# CLIMATE AND CHANGE IN BRAZILIAN WATER MANAGEMENT: A CASE STUDY OF GOVERNANCE AND ADAPTIVE CAPACITY

By:
Owen Johns

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Faculty Advisors:
Associate Professor Maria Carmen Lemos, Chair
Professor Dan Brown

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## ABSTRACT

To address the growing stressors on freshwater resources, efforts to improve water management have included institutional and governance reforms, rearranging our social interaction with the environment. Some tenets of the reforms touted by international organizations and academics include integration of actors in management, participation of official stakeholders and civil society, deliberation and conflict management. Improving institutional capacity and governance are also highlighted as important components to foster adaptive capacity to climate change, that is, the ability to respond and recover to impacts in a manner that mitigates damage and takes advantage of opportunities. Yet, the literature includes relatively few studies of the specific governance factors that contribute to adaptive capacity. This study looks at the role of governance in Brazilian water management reform through an analysis of four basin-level case studies: the Paraíba do Sul, Lagos São João, Itajaí and Lower Jaguaribe. The Brazilian reform established basin-level committees to promote participatory management by public agencies, water users and civil society. This study investigates the variable success in the implementation of the reform and the effect of these governance changes on response to specific climate events. Findings show that governance indeed plays a role in promoting adaptive capacity. Furthermore, this analysis shows how financial and physical resources are inherently important to enable effective governance, and that critical components include integration, knowledge, democratic participation and conflict management. However, the reform has not improved adaptive capacity in all cases, in part due to governance failures, but also due the neglect of the committees to include disaster relief agencies and incorporate flood planning into their activities. In addition, a greater integration of complementary development issues, namely urban land management, would increase adaptive capacity in the cases.

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# I. INTRODUCTION

Despite having the largest freshwater resources in the world, Brazil has historically suffered from water-related problems including rampant pollution, shortages and flooding (ANA, 2006). Climate change will compound these existing water-related problems in Brazil by increasingly threatening water resources. This places pressure on water management systems that suffer from historical legacies of mismanagement. Significant effort in the climate change field has focused on improving our understanding of adaptive capacity, that is the ability of systems to adjust and cope with changes, take advantage of opportunities and moderate damages (Parry, Canzaiani et al. 2007). Adequate governance mechanisms and institutional arrangements are increasingly seen as inextricable elements of the adaptive capacity to climatic shocks (Brooks, Neil Adger et al. 2005). Hence, in the context of water resources, the looming challenge of climate change makes good water management practices even more salient in order to promote adaptive capacity. In order to address the multiple stressors on freshwater supplies, Brazil has heeded these calls for reform from academia and international bodies, to make water resources governance more sustainable and effective, which should have ancillary benefits on responding to extreme events (see for example, UNESCO 2006).

Brazil's attempt to improve governance through water management reform incorporates elements that are consistent with prescriptive water management approaches, including integrated water resources management (IWRM) and adaptive management. IWRM focuses on decentralizing water management to the basin scale and coordinating various elements of planning, such as water quality and quantity, land use, infrastructure and ecosystem health (Blomquist, Dinar et al. 2005). This paradigm shares institutional elements with approaches that are advocated in the literature to enhance adaptive capacity, such as adaptive management, which is an intervention to manage uncertainty with flexible institutional processes that continuously evaluate and revise management interventions through process-based learning (Huitema, Mostert et al. 2009). This study focuses on the experience of Brazil in pursuing reform in the water sector and investigates to what extent these governance and institutional rearrangements improve adaptive capacity. In doing so, it seeks to answer what factors contribute to variable success of the reform process in different cases and how governance changes have affected adaptive capacity.

In Brazil, the push for water reform came in the 1990s as states began to break away from the top-down and command-and-control style of management typical to Brazil's legacy of technocratic public management and move towards more inclusive forms of governance at the river basin level. In 1997, Brazil passed legislation that called for nationwide water sector reform based on these new principles, allowing states to manage their own water resources and promoting local basin committees that include stakeholders from civil society, public representatives from multiple scales, and water users. The formation of river basin committees followed the principles that water is a finite good with social value, ecosystem-based management structures are more effective, and that stakeholders should be involved in water management (ANA, 2006). This integrated approach represents a marked change from Brazil's historical management of water as an engineering problem focusing on the deployment of large infrastructure projects to optimize water resources for hydroelectric production. The goals of stakeholder involvement, participatory governance structures, ecosystem-based management, and the focus on decentralization represent significant improvements in water governance that echo IWRM and adaptive management theories. The reform has changed the institutional structure and processes related to water management, but in many ways is still incomplete or has resulted in tensions that have limited the maturation of reform.

This paper will investigate the successes and failures of the Brazilian water reform in the context of adaptive capacity and response to extreme climate events. Successful management changes should improve the adaptive capacity in different basins by promoting governance processes and institutional arrangements that allow for flexible decision-making regarding water management, which has intrinsic linkages to flood and drought events. The integration of stakeholders and issues, and the decentralization of decision-making to the basin-scale allow for more comprehensive and interactive decision-making that considers local realities, resulting in more effective responses to extreme climate events. Hence, the governance changes inherent in the reform should contribute to a higher adaptive capacity. In investigating the relationships between governance and adaptive capacity, I look at the experiences of four basins in undertaking the reform and the institutional character of the resulting water management regimes. The Itajaí, Lower Jaguaribe, Paraíba do Sul and Lagos São João river basins range in their size, socioeconomic conditions, and experiences with climatic stressors. The implementation of the reform in the different cases has involved the formation of new basin

committees, which alter the power dynamics and relationships among existing agencies. Through case study comparisons, I investigate the general question of how implementation of the reform may contribute to the different levels of adaptive capacity in these four basins. In doing so, this paper seeks to answer the specific questions:

1. **How successful has water management reform been in the four cases in terms of the governance capacity and performance of basin committees?**
2. **How does adaptive capacity vary in the four cases in terms of successful response to extreme events by the relevant agencies?**
3. **What role have the water reform and basin committees played in affecting this adaptive capacity?**

Engle and Lemos (2010) investigate the water reform in Brazil in the context of institutions and governance and their role in shaping adaptive capacity. I seek to build on their study to give a deeper qualitative analysis of how specific governance factors enable the response to extreme climate events. This analysis expands on the range of governance variables explored in Engle and Lemos (2010) and includes a more in-depth analysis of how the different governance factors are significant to adaptive capacity, in addition to investigating how these variables might relate to one another. Drawing on the literature on IWRM and adaptive management, I focus my analysis of governance variables on integration, democratic participation, knowledge use and conflict management, which are enabled through effective resources (financial, technical and physical). I hypothesize that effective maturation of these specific governance processes should bolster adaptive capacity, and that there are relationships among these variables that shape water management performance.

Nonetheless, while many of the governance elements that enable the reform should increase the adaptive capacity and response to events, there may be unforeseen challenges or trade-offs, which I seek to identify. For example, integration should lead to greater policy coordination, which should improve the overall response and integrity of stakeholders making decisions in the system, but may also lead to bureaucratic competition. Furthermore, deeper democratic decision-making should improve locally relevant decisions that consider the ecosystem function, but may restrict the flexibility to make rapid decisions in extreme events due to increased deliberation and conflict. Integration and democratic participation should improve

knowledge diffusion, but may also slow decision-making as actors are exposed to multiple sources of information. I also expect that factors such as pre-existing power relationships, entrenched bureaucracies or lack of resources can thwart the successful implementation of the governance prescriptions of the reform, such as expanding democratic participation. Hence, the legacy of existing institutional dynamics should shape the path of the reform in the different cases. This study will explore these possible incompatibilities and synergies among such governance variables.

