to create the capacity to adapt. These observations highlight two conceptual issues obstructing the scholarly development of adaptive capacity and its application in policy and practice: (1) a lack of focus on the agency dimension of adaptive capacity, needed to read system conditions and mobilize ambient qualities in order to adapt; and (2) there is uncertainty as to the role adaptive capacity plays in generating system change.

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In relation to the first issue, recent work has highlighted the importance of human agency for responding to stressors and enabling social–ecological system adaptations, but noted most studies continue to employ resource or structural lenses to assess this capacity (Brown and Westaway 2011, Eisenack and Stecker 2012). Indeed Wyborn and Dovers (2014) observe that research has not yet progressed far beyond propositional stances of what adaptive governance should resemble, to prescribing the operational processes and enabling mechanisms (adaptive capacities) to build adaptiveness. Such observations have led Brown and Westaway to propose a definition of adaptive capacity as "the preconditions necessary to enable adaptation to take place; it is a latent characteristic that must be activated to effect adaptation" (Brown and Westaway 2011:322). This raises a key conceptual issue: does adaptive capacity include the capacity to utilize ambient system qualities? Although it is important to distinguish between potential and actual adaptation (Brooks 2003, as cited in Eisenack and Stecker 2012), we argue the term adaptive capacity should include the skills and resources needed to adapt, along with the access, influence, and capability to harness and combine these system attributes into adaptation processes. Without this agency element within definitions, studies risk continuing to miss critical insight into how system capacities can be mobilized for adaptation, and how this can be achieved in different social contexts.

The other main source of ambiguity in understanding adaptive capacity is its relationship with two commonly cited outcomes of adaptation, resilience and transformation. Both denote systemic change, but diverge on whether the functional purposes (objectives) of the system remain constant or are transformed. A resilient system absorbs shocks and perturbations without significant loss of results; i.e., without changing the system's objectives (Berkes and Folke 1998, Walker et al. 2004). In contrast, a transformed system is reconfigured to meet fundamentally different objectives (Walker et al. 2004, Folke et al. 2005). Some authors argue that this transformative aspect is part of a resilient system (Folke et al. 2005). Without clarity on the distinction between these two forms of adaptation, it is difficult to trace the processes that lead to these different system outcomes and determine how adaptive capacity contributes. From an empirical standpoint, it also makes it difficult to recognize adaptive capacity in practice. As such, this paper adheres to the distinction between resilience as resisting fundamental change by maintaining system objectives by restructuring, and transformation as pursuing fundamental change by exploring new objectives and reconfiguring the system to achieve them. In this way, questions can be asked of how adaptive capacity contributes to different forms of system change (Wilson et al. 2013). We argue that this differentiation provides analytic scope to understand adaptive capacity in practice, by providing a means of comparing and contrasting the different capacities that contribute to the different adaptation responses. This speaks to Brown and Westaway's (2011) call for distinguishing between agency for transforming and that for coping with change. In this light, we define adaptive capacity as:

> *The ability to mobilize and combine different capacities within a system, to anticipate or respond to economic, environmental, and social stressors, in order to initiate structural or functional change to a system and thereby achieve resilient or transformative adaptation.*

This definition emphasizes agency (mobilize, respond, anticipate, initiate, achieve) while acknowledging variation in the outcomes of adaptation (resilience and transformation). Based on this conceptualization of adaptive capacity, the paper draws together an analytical framework with agency and temporal dimensions to examine these perspectives currently missing in adaptive capacity research. We then apply the framework to empirical cases of urban water regimes in flux to explore the question: Can an agency-oriented perspective shed light on the mechanisms and role of adaptive capacity in achieving different forms of adaptation? Empirically based propositions for identifying and building adaptive capacity are then derived for further theoretical development and empirical testing.

ANALYTICAL FRAMEWORK

To examine the conceptual gaps in understanding adaptive capacity described, this study focused on identifying adaptive mechanisms contributing to the potential form of adaptation occurring. A recent assessment of ten advanced social–ecological system analysis frameworks found that none enabled the study of how social processes result in mechanisms of system change (Binder et al. 2013). Other frameworks include agency mechanisms, but conceptualize these within a narrow focus, for example as innovation/entrepreneurism (Westley et al. 2013), learning processes (Pahl-Wostl et al. 2010, Herrfahrdt-Pähle and Pahl-Wostl 2012), networks (Hill and Engle 2013), or how to diagnose and overcome barriers to adaptation (Eisenack and Stecker 2012, Ferguson et al. 2013). This study sought a broader exploratory approach to identify a range of actions and examine how, in concert, these induce and influence system change. The Transformative Agency framework by Westley and colleagues (2013) provided the closest fit to this aim, by recognizing the importance of situating skills and strategies of actors within the context of broader system dynamics (represented by the adaptive cycle of Gunderson and Holling 2002). We build on their conceptual framework by drawing on institutional theory to identify the broad range of agency mechanisms and to unpack in specific detail what elements of the system are changing as a result.

To balance the need for detail on the agency dimension of adaptive capacity with an understanding of contextual conditions, Gupta et al. (2010) have suggested that institutions provide a useful analysis unit for researchers. As foundational organizing structures in society, institutions not only shape and guide actors' behavior and actions, but enable social actors to rally and respond to sustainability challenges through collective action (Ostrom 2000). These formal and informal shared constructs and rules of conduct provide a wide lens for understanding the structural and functional elements of a social system. Institutional work is a developing branch of theory focused on how actors purposively express their agency to affect institutions (Lawrence et al. 2009, Kraatz 2011). In a synthesis of contemporary empirical studies, Lawrence and Suddaby (2006) identified three forms of institutional activity or work that actors conduct: maintaining, creating, or disrupting. Analyzing these studies further, the authors compiled a wide range of strategies or mechanisms actors (individuals and organizations) drew on to generate these three dynamic change processes. Their preliminary schema of institutional work is described briefly in Table 1. By identifying the variety of actors' activities influencing the way a system is configured (i.e., formal structural institutions) and how it

Table 1. Dynamics and mechanisms of institutional work

DYNAMICS → MECHANISMS ↓	Creating: Develop alternative institutions	Disrupting: Challenge current institutions	Maintaining: Uphold current institutions
Cognitive: Thought processes, problem frames, decision logics.	*Mimicry:* Associating new practices with taken-for-granted practices in order to ease adoption. *Theorizing:* Development and specification of abstract categories and chains of cause and effect. *Educating:* Teaching actors in skills and knowledge necessary to support a new institution.	*Undermining assumptions and beliefs:* Decreasing the perceived risks of innovation by undermining core assumptions and beliefs.	*Embedding and routinizing:* Actively infusing the normative foundations of an institution into day-to-day routines and practices.
Normative: Beliefs, assumptions, norms of behavior, cultural constructs.	*Constructing identities:* defining the relationship between an actor and their operational field *Changing normative associations:* remaking the connections between practices and the moral and cultural foundations of those practices. *Constructing normative networks:* interorganizational connections through which practices are normatively sanctioned and formation of a peer group for compliance, monitoring, and evaluation.	*Disassociating moral foundations:* Disassociating the practice, rule, or technology from its moral foundation.	*Valorizing:* Providing positive examples that illustrate the normative foundation of an institution. *Demonizing:* Providing negative examples that illustrate the normative foundation of an institution. *Mythologizing:* Preserving the normative underpinnings of an institution by creating and sustaining myths regarding its history and relevance.
Regulative: Rules supported by rewards and sanctions.	*Defining:* Constructing the rule system that confers status, identity, defines boundaries or creates a hierarchy *Vesting:* Creating rule structures that confer rights *Advocacy:* Mobilizing political and regulatory support	*Disconnecting sanctions and rewards:* Disconnecting rewards and sanctions from a set of practices or rules.	*Deterring:* Establishing coercive barriers to change. *Enabling:* Creation of rules that facilitate, supplement, and support current institutions, such as authorization or diverting resources. *Policing:* Ensuring compliance through auditing, monitoring, and imposing sanctions for noncompliance.