This practicum represents a partnership of the University of Michigan with the *Projeto Marca d'água,* or Watermark Project, which is an interdisciplinary academic collaboration to investigate water reform in 18 basins in Brazil. In pursuing this practicum, I draw on data from previous research collected by the Watermark Project and continue the study of water management reform in Brazil especially in the context of climate change and adaptation. This practicum also developed out of a partnership with the State Institute of the Environment (INEA) in Rio de Janeiro, which provided logistical support and helped to develop the research questions involved in this study. In developing the rationale of this practicum and conducting research, I worked with officials from INEA and other agencies that have participated in the Watermark Project. The results of this practicum are relevant for increasing the knowledge of water management reform in Brazil and improving adaptive capacity. This study will add to the understanding of adaptive capacity at the basin scale through case studies and the possible governance tradeoffs with the reform. Furthermore, I hope to identify factors that may improve or hinder policy implementation and adaptive capacity, in addition to identifying areas where further research could improve understanding of climate change and water resources.

The following section will outline the literature on management theories that inform the framework of this study. This includes elaborating the various currents in integrated water resources management, adaptive management and the role of governance in increasing adaptive capacity. The paper then engages in a background discussion of the history and nature of reform in Brazil, an overview of the specific basins, and the institutional structures involved in water management in the four cases. This is followed by a discussion of the research methodology and sources of data used in this research. Results of the data and the interviews comprise the next section. For each of the four cases I outline the elements of governance and the success of the reform, followed by a discussion of the response to specific extreme events to investigate

adaptive capacity. The final section of the paper compares the cases in terms of institutions and governance in the reform process, identifying relationships between the governance and the response to extreme events to draw conclusions on adaptive capacity. Finally, in the conclusion, I discuss the results and highlight some of the implications of this work on the reform process in Brazil and more generally, the implications for management and adaptive capacity, and areas of future research.

# II. LITERATURE REVIEW

Watershed management has traditionally relied on top-down hierarchical control of resources by centralized governments that impose regulatory frameworks on resource users. This emphasis on rigid control of natural processes can marginalize users at the local level and sacrifice the long-term sustainability of ecosystems (Holling and Meffe 1996). To address the complex and emerging challenges to water resources, a rich literature has developed from a variety of different disciplines, providing theory and management paradigms. Integrated water resources management (IWRM) is perhaps the most popular new management paradigm that addresses the perceived failures specific to the water sector, including hierarchical and centralized control of water resources. IWRM challenges the tradition of command-and-control by promoting integration across sectors and users, decentralization and management at the level of the basin (Blomquist, Dinar et al. 2005). The Brazilian model of reform closely resembles IWRM in its features and prescriptions. Nonetheless, other paradigms that are not tailored exclusively to water resources have become increasingly popular in redressing the mismanagement of natural resources by emphasizing regimes that are flexible, adaptive and able to respond to uncertainty in climatic changes.

One of these new paradigms, adaptive management, embodies a series of linked iterative steps including problem identification, collaboration, hypothesis testing, planning, experimentation, and monitoring in order to manage resources in the face of uncertainty (Habron 2003). Adaptive co-management uses flexible community-based systems of organizations working at different levels to provide resource management tailored to a specific place (Olsson, Folke et al. 2004). Adaptive governance incorporates both adaptive management and co-management, using iterative and participatory adaptive management of ecosystem dynamics operationalized through co-management, thus expanding the scope of ecosystem management to include social dynamics of the system through ordered rule and collective action. These adaptive paradigms intend to increase the resilience, or the ability of a system to absorb disturbance and maintain the same structure and function, which is broadly analogous to adaptive capacity (Folke, Hahn et al. 2005). While distinct in their disciplinary origins and respective epistemic communities, IWRM and the adaptive paradigms share features and goals, and they are increasingly used interchangeably or in blended frameworks (Engle, Johns et al. 2011). In some

respects, adaptive management is viewed as a path towards the broader goals of sustainability under IWRM through the emphasis on experimentation and learning (Pahl-Wostl 2007). Table 1 defines and compares some of the fundamental concepts of the approaches.

The fundamental distinction is IWRM's goal of the sustainability of water resources specifically, whereas the adaptive models seek to foster flexibility, adaptive capacity and resilience in general. Nonetheless, many of the tenets of IWRM and the adaptive paradigms promote governance and institutional qualities that increase adaptive capacity in theory. While the Brazilian reform does not formally espouse an adaptive model, many of the elements of these paradigms are explicitly evident in the Brazilian effort, such as increasing participation and collaboration, or implicitly as factors that bolster the success of the reforms, such as knowledge use and flexibility (Engle and Lemos 2010). In order to understand water management and the Brazilian reform in the context of responding to extreme events, it is necessary to outline the institutional and governance factors that contribute to higher levels of adaptive capacity in theory, many of which are embedded in the adaptive management and governance paradigms. This literature review will examine the theoretical tenets of IWRM, the adaptive management

| Management Type | Definition | Key Concepts |
|---|---|---|
| Integrated Water Resource Management | "...A process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2000, 22) | Watershed as management unit; consensus; participation; stakeholder interests; sustainability; entire water cycle; integration of spatial and temporal scales |
| Adaptive Management | "Adaptive management approaches explicitly recognize the existence of uncertainty and propose that a range of management alternatives be tested and refined over time based on a careful comparison of the results…" (Gregory, et al 2006, 435) | Uncertainty; modeling; experimentation; learning; monitoring; cooperation; leadership |
| Adaptive Co-Management | "…Flexible community-based systems of resource management tailored to specific places and situations and supported by, and working with, various organizations at different levels." (Olsson, et al 2004, 75) | Flexible; community-based; networks; diverse stakeholders; knowledge; cooperation; collaborative learning |
| Adaptive Governance | Goes beyond adaptive management to broaden the scope to the social dimensions, not just working with and responding to the ecological aspects of the system. The framework stresses experimentation and learning, linking a broad range of actors at various scales to deal with dynamics of resources and ecosystems, including uncertainty, unpredictability and surprise. (Folke, et al, 2005) | Community-based; uncertainty; experimentation; collaboration; flexible; networks; social capital; monitoring; polycentric; trust |

**Table 1: Comparison of different management regimes**

paradigms and the organizational underpinnings of adaptive capacity, in order to inform the analysis of the Brazilian reform in the context of climate change adaptation.

## INTEGRATED WATER RESOURCES MANAGEMENT

IWRM is a management paradigm based on the Dublin Principles that the United Nations widely promulgated at the Rio Earth Summit in 1992. These principles argue that: (1) water is a finite and vulnerable resource that sustains life; (2) water management should be a participatory endeavor involving users and policymakers at multiple levels; (3) women play a central role in managing and providing water; and, (4) the multiple uses of water have value and should be treated as an economic good (Dublin Statement, 1992). To address these principles, IWRM is defined as a system of "…coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2000, 22).

Translating these ideas from theory to practice often requires the reconceptualization of how managers view and treat water resources. Integration requires the incorporation of multiple dimensions of water resources and water users, in addition to variation across spatial and temporal scales (Savenije and Van der Zaag 2008). In treating the natural dimension of water, resources managers must address the comprehensive elements of the water cycle in a natural basin and their interrelationships with the ecosystem, including rivers, surface water, groundwater, wetlands and so on (Born and Sonzogni 1995). With respect to water users, successful management must evaluate the various human uses of water: agriculture, industry, human consumption, flood control, sanitation, hydroelectricity, etc. in a manner that recognizes competing social and economic interests (Jonch-Clausen and Fugl 2001). Management regimes should fully account for variation in spatial and temporal scales, including distribution of water in time and space, upstream and downstream dynamics in water use and seasonal availability (Savenije and Van der Zaag 2008). The comprehensive analysis of diverse human and natural dimensions of water resources at multiple scales contributes to the effective synergy of social and natural dynamics under IWRM.

While the intrinsic concept of integration is relatively straightforward, there is no blueprint or clear set of institutional prescriptions to implement IWRM in practice (Biswas 2008). The institutional arrangement of water governance to effectively encompass these

multiple dimensions ultimately requires the organization of users and uses at the hydro-ecological level of the watershed. IWRM reform inherently requires the decentralization of decision-making capacity to the lowest appropriate scale, which intends to increase local capacity and foster democratic inclusion (Blomquist, Dinar et al. 2005). Organization at the basin scale aligns the human and socioeconomic dimensions with the natural dimension. This is an important reform prescription, since scale mismatch due to state or other jurisdictional divisions that ignore ecosystem boundaries can result in fragmented natural resource decision-making that does not fully account for natural processes (Cumming, Cumming et al. 2006). This often contributes to environmental degradation and unsustainable management practices. Therefore, IWRM promotes the reorganization of management institutions by creating structures at the basin level, rather than local or municipal levels. This prescription distinguishes IWRM from general theories of decentralization based on socio-political jurisdictions.

Basin-level organizations should include all relevant stakeholders that operate within the natural watershed boundaries, including officials from the various administrative units within or overlapping the basin, water users and civil society (Medema, McIntosh et al. 2008). This often produces polycentric and horizontal integration of multiple institutions across scales by bridging networks into a new boundary organization at the basin scale (Pahl-Wostl 2007). This basin-level institutional structure allows government and civil society users to consider a comprehensive scope of local issues based on biophysical and social knowledge in order to promote collaborative planning and consensual problem solving (Genskow and Born 2006). Such watershed-scale institutional structures can include both new basin-level organization, integration of existing structures at the watershed scale or a combination of arrangements that aim to produce interconnectivity (Born and Sonzogni 1995). Important factors that enable integrative institutions are clearly defined institutional responsibilities, coordination mechanisms and operational tools to manage conflict and evaluate tradeoffs (Jonch-Clausen and Fugl 2001). Overall, the structural reform mechanisms of IWRM include basin level organization with cross-scale and sectoral integration involving a diverse array of interests to consider the multiple uses and interests of water.

This structure provides the arena for deliberative decision-making processes and planning that involve broad participation of users, civil society and public officials in the domain of the watershed. Through reform that organizes interests at the basin level, all sectors and interests are

involved, ideally leading to cooperative and deliberative action that can limit water conflicts (Genskow and Born 2006). Explicit recognition of multiple and often competing interests through collaborative actor platforms allows for the transparent and democratic assessment of trade-offs and the negotiation of priority uses of water to create integrated management plans (Savenije and Van der Zaag 2008). IWRM therefore involves inclusive social processes that draw on various interests and forms of knowledge in problem definition, direction setting and implementation to foster consensus (Pahl-Wostl, Sendzimir et al. 2007). Elements of actor inclusion and basin decentralization also improve the effectiveness, transparency and accountability of water management (Jaspers 2003). These democratic and participatory decision making processes are often in stark contrast to top-down forms of water management.

However, despite the popularity of the IWRM, many authors have criticized the approach or have highlighted barriers to implementation in practice. Biswas (2008) has criticized the approach given its definitional ambiguity, unclear factors to promote implementation, and the lack of overwhelmingly successful examples in practice. Despite the commitment to integration and ecosystem-based management, it is difficult to actually include an exhaustive range of natural and social aspects of water in management. Also, even if an institution can successfully formulate watershed boundaries, which is prone to political interference, new institutions will not always eliminate boundary issues (Mitchell 2005). Abers (2007) explains how the Brazilian case has faced challenges in creating basin level organizations. Furthermore, the creation of new institutions can be financially costly, especially in the developing world, and due to the long-term political and institutional development of existing management bodies, transition is time consuming and requires significant commitment (Pahl-Wostl, Sendzimir et al. 2007). It can be difficult to reconcile the various scales and levels of networks involved in integration. As such, IWRM requires that a robust institutional structure and an effective governance structure already exist in order to be effective (Medema, McIntosh et al. 2008). Even with the adequate development of new management structures, increasing the scope of participation can often lead to greater conflict, problems with accountability within the new structures, or recreation of preexisting domination by entrenched interests (Blomquist, Dinar et al. 2005). Abers and Keck (2006) describe how placing power in deliberative institutions in the Brazilian case has often led to conflict rather than collaboration, which has strained the formation of new institutions as existing bureaucracies resist losing power. Furthermore, Lemos and de Oliveira (2004)

investigate how local politics and elites have infiltrated the reform process and prevented the maturation of participatory management in the Brazilian case.

## ADAPTIVE MANAGEMENT AND RELATED PARADIGMS

Adaptive management seeks to address uncertainty and complexity through the systematic design and implementation of policy on an experimental basis that promotes iterative learning from policy choice outcomes (Medema, McIntosh et al. 2008). In other words, adaptive management is the scientific method applied to decision-making: a process-based approach to management that explicitly seeks to test hypotheses through the evaluation and monitoring of decisions (Lee 1999). This process involves a series of iterative steps to identify the problem and test hypotheses through planning, experimentation, and monitoring in order manage uncertainty (Habron 2003). In treating management choices as experimental and ongoing, adaptive regimes can respond to extreme events and surprises by making flexible decisions that adapt to rapidly changing conditions or unforeseen circumstances (Gunderson 1999). These processes engender significant flexibility in policymaking as stakeholders repeatedly evaluate and refine actions to improve natural resource management approaches in dynamic contexts (Gregory, Failing et al. 2006). Adaptive management is germane to the water resources sector since it explicitly seeks to make decisions in the face of uncertainty, which may include seasonal climatic variability and climate change impacts such as drought and flood, or changes in the social system that place new demands on water resources. In pursuing this flexible and experimental approach, adaptive management ultimately aims to increase a water system's adaptive capacity (Pahl-Wostl, Sendzimir et al. 2007).

Adaptive management is an approach that focuses more on the process of decision-making than the structural reforms touted by IWRM. Like IWRM, it emphasizes the need to involve a large and comprehensive range of stakeholders in the decision-making process to understand different perspectives and types of knowledge, including scientific, traditional and practice-based forms of knowledge (Johnson 1999). However, the structures and institutions necessary to operationalize adaptive management are less obvious than the goals of the adaptive management process. Adaptive governance expands the scope of adaptive management to include the social coordination necessary for ecosystem management (Dietz, Ostrom et al. 2003). It is "operationalized through adaptive co-management," or rather, "flexible community-based

systems of resource management tailored to specific places and situations…supported by … organizations at different levels" (Folke, Hahn et al. 2005). These institutions play an important role in increasing adaptive capacity by promoting knowledge, collaboration and flexible organizations (Folke, Carpenter et al. 2002).

In order to consider possible alternatives from a wide range of views, adaptive management should include broad-based and long-term stakeholder participation in a structured manner (Medema, McIntosh et al. 2008). Enabling participation among actors is also a crucial requirement for adaptive governance (Dietz, Ostrom et al. 2003). Participation in watershed management through stakeholder input is vital since stakeholders have first-hand views of the problems and dynamics of the resource under management (Walker, Carpenter et al. 2002). This is important not only for reasons of equity, but also for effectiveness, since management cannot occur without considering users' cumulative knowledge of ecosystem dynamics (Pahl-Wostl, Sendzimir et al. 2007). Participatory and deliberative decision-making can allow diverse stakeholders to express differences in a manner that can reconcile multiple conflicting perceptions without forcing consensus. Eventually, participation and communication can build trust and shared understanding, leading to increased social capital (Lebel, Garden et al. 2005). Fostering arenas for collaborative learning can contribute to building trust and adaptive capacity (Olsson, Folke et al. 2004).