Source: compiled from Lawrence and Suddaby (2006).

functions (i.e., informal conventions, cognitive frames, beliefs), institutional work theory provided the study with an analytical tool to connect agency with system change processes. Thus, examining the three dynamic processes and the range of actions that instigate them offers analytical depth to explore where agency for adaptive capacity lies.

To explore the different manifestations of adaptive capacity that underlie both resilient and transformative adaptations, a means of establishing cases on a temporal process of changing system structure and function was required. The adaptive cycle is a well-established frame of reference for understanding the process of adaptation (Holling 2001, Gunderson and Holling 2002). The cycle's distinction between the connectedness (structure) and potential (functional purpose) of a system provides the dimensions needed to understand how adaptive capacity can produce resilience or transformation in a system.

In reality, adaptation is unlikely to follow a direct path toward either resilient or transformative change. The adaptive cycle provides a means of situating a case within different generalized phases of adaptation, while also recognizing that systems may maintain resilience or transform through this cycle, as illustrated in Fig. 1. Choosing cases at different phases of this generalized pathway of adaptation provides a means of establishing and differentiating the system conditions and agency underlying change processes. Over time such a repository of cases could offer insights into the role of adaptive capacity in resilient and transformative system trajectories. This study tested the applicability of this approach for understanding the role adaptive capacity plays in both forms of system change, using institutional work to identify the change dynamics involved.

METHODS

Research design
By choosing case studies situated at varying phases of the adaptive cycle, but driven by similar external conditions, theoretical replication provides the opportunity to seek tentative explanations of the role of adaptive capacity and how it was generated (Yin 2009). The experience of prolonged drought in Australia from the early 2000s to 2010 offered an opportunity for such a study. With relatively similar sociopolitical, cultural, environmental, and water governance contexts, the differing responses cities took to water scarcity provided an opportunity to explore adaptive capacity in practice. The research followed three successive objectives: first, to identify and map the dynamic change processes occurring within the urban water institutional setting (system structure) of each case, using the maintaining, creating, and disrupting classes of institutional work; second, to determine the cognitive, normative, and regulative mechanism employed by actors to generate these dynamics; and third, to examine the patterns and contrasts of these dynamics and mechanisms between cases to provide insight into the research question: Can an agency-orientated perspective shed light on the

Fig. 1. The adaptive cycle as a frame for understanding resilient and transformative adaptation . The adaptive cycle provides a means of situating a case within recognized phases of adaptation: lock-in, crisis, reorganization, and stabilization. This conceptualization of adaptation also enables the distinction to be drawn between a resilient and a transformed system: a system may maintain resilience by cycling within the boundary of the system's existing potential or functional purpose through structural changes, as represented by the bottom trajectory; or a system may transform by shifting to operate within a new range, defined by a new system potential and represented by the top trajectory. (Source: adapted from Gunderson and Holling. 2002. *Panarchy: understanding transformations in human and natural systems.* Island Press. Reproduced by permission of Island Press, Washington, DC. URL: http://islandpress.org/panarchy)
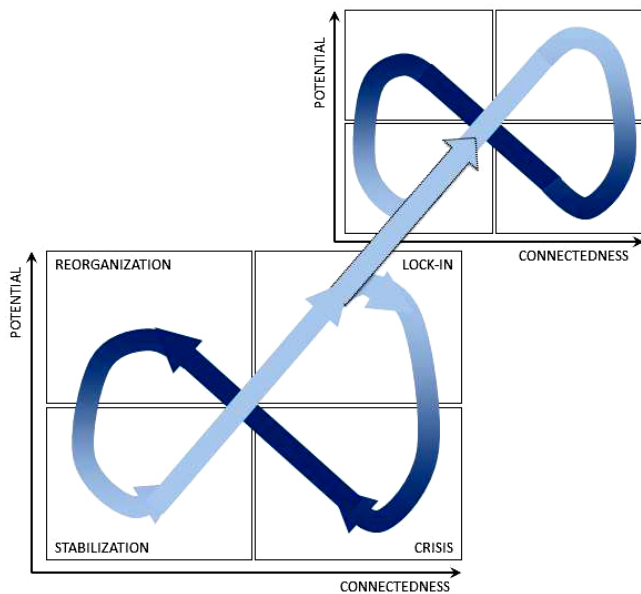
mechanisms and role of adaptive capacity in achieving different forms of adaptation?

Case study selection
Initial scoping interviews were conducted in late 2010 with a diverse set of practitioners from five state capital cities working in water policy and management, and practitioners from national water policy agencies and peak bodies (*n*= 30). The cities of Adelaide and Perth were subsequently chosen, as they offered similar contextual conditions (water industry structure, infrastructure system, use of groundwater as a supply source, climatic conditions), while presenting contrasting adaptation responses. Perth was selected as a case of lock-in adaptation, as the predominant response was water source development. The city's supply was augmented with seawater desalination and increased groundwater extraction, despite mounting scientific evidence that groundwater resources were under strain and the expense of desalination. This management response represented a continuation of current water management practices and

problem frames: adhering to the centralized infrastructure system and traditional water services (see Appendix 1 for detail of the Perth case). Although Adelaide's drought response was similar, their "portfolio of sources" was broader in scope. Clear policy targets were set for water recycling and stormwater harvesting. Such a move indicated commitment to mainstream these novel technologies, operating at a decentralized scale and producing new fit-for-purpose supply solutions. The appointment of an independent Commissioner for Water Security to develop a whole-of-government strategy to manage water scarcity, and the progression of a supporting legislative reform agenda, signposted a reevaluation of the State's water resources governance and service delivery objectives (see Appendix 2 for details of the Adelaide case). Given these responses, Adelaide's urban water system could be considered to be undergoing the reorganization phase of the adaptive cycle.

Data collection, analysis, and validation
A second round of semistructured interviews provided information on drivers, influences, events, conditions, and changes within the urban water sector within each city during the course of the drought (2000–2010). Interviews were conducted in early 2011 with management and executive-level practitioners from: state government water, environment, health, and planning departments; water utilities; local governments; peak bodies and consultancies. These interview transcripts and those from earlier scoping interviews with practitioners from each city were coded using a modified version of Strauss and Corbin's (1998) axial coding method (Perth, *n* = 19; Adelaide, *n* = 10). The coding process identified the key thematic areas where important change dynamics were occurring within each city. These "domains of change" were consistent in both cities and also correspond to factors identified in studies of system change from social–ecological systems and water governance literature. These domains of change are described in Table 2.