Knowledge and learning are key components of adaptive management and governance. Effectively managing water resources requires information from a variety of sources, especially from the collected experience and memory of stakeholders that have traditionally depended on the basin for ecosystem services (Walker, Carpenter et al. 2002). These multiple lenses of water use and system dynamics can inform novel policy choices that participants subsequently monitor and reevaluate in an interdisciplinary manner. Traditional knowledge, local knowledge and scientific knowledge have different perspectives on ecosystem dynamics that can be integrated through dialogue and deliberation to create locally relevant decisions (Berkes, Colding et al. 2000). The incorporation of many sources of knowledge of social and ecological dynamics to inform decision-making can contribute to social learning and sustainable resource use (Olsson, Folke et al. 2004). Moreover, small-scale governance regimes that assimilate local knowledge incorporate trust and lead to effective management arrangements (Janssen, Anderies et al. 2007). This process seeks to instill a sense of social learning among actors by internalizing multiple

points of view in collaborative decision making and evaluation, leading to shared meaning, understanding and goals of the management process. Ultimately, social learning occurs when individual cognition of multiple individuals becomes embedded into entire social entities (Pahl-Wostl, Sendzimir et al. 2007). Availability and access to knowledge is essential to effective participation, which cannot be ensured by institutional rules alone. This participation and a shared vision of management help to form a more nuanced understanding of the relationship between the natural and social systems.

The social dimension of adaptive management and governance requires a series of different flexible organizations and actor networks interacting and operating at different levels (Folke 2006). Polycentric and multi-level organizational structures promote power sharing and multiple centers of responsibility. This includes linkages and communication among a diverse set of stakeholders including user communities, scientists, researchers, NGOs, and government agencies at different levels through social networks, which can enhance coping with change and uncertainties (Folke, Hahn et al. 2005). Polycentric structures that seek to manage at the ecosystem-scale also promote participation of actors in a way that adequately considers the system being managed (Huitema, Mostert et al. 2009). Such platforms or arenas contribute to knowledge sharing, collaborative learning, and the promotion of successful ecosystem management (Olsson, Folke et al. 2004). Networks embedded across different scales can also nurture a shared vision among the various actors, and help to allay tensions and conflicts over resources (Olsson, Gunderson et al. 2006). This collaboration in networks allows for the broad consideration of different types of knowledge in decision making, which a committed leadership should balance for questions of stability (Pahl-Wostl 2007). Polycentric and multi-layered institutions can also improve the fit between knowledge and the contexts of the watershed, allowing societies to address multi- and cross-scale dynamics (Lebel, Anderies et al. 2006). Knowledge transfer and cooperation through social networks increase the adaptive capacity of societies in the face of climate variation and change (Young and Lipton 2006). Yet dependence on knowledge can lead to technocratic insulation and hence accessibility is a parameter of knowledge that has implications for democratic decision-making (Lemos and de Oliveira 2004)

Many authors have argued that there are shortcomings to the theoretical benefits of adaptive management, co-management and governance. For one, the experimental nature of the process can be cumbersome, and many actors may be unwilling to participate, especially if they

feel the process undermines their expertise or is unnecessary to hypothesize the outcomes (Gregory, Failing et al. 2006). In addition, the formal process of experimentation can overemphasize models and scientific data. There is a tendency towards technocratic dominance to the detriment of other stakeholders, which can counteract the production of social learning (McLain and Lee 1996). Polycentric structures can entail high transaction costs and may inadvertently limit the level of democratic participation and accountability. Also, participation may be difficult for small actors due to the opportunity costs involved (Huitema, Mostert et al. 2009). Finally, similarly to IWRM, transition to adaptive management and government may be thwarted by lock-in effects due to the legacy of command-and-control management (Pahl-Wostl 2007). This might involve bureaucratic resistance or elite domination that limits other actors' access to knowledge or the decision-making process (Lemos 2008).

## Institutional and Governance Determinants of Adaptive Capacity

The abovementioned paradigms seek to promote management processes and structures that make organizations more cognizant to possible stressors and more flexible to make decisions under duress, hence increasing adaptive capacity. On a more general level, there are institutional and governance factors that are important determinants of the adaptive capacity of a social system to climate events. Since adaptation is a social process and adaptive capacity a latent social quality, there is a deep connection to the role of institutions and quality of governance in how they order social interaction and behavior, especially in difficult contexts. For one, better governance directly improves institutional capacity to plan, act and perform in extreme situations. More indirectly, good governance can increase intangible factors such as political and social inclusion, representation and accountability that increase the adaptive capacity of the overall population (Brooks, Neil Adger et al. 2005). In contrast, poor governance or institutional weaknesses, such as lack of accountability or legitimacy, conflict, domination, corruption or opaque decision-making procedures can inhibit effective adaptive responses (Eakin and Lemos 2006).

While in theory, there is broad support that good governance and strong institutions increase adaptive capacity, few empirical studies have attempted to identify specific factors that shape this relationship. Brooks et al (2005) show that at the national level, governance, health and education factors have the strongest correlation with lower impacts of natural disasters, used here as an analogue for adaptive capacity. The IPCC also highlights institutions as a key factor

in promoting adaptation (Parry, Canzaiani et al. 2007). Lemos and Engle (2010) expand on generic conceptualizations of institutions and governance to investigate the specific factors that may contribute to adaptive capacity, including representation, participation, knowledge use, equality, networks and resources (see figure 1 below).

Many of these qualities are advocated by the adaptive paradigms, especially knowledge use, participation and networks (Olsson, Gunderson et al. 2006). The use of networks and diverse forms of knowledge enable adaptation as they increase the range of options understood by different actors, provide an informal structure that can be called upon in extreme situations, and help to embed the experiences of actors. In many ways, good governance can build social capital and foster collective actions, which increase the overall institutional capacity to respond (Lebel, Anderies et al. 2006). Institutions build trust and cooperation among the state and civil society through inclusion and access, which can lead to the formation of social capital, higher perceptions of legitimacy and collective decision making for adaptation that benefits stakeholders (Adger 2003). Many of the features of governance that are espoused by international organizations and NGOs to promote sustainable development also increase adaptive capacity. The IPCC emphasizes the role of institutions and sustainable development for