These domains were used as a basis for constructing a map of the institutional change processes shaping the responses to water scarcity in each city through the relationships and influences between domains. This exercise was informed by experts through interactive workshops with officer-level practitioners from state government water, environment, and health departments; water utilities; environmental regulation agencies; regional environmental management agencies; consultancies; and local governments (Perth: *n* = 21; Adelaide: *n* = 12). Workshops were conducted in early 2011 and were designed to draw out practitioners' experiential knowledge of the urban water management sector during and immediately following the drought (Perth, *n* = 3; Adelaide, *n* = 2). Individual reflection and focus group discussions identified the processes of change and described the activities and strategies that generated the three types of dynamics (maintaining, creating, and disrupting).

Qualitative concept mapping analysis was used to organize and structure the rich information generated in the workshops because this technique helps to articulate abstract ideas (Trochim 1989) and organize complex, nonlinear relationships between concepts in a simple but powerful pictorial representation (Novak and Cañas 2008). The technique has been widely applied in business and public administration contexts as a planning and decision-making aide (Lawless et al. 1998). Recent applications have also

Table 2. Domains of change within institutional setting

Domain	Description
Beliefs and cognitive frames	The values placed on water, aspirations to be achieved through its management, and the problem frames and other logics by which water management is conducted (e.g., risk perceptions). [†, §,ǀ, ¶, #, ††,‡‡,§§,ǀǀ]
Discourse	The informal discussions, debates, and conversations that occur about water management and its issues. Distinction between "in-house" professional discourse and more public debates, usually captured in the popular press. [§,¶,††,‡‡]
Governance setting	The formal structures in place to manage water, such as legislation, organizations and their remits, and regulatory processes. [‡,§,ǀ,#, ‡‡, ǀǀ]
Information	The information flows in the system. Includes access to and quality of information and performance monitoring and reporting. May also include information gaps and issues around interpretation and reporting of knowledge. [‡,§,¶,#, ‡‡, §§, ǀ]
Innovation and learning	The activities around experimenting with new alternatives (be they technologies or new management approaches) and learning mechanisms that apply new knowledge within the system (as distinct from the information flows). [†,ǀ,¶,††, ‡‡, §§]
Organizational relationships	The informal connections and interactions between key water management organizations, as distinct from their formal requirements for collaboration and consultation (e.g., as referral agencies on development applications). Encompasses the concepts of horizontal and vertical integration. [†,§,ǀ,¶,††, ‡‡, ǀ]
Policy direction and development	The statement of intent. A collectively agreed direction, or participatory process for determining a direction for water management. May include a vision for the city, targets, and objectives. [‡,§,ǀ,#,††, §§]
Professional capacity	The skills, knowledge, trust, networks, working relationships, and general workforce capabilities available for water management praxis [‡,ǀ,#,††, ‡‡]
Strategic support	Various "as needed" resources for driving changes to water management practice. Includes discretionary funding, the work of champions, managerial or organizational support for innovations, political will, and community advocacy. These resources are distinct from professional capacity, as they are injected in the system at various points to initiate, influence, or drive change (purposively or unintentionally), as opposed to the stable, certain resources required to carry out water management (e.g., maintenance works budgets). [†,§,ǀ,¶,††, ‡‡, §§]

Sources: [†] Bos and Brown (2012), [‡] Penna and Geels (2012), [§] Farrelly and Brown (2011), [ǀ] van de Meene et al. (2011), [¶] Westley et al. (2011), [#] Pahl-Wostl et al. (2010), [††] Gupta et al. (2010), [‡‡] Olsson et al. (2006), [§§] Huntjens et al. (2010), [ǀ] Hill and Engle (2013).

generated successful results in collective learning (Sutherland and Katz 2005) and as a data analysis method (Jackson and Trochim 2002). In this study, concept mapping provided a way to organize the workshop data (participants' reflections) by linking domains of change where system change processes were occurring (the concept element of the maps) with how these domains interacted to produce maintaining, creating, or disrupting dynamics in the system (the relationships between concepts). The resulting maps (see Figs. 2 and 3) provided a detailed but digestible picture of the change dynamics underlying the adaptive response observed in each city.

Written material from workshops and interviews was then coded using the classes of institutional work (Table 1) as a coding framework to identify the specific mechanisms (capacities) driving change dynamics identified in the maps. The results of this analysis were tabulated and, along with the concept maps, provided the case material for comparisons. Pattern matching techniques were employed to explore points of similarity and difference in the adaptive mechanisms and dynamics identified (Yin 2009) through an exploration of the patterns of connections (configurations) between domains illustrated in the maps.

Throughout the research, standard methods of qualitative social science research were used to ensure validity and reliability, including: theoretical replication logic in case selection for external validity (Yin 2009), the use of a multiphase research design to provide internal validation opportunities within case analyses (Blaikie 2009, Creswell 2009), extensive member checking and peer review of progressive research results (Lincoln and Guba 1985, Miles and Huberman 1994), the use of multiple sources of evidence (Creswell 2009), and procedural challenges to explanations and addressing rival explanations during data

analysis and interpretation (Miles and Huberman 1994). The software package NVivo was used to conduct coding analyses and document a chain of evidence, including coding protocols, annotated workings, and interview/workshop reflections.

MAPPING INSTITUTIONAL ADAPTATION

The concept maps that were produced of each city's institutional dynamics are presented in Figs. 2 and 3. These maps illustrate the institutional domains influencing the adaptive response of each city. The nature of this influence was ascertained through the coding of institutional work mechanisms in the research data and is aggregated into the maintaining, creating, and disrupting descriptors of the maps (rather than describing the range of specific mechanisms actors are using). The key features of each city's map are described in the following commentary, with bold text used to point the reader to the specific domains of change in the concept maps. Representative participant quotes in italics supplement the authors commentary.

Perth's institutional setting was dominated by maintaining dynamics (Fig. 2). This was due in part to the prescriptive **governance setting** that horizontally segregated water management responsibilities, employed regulation as the main performance management mechanism, and led to discrete management and service objectives. *"[They] do have such a strong, clear mandate, and that's what they want to stick to, so it's really difficult to get them to shift beyond that"* (senior executive, state government). The maintaining influence this produces throughout the institutional setting is extensive. For example, segregated responsibilities perpetuate a lack of collaboration and historic tensions in **inter- and intraorganizational relationships**. *"Individual personalities—people 'pushing back' and only doing what's strictly in their job description rather than working together"*

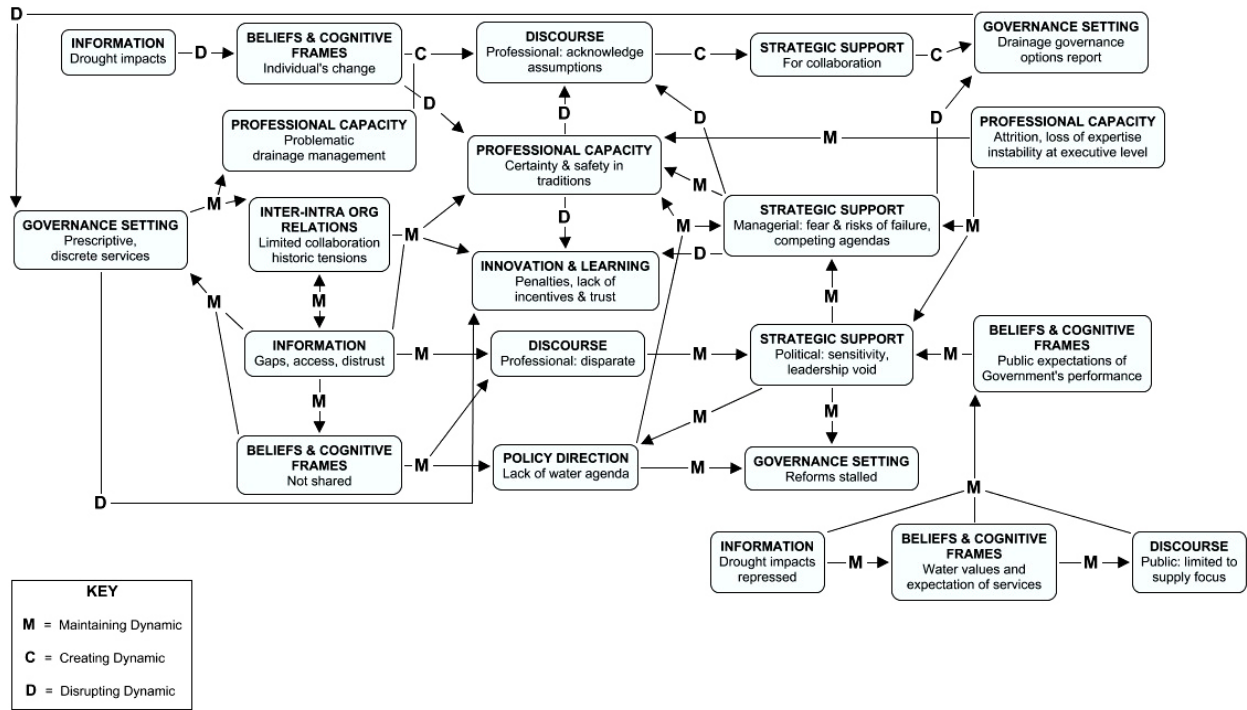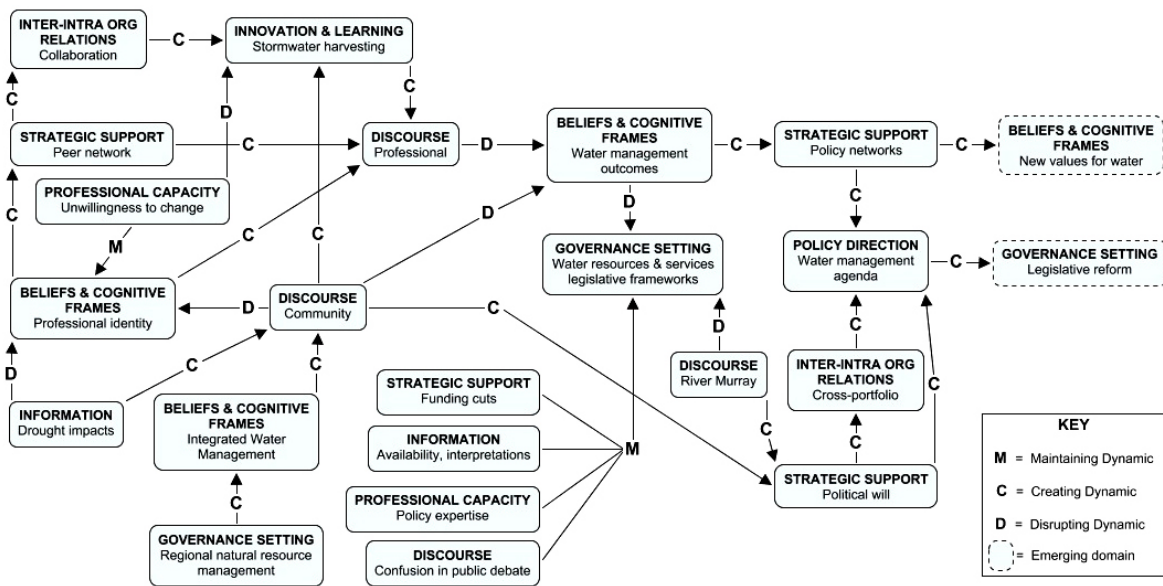**Fig. 2.** Perth institutional dynamics.

Fig. 3. Adelaide institutional dynamics.

(anonymous, workshop participant). However, other less immediately apparent influences were also revealed. For example, in the **information** domain, not only did the absence of trusted information lead to fall back on the certainty and safety of professional practices (**professional capacity**), but the lack of transparency with information contributed to disparate **beliefs and cognitive frames** and hampered the development of shared professional **discourse** around problems and solutions. In the absence of a shared narrative for change from the water sector, **policy directions** were maintained, and no driver emerged to build **strategic support** for change in the form of political will or managerial leadership. *"There's this strong middle layer management that just want to keep doing it the same old way"* (consultant).

As Fig. 2 illustrates, the flow-on effect of these maintaining dynamics are extensive, and some were strengthened through positive feedback loops. For example, the lack of **information** provided to the public on the true extent and costs of water scarcity continued **beliefs and cognitive frames** for the value of water and service-level expectations, and generated little public **discourse** on water issues. All three of these domains in turn maintained the Perth community's **beliefs and cognitive frames** of the good performance of government in delivering expected water services. This situation made the government reluctant to change water services, despite evidence that a cheap, unrestricted water supply was increasingly unviable. *"You've had total sprinkler bans in the east[ern states]; we've never got near that and our government's reluctant to go near that"* (senior executive, state government).

One of the key impacts of the maintaining dynamics throughout Perth's institutional setting was the limited creating and disrupting work. Throughout the institutional setting, a range of disincentives to thinking differently, voicing new ideas, and challenging the status quo were established by strong maintaining dynamics. Detailed analysis of the institutional work of actors revealed: regulative work to deter the application of new ideas; enforcement of current rules by adhering closely to traditional scripts of action and decision logics; and "pushing back" or sanctioning those actors trying to reinterpret these formal and informal rules. Similarly, the embedded problem frames and knowledge assumptions of organizations perpetuated the current management paradigm. From a normative standpoint, lack of scrutiny of the performance of the current water management practices and limited challenges to the assumptions underlying the perceived suitability of these approaches left little scope to reconsider the water supply problem and explore alternative solutions. *"Not willing to invest or innovate as this is a liability"* (anonymous, workshop participant).

Thus, the Perth case analysis showed an institutional setting displaying cognitive, normative, and regulative maintaining mechanisms, locking the city into traditional practice by confining the urban water sector to its current configuration (structure) and service delivery objectives (function or potential). These conditions provided institutional stability and enabled the city to sustain water service levels throughout the drought (i.e., maintain resilience). However, this approach has borrowed water from the future by extracting groundwater at a higher rate than natural recharge while also investing limited resources into experimentation with alternative solutions and narrow reinterpretation of water values and appropriate uses under unprecedented dry conditions. As such, there has been limited learning in how to adapt urban water supply, or consideration of new service standards and objectives under future climatic changes. Without these types of creative and disruptive responses, the city's future resilience may be compromised.