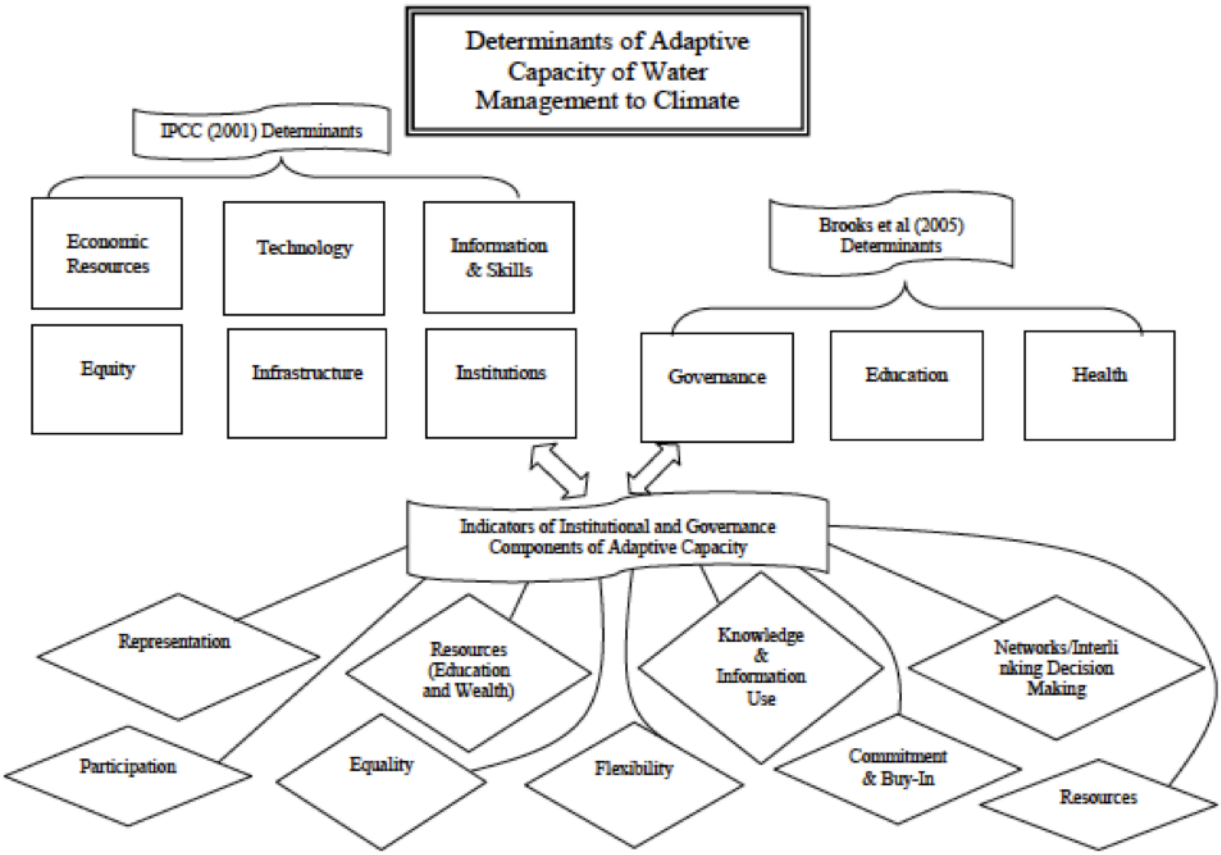



**Figure 1: Determinants of Adaptive Capacity (Engle and Lemos 2010)**

enhancing adaptive capacity by strengthening livelihoods and promoting good management of public resources that benefit society (Parry, Canzaiani et al. 2007). That is, the factors that raise livelihoods through empowerment and access to official institutions help effective adaptation and response to extreme events as well (Smit and Pilifosova 2003). Furthermore, equality and justice are important to improve adaptation at both the individual and institutional levels, in that equitable relationships and accessibility reduce the disparity between winners and losers in extreme events, making the system more adaptive overall (Adger 2001). Adaptive capacity is greater in situations where institutions and governance arrangements that act as a social interface to power and resources ensure equitable access and democratic representation (Smit and Pilifosova 2003). This equity determinant is important in the representativeness of a population by official institutions in addition to the equality of internal institutional relationships. Overall, the quality of the official response to an extreme event will be more effective (and hence exhibit greater adaptive capacity) when institutions practice good governance.

While the Brazilian reform does not explicitly seek to address climate change or conform to IWRM or adaptive models of management perfectly, many of the features of the reform are similar. The tenets of inclusionary, flexible and experimental decision-making differ from conventional technocratic systems of water management, which rarely involve stakeholder input. Brazil's reform represents a departure from command and control style management that relies on engineers to optimize the system for a given output. In the Brazilian water sector, this has meant managing water for a single use or purpose, such as hydroelectric power generation, and making choices based on probabilistic models that do not adequately account for uncertainty. Furthermore, rigid bureaucratic structures that operate at scales distant to the watershed detach decisions from their local ecological realities. IWRM and adaptive forms of management seek to remedy the shortcomings of traditional regimes by making structures that integrate multiple uses and interests at the level of the ecosystem, and decision-making processes that are flexible, involve knowledge diversity and consider uncertainty. However, there may be potential tradeoffs in these two approaches. For one, the emphasis on building consensus and deliberation can slow the decision-making process, hence limiting the ability to make nimble decisions in an extreme situation. Furthermore, the technocratic model gives significant leeway to managers that can also promote flexibility but limit pluralistic accountability (Engle, Johns et al. 2011).

# III. BACKGROUND

## WATER REFORM IN BRAZIL

With 13% of the world's freshwater stocks, there has long been a perception of abundant and unending water supply in Brazil (ANA, 2002). Yet increasing demand for water, due to urban, industrial and agricultural growth, combined with perennial drought in Brazil's Northeast, have revealed a much more precarious portrait of water resources. Furthermore, Brazil suffers from myriad problems related to water resources, including industrial pollution, lack of basic sanitation, frequent service interruptions, flooding and drought. The centralized and hierarchical management structures that have traditionally dominated water management have been unable to adequately address such challenges.

From a historical perspective, Brazilian water management followed the logic of the dictatorship, which installed corporatist bureaucracies staffed with professional technocrats (Abers and Keck 2006). Such bodies were insulated and depoliticized in theory, but tended to favor certain sectors of the economy and social elites. Consonant with the goals of the positivist and modernizing military regimes, water management overwhelmingly focused on the generation of hydroelectricity over any other use. The 1934 Water Code was a landmark in legislation that enabled the remarkable expansion of the country's hydroelectric sector. The 1934 law was surprisingly progressive, calling for a polluter-pays principle for pollution control, but the articles referring to water quality, conservation and multiple use of water were never enforced (ANA, 2002a). As a result, massive hydraulic infrastructure projects were the predominant tool to address water scarcity and other problems, including reservoirs and water transfers (Engle and Lemos 2010). The view of water and watersheds as a raw input to engineer and reconstruct for electricity generation contributed to environmental degradation. Furthermore, water management proceeded via a command and control style, with optimization targets and directives passed down from the federal to state technocracies. This system resulted in waste and inequitable water allocation due to mismanagement (Kelman 2000). The legacy of this technocratic management style persists throughout the Brazilian public sector.

In the 1990s, governments in São Paulo and Ceará states pursued reform in order to improve the management of water resources. In the case of São Paulo, the state modeled its new governance institutions on the prescriptions of the Dublin Principles to address what it perceived

as chronic mismanagement (Abers and Keck 2006). São Paulo is the richest and most industrialized state in the Brazilian federation, yet suffers from some of the highest rates of pollution and uncontrolled water use, due in large part to rapid and uncontrolled urban growth (Interview, 2010). In 1991, a group of progressive technocrats from the state Water and Electricity Department (DAEE) led the movement for reform, involving other agencies responsible for water quality and environmental issues. They were successful in promoting and passing a state law implementing water reform in 1991. The creation of basin committees was the centerpiece of the reform along with charging for bulk water use, both primary tenets of the Dublin Principles (Formiga-Johnsson and Kemper 2005). Water reform occurred simultaneously in the state of Ceará, located in the drought-prone northeast, in response to a lengthy dry period that prompted calls for changes in water management. The water crisis that ensued resulted in the mobilization of NGOs, left-leaning technocrats and water users to promote bulk water charges and water allocation as a solution to recurring water scarcity. In response to this organizing, the state passed a water reform law in 1992 (Lemos and De Oliveira 2004). In this case, the emphasis was on water charging first, with basin-level management coming second. Ceará had a history of highly centralized water management due to the long tradition of drought planning and federal interventions, and the state water agency retained much of the control on subsequent basin plans and water allocation permits (Formiga-Johnsson and Kemper 2005).

These early inroads to reform at the state level encouraged officials to draft federal legislation on water resources in 1997. Water reform was a federal priority enshrined in the 1988 constitution as part of a larger movement to decentralize government agencies in the transition back to democracy after the fall of the dictatorship in 1986, but had been neglected (Kelman 2000). The state reforms pressured the federal government to follow through on the constitutional requirement to pursue a national water policy. The 1997 Water Law has the primary objectives of sustainability, integrated management and user participation, the water basin as management unit, participatory basin committees, placing economic value on water and multiple water use with priority for human consumption (Porto and Kelman 2000). This law established the National Water Resources Policy and National Water Resources Management System, which were based on the Dublin Principles. The National Water Resources Management System established the institutional framework for implementing the reform, creating state and national Water Councils. In 2000, the government created the National Water

Agency (ANA), subordinate to the federal Ministry of the Environment to implement the water policy and to mandate change in federal basins (i.e. those that cross state boundaries) (ANA, 2002). Figure 2 illustrates the institutional structure of the reform.