In contrast to Perth, the overall impression of Adelaide's institutional dynamics (Fig. 3) is predominance of creative and, to a lesser extent, disrupting work. Like Perth, Adelaide experienced maintaining influences through **information** availability, confused debates in public **discourse**, and **professional capacity**. However, although these influences maintained the formal **governance setting**, unlike Perth, they did not appear to have blocked creative and disruptive work within **professional discourse**, **inter- and intraorganizational relationships**, and **innovation and learning** domains. *"And we will have a, we will end up having a healthy debate with them about that..."* (senior manager, water utility). Although there was some maintenance of **beliefs and cognitive frames** of traditional professional practices through unwillingness to change **professional capacity**, this seems to have been outweighed by other influences on **beliefs and cognitive frames**. *"These funny people who are responsible for the approval process…[I'm] sick of all these rules which have been there for donkey's years"* (academic/training provider, local university). In other words, the enforcement of outdated cognitive frames through traditional practice is beginning to be challenged by new beliefs and cognitive frames.

One reason for the extensive influence of creative and disruptive work may be the greater public involvement in water management in Adelaide. With a formal avenue for participating in water management through the **governance setting** of regional natural resource management organizations, and extended engagement and education activities offered by these organizations, community understanding of water issues and **beliefs and cognitive frames** around integrated water management had been fostered to a greater extent in Adelaide than was reported in Perth. *"People were rightly asking questions about well, business-as-usual,... Just rolling out more and more mains water from reservoirs is not necessarily the right way to go, and what are you going to do about it?"* (policy officer, state government). This created public **discourse** that had a wide-reaching effect on other domains; creating **strategic support** in the form of political will, challenging the **beliefs and cognitive frames** embedded in current water management objectives and professional identities, and providing a driver for **innovation and learning** in stormwater harvesting and reuse technology. *"There are public perceptions on what is the right and wrong thing to do in terms of integrated water management and what are the best options and what are the bad options and that sort of thing"* (policy officer, state government). *"During the most recent state election, it was one of the main issues, which of the main two parties would do the most stormwater harvesting"* (policy officer, state government).

Other significant creating and disrupting influences were identified in the activities of Adelaide's practitioners. Cognitively, some were reinterpreting and stretching the bounds of legislation by mimicking the decision-logics contained in these formal institutions to accept alternative practices under current

regulation. *"We, as an [approval] authority, waive the requirement for a rainwater tank if they're using recycled water"* (senior manager, local government). Normatively, the **information** on the impact of the drought disrupted traditional **beliefs and cognitive frames**, leading to open professional **discourse** and the formation of **strategic support** within a peer network of like-minded and well-connected practitioners. *"Networks in Adelaide are key. The people in them have been in the business for a long time, so they know the business well, and have long held relationships with trust, and know how to work strategically together"* (anonymous, workshop participant). This network generated collaboration in **inter- and intraorganizational relationships**, critical for creating opportunities for **innovation and learning**. Importantly, the network also created a shared narrative of water scarcity that challenged the **beliefs and cognitive frames** underpinning current water management objectives. Unlike Perth, where a cohesive network and shared narrative were lacking, the practitioners in Adelaide generated **strategic support** for a change agenda in the form of a policy network, formed around alternative water sources such as stormwater, which enabled the adoption of new **policy directions**. Taken together, the influences described led to new thinking about water management in the city, and policy programs and legislative reforms to translate these new ideas into practice (emerging **belief and cognitive frames** and **governance setting**).

Thus, the Adelaide case analysis revealed cognitive and normative reflexivity and regulatory flexibility. These conditions led to the development of decentralized water supply schemes (i.e., system restructure), and new water services, such as fit-for-purpose supplies (new functions or potential). These changes were in the process of being formally established through policy programs and legislative reforms at the time of data collection, suggesting Adelaide may have been moving from reorganizing toward the stabilization phase of the adaptive cycle.

IDENTIFYING ADAPTIVE CAPACITY

Reflecting on the case study results and common themes in the social–ecological systems literature, three key features of system adaptation were evident: capacity to learn, to decide, and to act. Adelaide had taken system feedbacks into account, experimented with new solutions, established new water management objectives, incorporated these into policy settings, and were beginning to mainstream the new thinking and practice through legislative reforms. Perth's feedback systems did not influence the system to the extent required to change beliefs and cognitive frames, or to challenge current practice. As such, learning was limited, decision making was conducted within traditional logics, and support for change and, thereby legitimacy to act, was negligible. The three distinct but interrelated processes of learning, deciding, and acting present three forms of capacity that appear central to adaptation, hence in combination provide an adaptive capacity. It could be further expanded that adaptive capacity in a system enables the ability to:

1. recognize feedback from the operating context;

2. assess this feedback in terms of how it affects the current system's structural integrity;

3. assess the implications of this feedback for the system's functional purpose;

4. determine, based on the outcomes of the two previous steps, what type of adaptation is needed, resilient or transformative; and

5. reconfigure for resilient adaptation or transform to deliver new outcomes.

Points 1–3 represent learning, point 4 represents deciding, and point 5 represents acting capacity. These activities may not occur as sequential steps, or even be completed. In the Adelaide case, novel water schemes were already contributing to new system objectives in the form of fit-for-purpose water sources (i.e., point 5) before new policy directions had been agreed and reforms decided (i.e., points 3 and 4). The Perth case arguably showed the omission of point 3, with limited consideration for how contemporary water-use behavior may not be possible in a drying climate. Neither will these activities occur intentionally in all cases. In both cases, the activities occurred largely in isolation, reacting to the drying conditions as they progressed and not within a planned logic of response. These observations imply that at various points of the adaptive cycle, adaptive capacity encompasses different levels of learning, deciding, and acting capacity. The key question for adaptive capacity research is whether better understandings of when and how to harness learning, deciding, and acting capacity will enable a more proactive adaptation response, or more preparedness for reactive responses to surprise. Hill and Engle (2013) highlight tensions between reactive and proactive responses, in that actions at different spatial and temporal scales may not result in a synergistic effort to address problems. Although this study did not look at responses across different governance scales, the results did not suggest tensions between proactive and reactive responses within the relatively integrated multilevel governance system of municipal–state urban water management in the cases. More work is required to establish if the forms and mechanisms of adaptive capacity for proactive and reactive responses are mutually counterproductive or can exist simultaneously.

Considering these three potential forms of capacity and the empirical results, we now discuss possible mechanisms of adaptive capacity, particularly in relation to common tenets of adaptive governance recognized in the social–ecological systems literature.

Learning capacity: information, feedbacks and transparency

Social learning is often cited as a key ingredient of adaptation (Lee 1999, Pahl-Wostl et al. 2007, Chapin et al. 2010, Pearson et al. 2010). However, it has been recognized as a problematic way of linking causal action with sustainable outcomes (Reed et al. 2010, Cundill and Rodela 2012), viewed as somewhat of a panacea (Huitema et al. 2009), and operationally difficult to achieve due to conflicting worldviews and contested knowledge (Ison et al. 2007). Nevertheless, the availability, access, and interpretation of information to provide feedback within a governance system are critical elements of the adaptation processes (Olsson et al. 2006, Huntjens et al. 2010, Engle 2012, Hill and Engle 2013). In both Adelaide and Perth, participants recognized information gaps about the water management system's performance in light of new environmental conditions. In Adelaide, information on drought impacts was also publicly acknowledged. This generated community discussion on the water scarcity situation and challenged the assumptions and principles of professional practices. Thus, disruptive and creative influences were generated

throughout the system. In contrast, limited public recognition of drought impacts in Perth maintained the assumptions underlying water management institutions, did not stimulate public discussion of water issues, nor prompt reconsideration of water use behavior and service delivery requirements. The public's expectations for water supply, only weakly informed by the limitations of the drought, became an increasing public relations issue for government, increasing political sensitivities hence decreasing strategic support for change. In addition, lack of access to information on costings and performance of current water management systems strengthened maintaining dynamics, by shutting off important feedback mechanisms and blocking a more balanced consideration of alternative water services solutions with multiple benefits.

While confirming the importance of learning in adaptation, this study also highlights social learning arguments in the social–ecological systems and water governance literature, in that there is limited understanding of how the content, depth (i.e., single, double, or triple loop, following Argyris and Schön (1978)), and learning outcomes will vary across the adaptive cycle. To illustrate, learning in the Adelaide case included the reevaluation of water's value to society, and thereby the principles underpinning water management in the city. This reevaluation of water system performance in light of underlying principles is referred to as double-loop learning (Reed et al. 2010). The Perth case presented a classic example of single-loop learning, where information and feedback was processed to optimize current system performance. This depth of learning may be problematic in a locked-in system such as Perth, but may be desirable in a stabilizing system, where practices and processes need to be refined to achieve the new objectives, or potential, of the system. The results of this study suggest that understanding the forms of learning (single, double, and triple loop) dominant in different phases of adaptation, and the effect (maintaining, creating, and disrupting) this learning capacity exerts on other system conditions (e.g., management structures, objectives and outcomes sought, institutional instruments utilized) will be critical to the ability to harness adaptive capacity.

Deciding capacity: participation, collaboration, and power
A key explanatory factor for the different progression of reform (i.e., structural change) in each case was the dynamics created in the professional discourse domain: critical for producing shared understandings, problem frames, and solution options. In Perth, beliefs and cognitive frames were challenged at an individual level, but maintaining dynamics from the professional capacity domain countered opportunities for discussion of this increasing dissonance between traditional frames of reference and changing operational conditions. This maintaining influence resulted in practitioners seeking safety in traditional practice. In contrast, challenges to beliefs and cognitive frames in Adelaide emerged from professional and public discourse on water issues. This relationship between the belief and discourse domains generated widely shared frames of reference as well as momentum, in the form of policy networks and political support, to progress new ideas. The progression of new ideas into reform actions was also influenced by the different inter- and intraorganizational relationships within each city; Perth's being strained and uncollaborative, and Adelaide's displaying greater cohesion.

These insights on translating new ideas into proposed actions correlates with ideas of participation and collaboration highlighted by a variety of scholarly perspectives on system change, including social–ecological systems theories, social innovation, policy entrepreneurs, and sustainability transitions. The need to involve stakeholders, so that multiple views and perspectives can be aligned and common values and problem frames established, provides the basis for developing shared visions or objectives, and gaining commitment to these change agendas through policy or plans (Olsson et al. 2006, Huitema et al. 2009, Gupta et al. 2010). However, this process is often considered under the label of learning (Ison et al. 2007, O'Brien 2012, Bos et al. 2013). The results of this research suggest that the translation of such cognitive developments into tangible ideas and commitments should be considered separately, as a process of negotiated collective decision making. Learning has altered the frames of reference for urban water managers in both Perth and Adelaide, but collective decisions about the implications of these cognitive developments, what (if anything) needs to change as a result, and how best to make the changes, differentiate the two cities. This process of appropriating the ability to make and gain commitment to change agendas through social learning assumes direct connections among understanding, attitudes, and behaviors and disguises the contested nature of decision-making processes and other influences on behavior, such as authority and politics (Ison et al. 2007, Mollinga 2008, O'Brien 2012). Questions of who is included and whose perspective and voice are heard are important for social learning processes. Who wins and who loses and what is at stake must also be asked once the task turns to deciding what happens next. Answering these questions involves understanding where in the institutional setting power and influence lie (O'Brien 2012, Vink et al. 2013). In the Perth case, power is embedded in prescriptive governance arrangements and the inflexible interpretations of rules. In Adelaide, influence from public discourse and the ability of practitioners to collectively consider the implications of what had been learned helped to mobilized strategic support for change in the form of political will. These results suggest that examining the translation of new knowledge into shared objectives and action plans as a process of negotiation and decision making would help provide a more fruitful understanding of what capacities are needed to agree on shared visions and commit to subsequent objectives and action plans. Specifically, a more nuanced understanding of how institutional dynamics influence participation, collaboration, and power in decision making should shed light on the quality of decision-making processes and their change impact on system conditions.

Acting capacity: leadership, networks, and flexible governance
A final key difference in capacity observed in the case studies was the creation of a pathway to realize system change through innovation, experimentation, and commitment. Adelaide followed a pathway to policy reform (system change) by implementing alternative water supplies and advocating their broader uptake. Collaborative culture in inter- and intraorganizational relationships and flexible interpretations of administrative and regulative frameworks enabled experimentation with technology and system configurations to successfully capture and treat storm water. Changes in the beliefs and cognitive frames of professional practice led peer networks to coalesce

around these solutions. The existence of a viable alternative water supply that did not align with assumptions of what constituted "safe" water supply or current service delivery goals (i.e., drinking-quality water supply vs. fit-for-purpose sources) drove a reconsideration of water management objectives. The performance of traditional supply solutions was assessed against these new cognitive frames. The emerging new frames, principles, and logic for water management, coupled with engaged citizens and a policy-connected water sector, catalyzed disruptive influences on governance arrangements and garnered strategic support for reform. In Perth, land-use development policy drove innovation by placing the onus of finding adequate water supply for new developments largely on private developers. This situation also generated support for incorporating water management planning into land development legislation. However, without a network of professionals seeking and sharing knowledge of alternative water supply schemes, these innovations, and the possible water management objectives they espoused, were not translated into a compelling argument for change.

These results follow the repeated observation that various forms of leadership are required in change processes to make sense of issues, facilitate relationships, build partnerships, exploit opportunities, garner resources and support, and maintain direction and momentum (Olsson et al. 2006, Engle 2012, Westley et al. 2013). However, the experience of Perth also supports the conclusions of Westley and colleagues (2013) that the emergence of leadership can be highly dependent on the institutional context. As the Perth case demonstrated, when maintaining dynamics are strong, the cost of transformative leadership is high. Perceived benefits accompanying a reputation as an innovator or change agent are not as high as the costs of being viewed as an agitator. Actors, both individual and organizational, are unlikely to risk professional reputations to advocate for change or champion alternatives, or are simply unable to. These results point to a gap in understanding how different forms of transformative agency are enabled, or disabled, by the institutional context. As Westley et al. (2013) note, knowledge of how various skills and strategies associated with leadership are supported within different opportunity contexts is sparse. This is particularly problematic for adaptive capacity, as understanding how certain leadership skills mobilize the development, legitimization, and resourcing of a purposive change agenda is foundational to the idea of a proactive form of capacity. These findings highlight the need for research focused on how institutional context constrains the actions of various change agents (e.g., leaders, entrepreneurs, networks) and how these agents use particular institutional instruments to set up dynamics within institutional domains that open pathways to fundamental system change, be it structural or functional.