The creation of basin committees represents a shift towards participatory and decentralized governance, but the federal law does not outline the composition of actors required in the basin councils, nor does it explicitly mandate how they should be created, leaving such matters to the discretion of individual states (Engle and Lemos 2010). In most basins, the committees include participation by some combination of local and state public officials, large water users and civil society (such as NGOs and universities). In some states, the committees have deliberative meetings to determine water permits and create basin management plans. The committee is also a forum for managing conflicts. Many large basins also have executive bodies that implement committee policy and technical chambers that provide guidance on complex issues. They implement bulk water charges and allocation, using the revenues to fund projects in the basins (Kumler and Lemos 2008).

While the federal reforms constitute a move towards IWRM and adaptive forms of

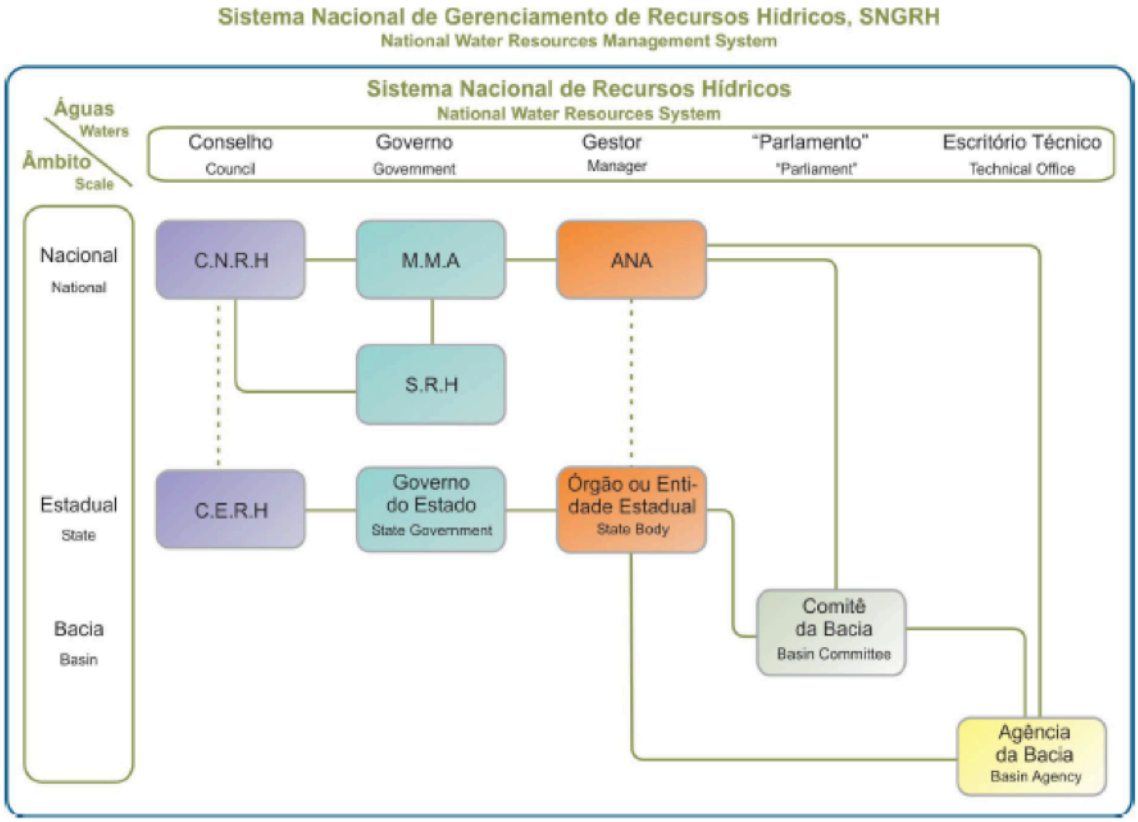



**Figure 2: Institutions in Brazilian Water Management (Source: ANA, 2002)**

management in theory, there have been bottlenecks to implementation in practice. For one, the federal law is ambiguous and has not resulted in meaningful forms of decentralization or stakeholder interaction in all cases, but rather de-concentration in which administrative powers are simply devolved and there is no downward accountability to local actors (Brannstrom 2005). Second, the reform stipulates for deliberation at the basin level, yet since such an administrative level previously did not exist, action must occur to create a new body and provide staff, which has been difficult in some cases due to scarce resources or lack of political will. Therefore, while the reforms have resulted in the creation of over 100 basin councils, many exist only on paper and never actually meet or make meaningful decisions about water management (Abers 2007). Furthermore, in certain cases, resistance by existing bureaucracies and powerful water users that do not wish to cede control or commit to paying for bulk water charges have stalled reform. Such manifestations by powerful actors have produced stalemates in terms of decision-making resulting in ineffectual committees. In other cases, the new committees have been unable to overcome the legacy of centralization, with decisions made by existing agencies through the new structures in a manner that limits and dilutes participatory stakeholder inclusion (Lemos and De Oliveira 2004). Finally, some basin councils have involved so many stakeholders that they ignore pertinent issues and decision-making becomes difficult (Abers and Keck 2006). Despite the success of implementing new reform laws, there are still many changes necessary.

## CASE STUDIES

### *PARAÍBA DO SUL*

The Paraíba do Sul (PDS) is a large river basin that occupies around 55,000 km sq. and crosses the three wealthiest and most populated states in Brazil – São Paulo, Rio de Janeiro and Minas Gerais. Each tributary that lies completely within the borders of one state are characterized as state waters, whereas water in tributaries that cross state borders are the domain of the federal government, hence complicating management (Formiga-Johnsson, Kumler et al. 2007). The basin is home to 5.6 million people, and is responsible for 10% of Brazilian GDP (Formiga-Johnsson and Britto 2009). The water use in the basin is distributed among urban supply (16.8 $m^3/s$), irrigation (49.7 $m^3/s$) and industry (13.6 $m^3/s$). Most importantly, about two-

thirds of the basin's water use (180 $m^3/s$) goes towards the water transfer from the PDS to the Guandú basin that supplies water to another 8.7 million people in the Rio de Janeiro metropolitan area and is one of the largest inter-basin water transfers in the world (Formiga-Johnsson, Kumler et al. 2007). The basin has experienced dramatic growth and population increase over the past decades as industry has expanded along the major highway that runs parallel to the river, connecting the country's largest cities -- São Paulo and Rio de Janeiro. Agriculture and pasture account for the majority of land use in the basin, including dairy, sugarcane and tree plantations for paper production. Pollution from industrial effluent, agricultural runoff and untreated sewage represent major challenges for water quality in the basin. Environmental disasters due to industrial spills of chemicals and toxic materials into waterways are frequent (Interview, 2010). Climatic events in the basin are predominantly floods, which are exacerbated by poor land use planning and sprawling slums, contributing to an increase in landslides in recent decades. Droughts are less frequent, but are a challenge for maintaining water supplies. Water conflicts are growing especially between increasing urban demand in São Paulo and the need to maintain water supplies for metropolitan Rio de Janeiro via the Guandú water transfer (Interview, 2010). Figure 3 shows the geography of PDS.

With respect to the institutional structure of water management in the basin, the state of

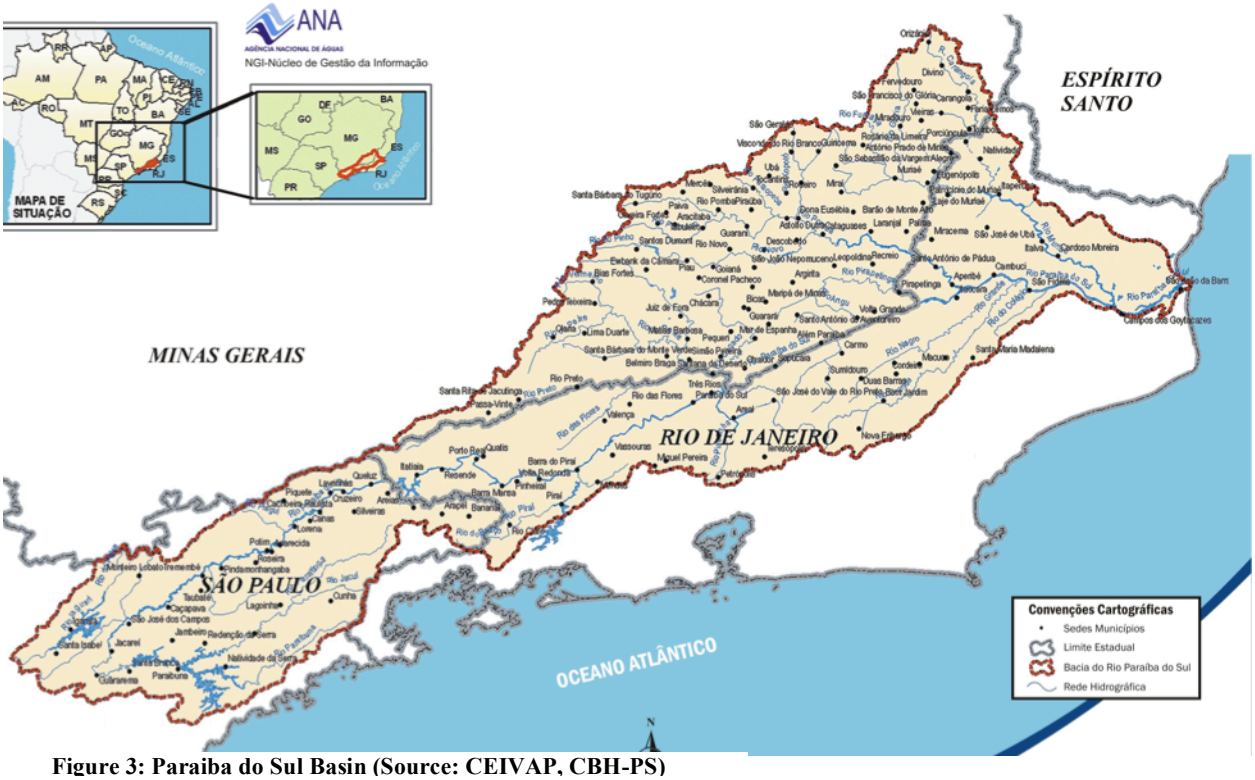



**Figure 3: Paraiba do Sul Basin (Source: CEIVAP, CBH-PS)**

São Paulo was a pioneer in the creation of basin-level organization, which influenced the subsequent federal reforms. The state of São Paulo created a basin committee for a sub-basin of the PDS river in 1987, which was legally instituted by the state water reform in 1991 (Gruben, Lopes et al. 2002). This state law included basin-level management, and prescriptions for reform such as multiple use of water and economic valuation of water, important tenets that inspired the federal law (Abers and Keck 2006). In 1996, the multi-state basin committee was created called the Committee for Integration of the PDS River Basin (CEIVAP), which was built upon an earlier model of integrated management in the basin that existed informally since the 1970s (Formiga-Johnsson, Kumler et al. 2007). The political entrepreneurs involved in organizing the precursor of CEIVAP and the state basin in São Paulo were active in promoting the state water reform in São Paulo and ultimately the federal water law in 1997.

CEIVAP involves a complex system of organizations, given its status as a federal committee comprising three states. Within the PDS basin, there are 14 sub-basin committees, consortia and user associations organizing officials and civil society at an even smaller scale (CEIVAP 2011). The larger structure of CEIVAP includes 60 members, 3 from the federal level and 19 from each state. The membership is composed of 40% water users, including water companies, industry, hydroelectric producers, agriculture, fishing and tourism; 35% public representatives at the federal, state and municipal levels, and; 25% civil society, including NGOs, professional associations and universities. Members are elected democratically, and the leadership – president, vice president and secretary – are selected by the members every two years (CEIVAP 2011). CEIVAP also includes three technical chambers, which provide advice on planning and investment, institutional issues and environmental education, in addition to thematic working groups. The basin was the first to implement the collection of bulk water fees at the federal level and the first to create a permanent administrative agency (AGEVAP) to manage and finance projects (Kumler and Lemos 2008). Overall the major responsibilities of CEIVAP are to: define water quality targets in the basin; propose guidelines for water use permits granted by public agencies; approve and execute basin plans; and, execute water charges (CEIVAP 2011). These actions occur through regular decision making plenaries involving the members, and specific projects are implemented by AGEVAP, which receives 7.5% of the revenue from bulk water charges for administrative support (Interview, 2010).

The basin committee is an important institution for water management in the three states and acts as a polycentric arrangement involving public, private and civil society actors. Its structure provides a democratic forum involving major actors in the water sector in the three states in order to make plans, manage conflict and promote decision-making. CEIVAP is composed of the major public agencies and users of water in the three states. In Rio de Janeiro, this includes the State Institute of the Environment (INEA), which grants water permits and monitors water quality, in addition to the major water companies, such as CEDAE. Members from São Paulo include the Department of Water and Energy (DAEE), which issues water permits, and the major water company SABESP. Finally, in Minas Gerais, the public water agency counterpart is the Institute of Water Management (IGAM). The federal nature of CEIVAP also merits the involvement of the National Water Agency (ANA), which manages the federal waters, including water permits.

### *LOWER JAGUARIBE*

The Jaguaribe basin is located in the state of Ceará in northeast Brazil – a region characterized by persistent drought. Consequently, the state is one of the poorest in Brazil. The Jaguaribe basin occupies an area of 72,560 $km^2$, occupying nearly half of the state's territory and two million people (Formiga-Johnsson and Kemper 2005). Given the vast size of the basin, it is split administratively into five sub-basins, and this study will focus on the Lower Jaguaribe. The Lower Jaguaribe covers an area of 6,875 $km^2$ and has a population of approximately 300,000 (Ceará 2010). The dry lands, or *sertão*, have a highly variable rainfall, a high rate of evapotranspiration, low levels of water retention, and cyclical droughts that occur at least every five years. Thus, multiyear drought events are common and have dramatic impacts on human and natural systems (Lemos and De Oliveira 2004). Historically, the main policy intervention in the region to address water scarcity has been multiple infrastructure projects to store water from the rainy season in the dry season and potentially for drought years, without which all of the rivers would be seasonal or intermittent (Formiga-Johnsson and Kemper 2005). The reservoirs include three massive projects (the Orós, Banabuiú and Castanhão dams) that account for the majority of water storage and provide water to the capital, Fortaleza. In addition, there are many small regional dams. Given the historical need to confront drought, the region has a well-developed institutional presence in water resources, which in the past included the infamous

'drought industry,' or the common practice of diverting public drought-relief funds to benefit local elite and political strongmen (Lemos and De Oliveira 2004). In addition to drought, intense rains have increasingly contributed to floods and landslides. The major dams have helped to dampen the impact, but do not completely mitigate flood damages (Interview, 2010). In the Lower Jaguaribe, the main use of water is human consumption in urban areas and agriculture. The sub-basin has considerable small and large-scale farming operations and irrigation districts, which constitute the largest water users. Irrigation is water-intensive, especially in rice cultivation, which uses a large amount of the water earmarked for irrigation, but produces little economic value or jobs (Lemos and De Oliveira 2004). The demand for irrigation causes conflict over water use during the dry season (Garjulli, De Oliveira et al. 2002). Figure 4 shows the extent of the basin and sub-basins.