CONCLUSION: PROPOSITIONS FOR IDENTIFYING ADAPTIVE CAPACITY IN PRACTICE

The analytical framework employed in this research offered a means of identifying and exploring the institutional dimensions of resource governance systems. This approach shows potential for understanding how various system conditions and attributes generate different components of adaptive capacity, by:

- mapping the dynamics (maintaining, creating, disrupting) generated by particular institutional conditions within various domains of the system;

- tracing the influence of these dynamics to the system's adaptive phase and possible trajectory;

- identifying the specific institutional instruments (cognitive, normative, and regulative) employed by agents that produce the dynamics; and

- recognizing how different institutional conditions and dynamics can empower or disempower actors to express their transformative agency.

In doing so, this research has demonstrated that using institutional conditions and dynamics as a heuristic device provides a means of identifying the components of adaptive capacity in resource governance systems. Furthermore, the techniques employed in this study show potential for explaining the adaptive capacity within systems at different phases of adaptation. Developing this insight further will help move adaptive capacity scholarship toward more applied research to enable the active utilization of adaptive capacity to strengthen proactive adaptation and improve reactive responses. To these ends, propositions about the institutional conditions and resultant components of adaptive capacity in the four phases of the adaptive cycle are put forward in Table 3.

The institutional conditions used in Table 3 to describe the system under consideration are drawn from the analytical framework used in the study, and include:

- The degree of structural connectedness in the system. This may involve the level of integration between administrative, regulative and legal frameworks, and the cooperation between organizations and other informal relationships.

- The degree to which the system is attaining its potential. This entails whether the goals or outcomes foundational to the system's purpose, are being attained.

- The dominant dynamic of the system—maintaining, creating, or disrupting. This may be determined by assembling the variety of dynamics displayed within and between institutional domains of the system.

- The dominant institutional instruments generating the dynamics observed—cognitive, normative, or regulative. This may be identified by examining the various institutional work strategies being conducted by actors.

These institutional conditions combine to produce forms of adaptive capacity characteristic to each phase of the adaptive cycle, composed of varying learning, deciding, and acting capacities. Propositions about these conditions and capacities based on the results of this research have been proposed in Table 3 for Locked-in and Reorganizing systems. Tentative propositions for Crisis and Stabilizing systems have been extrapolated from the study results. These propositions provide a starting point for identifying and explaining the underlying mechanisms of adaptive capacity and testing how different capacities in learning, deciding, and acting combine to create resilient or transformative adaptation.

Further application to a range of cases at different phases of the adaptive cycle and from diverse contexts will be needed to validate and refine these propositions. In particular, the lock-in phase should be a targeted area of study, as this "rigidity trap" in the system is where adaptive capacity is seeming least available, but

Table 3. Propositions for identifying adaptive capacity in practice

	Lock-in	Crisis	Reorganization	Stabilization
Institutional conditions				
Connectedness and potential	High connectedness, optimized performance to deliver outcomes	Rapid disconnection, following ineffective performance and/or inappropriate outcomes	Development and testing of new connections, suboptimal performance as new outcomes are identified	Increasing connectedness, continual improvement in performance to deliver outcomes
Dominant Institutional Dynamic	Maintaining	Disruptive	Creative	Maintaining
Dominant Institutional Instruments	*Normative and regulative:* Institutional stability formed through entrenched practices and first principles	*Cognitive and normative:* Dissonance between normative foundations and emerging cognitive frames cause regulative to lose legitimacy	*Cognitive and normative:* New normative associations and related cognitive frames and logics developed	*Regulative and normative:* New cognitive frames are institutionalized in regulations and norms
Forms of adaptive capacity				
Learning capacity	*Single loop:* System focused on optimizing performance	*Triple loop:* Crisis highlights assumptions behind system structures and functional outcomes. System must reassess "fit" to new operating conditions	*Single and double loop:* System monitors performance against new objectives, refining objectives and actions to achieve	*Double and single loop:* System moves toward formalizing new objectives, principles, and assumptions in governance arrangements
Deciding capacity	*Day-to-day:* Objective clearly defined, established logics to decide actions	*Fundamental:* Values, beliefs, assumptions, and first principles no longer hold. Significant decisions about purpose of system need to be made	*Complex:* As the system reorganizes, many interrelated decisions about how best to deliver new outcomes need to be made	*Day-to-day:* System fine tunes performance to new objectives
Acting capacity	*Highly entrenched:* Traditional scripts of behavior and standard operating procedures prescribe actions	*Disparate and conflicting:* Outcomes and objective unclear, actions become uncoordinated and may conflict	*Learning-by-doing:* Widespread experimentation with new practices to establish best practice	*Narrowing:* As system becomes more efficient, the range of activities narrows

when it is most critical for anticipating and planning for resilience or transformation. Further work to define and describe system connectedness and potential will be needed, as these system characteristics provide the criteria for positioning cases on the adaptive cycle.

There is also much scope for exploring and refining suitable methods for eliciting knowledge on the institutional settings of cases. The use of concept maps in this study proved a useful technique for organizing complex and largely abstract information on the institutional setting of cases. However, there may be limitations to accessing the information required for these mapping exercises, as the technique relies on the experiential and largely tacit knowledge of participants. Care also needs to be taken to seek and capture a variety of perspectives in the concept mapping exercise, through both participant selection and including mechanisms for internal and external validation of the maps in the research design.

Due to its early stage of development, institutional work theory has not yet answered questions about the relationships between different dynamics. For example, are both creative and disruptive influences needed (Lawrence et al. 2013)? Is the process of

embedding new institutions a particular form of maintaining work, or a distinct, fourth dynamic? Identification of specific cognitive and normative mechanisms also requires a high level of expert judgment. The approach described herein could be adjusted to include quantitative measures and weightings of these institutional variables, enabling comparative assessments to further develop institutional work theory. However, this will require development of robust tacit knowledge capture techniques and indicators for informal institutional features.

Despite these limitations, this exploratory study has demonstrated the potential of the analytical framework to aid understanding of adaptive capacity in practice. Comparing these two cases of lock-in and reorganization has provided tentative propositions regarding, first, the roles adaptive capacity plays in adaptation processes (learning, deciding, acting) and second, the dimensions for identifying ingredients of adaptive capacity (institutional conditions, dynamics, and instruments). The paper has provided a stronger conceptual base for identifying and understanding adaptive capacity, through the analytical framework developed and the theoretical propositions put forward for further testing. In conclusion, we argue there is both theoretical and practical value in pursuing research into adaptive

capacity using an agency-oriented perspective, so as to understand how to realize system adaptation through more proactive practice, in order to deal with global environmental changes.

Responses to this article can be read online at: http://www.ecologyandsociety.org/issues/responses. php/7291

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APPENDIX 1. Perth Case Study Overview.

Perth is a city of 1.7 million people (Australian Bureau of Statistics 2013) inhabiting a coastal strip of south-western Australia. Winter dominated rainfall, hot dry summers (Australian Bureau of Meteorology, 2012) and sandy, porous soils give Perth the highest domestic use of water in Australia (Water Corporation 2009). Since the mid-1970s south-western Australia has experienced a decrease in rainfall (Bureau of Meteorology 2010), and inflows into Perth's dams have declined significantly (CSIRO 2009). To meet demand, the city increased extraction of the region's extensive groundwater systems. However, monitoring has shown a decline in the main aquifers used to supply the city (CSIRO 2009). Further detail on Perth's management and governance responses to water scarcity are summarized in the timeline below.

- **1975 – 2000**
  50% reduction in inflow to surface water storages based on pre 1975 long-term average. Various demand management water restrictions implemented. Groundwater extraction is increased to meet supply demands.

- **1986-1993**
  Concept of Water Sensitive Urban Design (WSUD) emerges in research and guidelines for implementation are developed.

- **1996**
  Following national water reform and competition policy initiatives, the WA water sector is corporatized into a services utility (Water Corporation), water resources development and conservation agency (Water and Rivers Commission) and regulatory body (Office of Water Regulation)

- **2001 – 2010**
  Surface water storage inflows continue to reduce. Total inflow of 6.2GL for 2010 is lowest in a century long record.

- **2001**
  Seasonal water sprinkler ban introduced.

- **2003**
  State Water Strategy released. Sets broad agenda for sustainable water management, and acknowledged the need for governance reforms.
  Various education, research, industry engagement and rebate programs to promote water efficiency established.

- **2004**
  Kwinana recycling plant opens to supply fit-for-purpose recycled wastewater for industrial use.
  'Security through Diversity' approach to water management adopted by Water Corporation. Includes plans for desalination, development of groundwater sources, and further demand management education campaigns.

- **2005 – current**
  Mining resource boom drives high economic growth and subsequent population growth and land development.

- **2005**
  Opposition loses state election largely on basis of water policy platform.
  12 year catchment 'thinning' trials to increase run-off begin
  Dedicated water policy agency, the Department of Water, is created.

- **2006**
  A blueprint for water reform in Western Australia in 2006 released, providing key recommendations on governance reform.
  Water Resources Legislation Amendment Bill transfers many functions and powers for water management to the Minister for Water (administered by the Dep. Of Water).
  The Perth Seawater Desalination Plant, Australia's first, is brought online to supply 45GL of Perth's potable water supply.

- **2007**
  State Water Plan released. Provides strategic framework for water resources planning and management.

- **2008**
  Better Urban Water Management released. Provides guidance on incorporating WSUD into land development through State Planning policies.

- **2009**
  Water Corporation's water supply management plan, *Water Forever*, released. Plans for reducing water demand, increasing water recycling, and development of new water sources.
  CSIRO Sustainable Yields research finds that groundwater systems are experiencing stress.
  Capacity of the desalination plant to be expanded to 100GL, supplying approximately 50% of current potable water demand.

- **2010**
  Significant water restrictions imposed.
  Three-year trial of Managed Aquifer Recharge begins.

- **2011**
  Water Corporation releases updated *Water Forever* plan. Emphasis on increasing recycling, desalination capacity and securing groundwater sources to offset current surface water supplies.
  The Southern Seawater Desalination Plant brought online, supplying 50GL of potable water.
  The WA Local Government Association develops an investment plan for the Swan-Canning Catchment, raising issues and options for drainage governance.

- **2012**
  Water services legislation is passed to cut red tape, increase competitiveness and ensure service efficiencies and standards.
  Relevant organizations sign partnership agreement to improve urban drainage management.

- **2013**
  The Southern Seawater Desalination expansion due for completion, increasing the city's desalination capacity to approximately 50% of its potable water supply needs.
  Governance reforms to water resources management legislative framework ongoing.

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APPENDIX 2. Adelaide Case Study Overview.

Adelaide is a city of 1.2 million people (Australian Bureau of Statistics 2013) stretching along the eastern coastline of the Gulf of St Vincent, and spreading inland to the Mt Lofty Ranges. Like Perth, Adelaide's climate is hot and dry in summer with winter dominated rainfall (Australian Bureau of Meteorology 2013). However, limited surface water resources make Adelaide the driest capital city in Australia (Office for Water Security 2010). Like much of the south-east of the Australian continent, Adelaide's climate began to shift to drier conditions in the late 1990s (Australian Bureau of Meteorology 2010). While the Adelaide region did not experience water scarcity till the mid-2000s, the city's major water source, the River Murray, had been experiencing record low runoff from 1997 (CSIRO 2008). As an inter-jurisdictional, over-allocated and nationally iconic river system, the health of the River Murray generated nation-wide public discourse and political discussion on the fate of this water resource. Due to Adelaide's high reliance on the river for potable supplies, inter-state politics and public engagement in water issues are influenced significantly by these national debates. Adelaide's management responses to the drought are outlined in more detail in the following timeline.

- **1990s – current**

Inflows to surface water storages reduce to approximately 65% of long term average. Inflows to Murray-Darling Basin system also reduced. City of Salisbury experiments with stormwater harvesting and aquifer recharge to maintain wetland health. Begins using harvested water for public open space watering, eventually expanding operations into a local government owned water utility supplying fit-for-purpose domestic and industrial water use.

- **1995**

Following national water reform and competition policy initiatives, water utility was corporatized (SA Water Corporation). Outsourcing of major functions through private sector contractors.
Catchment Water Management Act establishes regional management of water resources, with the provision of funding for catchment improvements through a levy.
The need for a transparent process to allocate funds from the levy drives significant community education and engagement activities.

- **1997 – current**

A number of wastewater recycling projects progressively increase city's capacity to recycle 25% (as at 2012) of wastewater for non-potable reuse.

- **2003 – current**

Range of water restrictions and education campaigns reduce domestic water consumption.

- **2004**

Natural Resources Management Act replaces *Catchment Water Management Act*, representing an integrated approach to natural resource planning, protection, water allocation and management. Includes formal mechanisms for community involvement in catchment planning.
SA becomes a signatory to the National Water Initiative.
SA signs Murray-Darling Basin (MDB) Water Agreement, a Commonwealth led initiative to reduce over allocation and improve the health of the Basin.

- **2005**

Diversification of water sources discourse emerges in Government water planning strategy: *Water Proofing Adelaide*.

- **2006**

Driest period on record experienced in late winter/early spring.
Murray-Darling System experiences lowest inflows on record. Adelaide's water security is significantly threatened.
SA Government mandates the installation of rainwater tanks on all newly built homes.

- **2008**

Independent Commissioner for Water Security appointed. Tasked with producing a whole-of-government strategy for water security.
Agreement on significant governance reform of the Murray-Darling Basin signed by relevant State, Territory, and Commonwealth Governments. Through this agreement SA secures greater storage capacity to capture Adelaide's full water extraction entitlement from Murray-Darling Basin system.

- **2009**

Economic Statement of the South Australian Economic Development Board recognizes access to water as a limiting factor to the State's economic growth prospects.
$150 million investment from Commonwealth, State and Local Government to provide non-potable supplies through stormwater harvesting, with an interim target of 20Gl by 2013.

- **2010**

Water for Good strategy for securing water supplies is released by Commissioner for Water Security.
State Government Department for Water formed to take carriage of water policy and provide a focal point for integration of water management activities.
30 Year Plan for Greater Adelaide released by the Dep. Planning and Local Government. Includes explicit objective to reduce water consumption in new dwellings.

- **2011**

Adelaide Desalination Plant (ADP) comes online at 50GL/annum capacity.
Commissioner for Water Security steps down, State Government abolishes the position.

- **2012**

SA Water announces the ADP to be placed in 'standby mode' when sufficient, cheaper water is available.
Water Industry Act introduced to open water services provision up to greater competition, with supporting regulatory and consumer protection mechanisms.
Department for Water amalgamated into the Department of Environment, Water and Natural Resources.

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