The water reform has helped to alleviate water conflict by managing water in times of

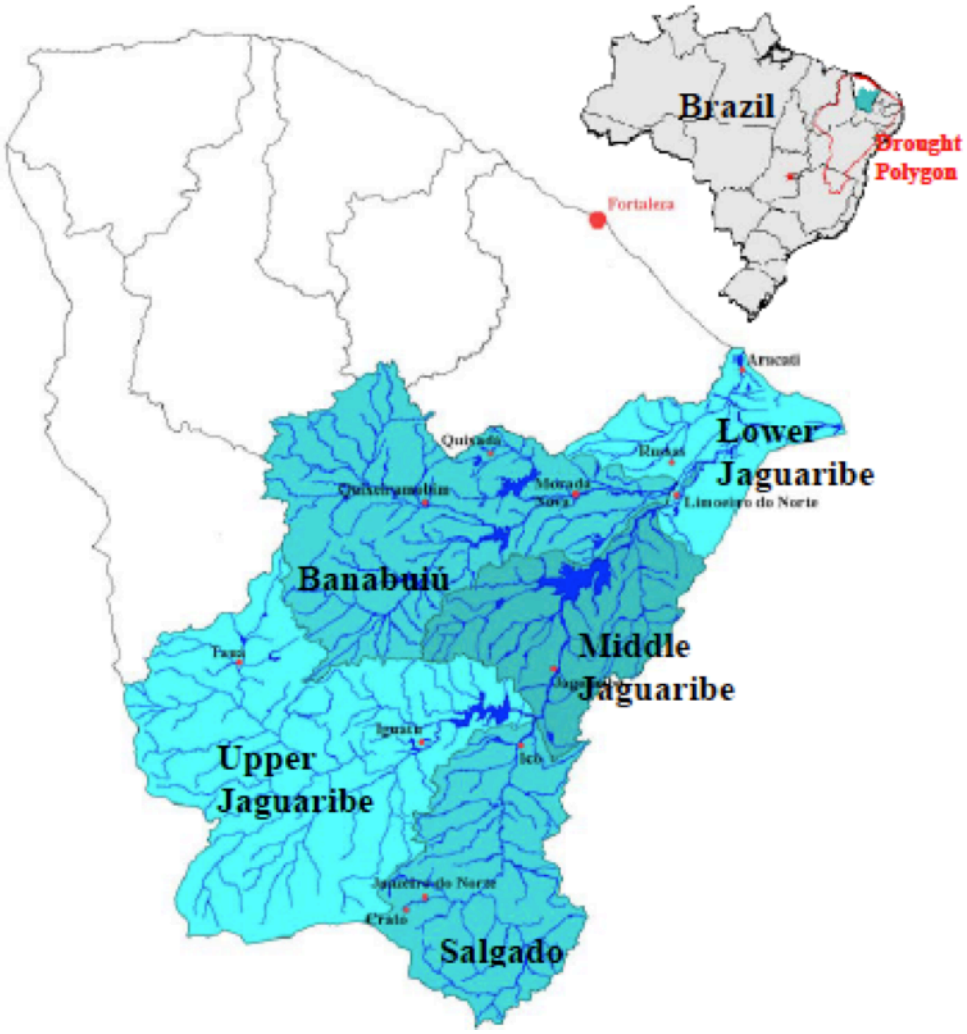



**Figure 4: Jaguaribe Basin and Sub-basins (source: Formiga-Johnsson and Kemper, 2005)**

scarcity, and has improved governance by uprooting the traditional patronage relationships of the 'drought industry.' Before the reform efforts began in the 1990s, water management in the region was strictly the domain of the federal government through the National Department of Drought Prevention (DNOCS), which invested federal resources in building large infrastructure projects. The state government also invested in smaller dam projects to respond to drought crises. The supply-based approach depended on a centralized, rigid and opaque bureaucracy that favored the interests of large landowners (Formiga-Johnsson and Kemper 2005). In the 1990s, a prolonged drought threatened agriculture in the region and the water supply of the capital, Fortaleza. The water crisis that ensued resulted in the mobilization of NGOs, left-leaning technocrats and water users to promote bulk water charges as a solution to recurring water scarcity. In response to this drought and as part of the state government's efforts to pursue modernization, state policymakers sought to design a new set of institutions to manage water resources based on models in other parts of the world (Lemos and De Oliveira 2004). In 1992, the state adopted a new Water Resources Law that outlined new policy and created the State Water Resources Management System (SIGERH), which emphasized participatory management with the creation of river basin committees and user's commissions for negotiating allocation of bulk water permits. With World Bank guidance and funding, the state also created the Water Resources Management Company (COGERH) in 1993, which is responsible for implementing the water law, supporting the basin committees, collecting water charges and distributing water permits (Garjulli, De Oliveira et al. 2002). The role of COGERH is unique compared to other states, since it directly supports the committees as a basin agency would in other cases, but in a centralized manner. Other important institutional actors are the Secretary of Water Resources (SRH), which supports COGERH in planning and implementation and the Ceará Foundation of Water Resources and Meteorology (FUNCEME), which provides climate forecasts and other technical support for water management in the state.

The participatory elements of water management in Ceará occur via the system of committees and user commissions. The user commissions evolved as a response to coordinate management and manage conflicts after a severe drought in 1992-1994. The 37 user commissions are organized around the strategic reservoirs in the basin, making the emphasis less on the natural watershed and more on infrastructure as the unit of management. While this runs counter to the tenets of IWRM, it is necessary due to the historical dependence on infrastructure

to regulate waters to combat drought. The structure of reform in Ceará, with the creation of COGERH as a centralized manager and the user commissions, has made the basin committees less powerful than in other cases. The committees in many ways have still not matured in terms of their role in water management. While they have many competencies on paper, they lack technical, administrative and financial support (Formiga-Johnsson and Kemper 2005). The Lower Jaguaribe committee was created in 1998, long after the user commissions and COGERH, and is composed of 46 members, with distribution of 30% civil society, 30% water users and 40% state and municipal officials (Garjulli, De Oliveira et al. 2002). The main responsibility of the committee is to set guidelines, manage conflict and elaborate basin management plans. The user commissions determine the allocation of water from the reservoirs in a negotiated and transparent manner, but ultimately COGERH and SRH allocate water permits. The relationship between the committees and the commissions has caused some tension, given the commissions are informal relationships and the committees are legally formalized, but the commissions have much more prowess with respect to decentralized water management. There have been calls to transfer the responsibility of the commissions to the committees (Formiga-Johnsson and Kemper 2005).

### *LAGOS SÃO JOÃO*

The São João region is in the southeast of Rio de Janeiro state and is comprised of the São João river basin and four smaller adjacent coastal basins, covering a total area of 3825 $km^2$. The region includes remnants of Atlantic rainforest with endangered endemic species and the largest hyper-saline lagoon system in the world, making the region important for ecotourism and conservation. The region has a resident population of 451,000 people, but is a popular tourist destination and the population can surge to over 2 million in holiday periods (Pereira, Barreto et al. 2009). The Juturnaíba dam on the São João River is the primary water source for the region's population, which is concentrated in the coastal area. Water is transported from the inland reservoir to the coastal population via hydraulic infrastructure. The major water use is urban supply and fishing, but there is also some agricultural use in rural areas. With the expansion of tourism, the region has experienced rapid growth over the past several decades, which has placed pressure on the fragile ecosystems and has led to demand for increasing infrastructure and

services. While the region is characteristically dry, there have been recent flood events and episodes of intense rain (Interview, 2010).

The drive for reform in the region involved active local mobilization in response to a perceived environmental crisis shared by local stakeholders, and the lack of attention by public officials. The region's rampant population growth led to pollution and hypoxia of the Araruama Lagoon in the 1990s. Due to a lack of adequate sanitation infrastructure, all of the region's sewage flowed into the lagoon, which resulted in terrible water quality, algal blooms and eventually the inability to support aquatic life. This caused the collapse of the lagoon ecosystems and the associated fishing economy in the 1990s. In 1999, a group of environmentalists, NGOs, and fishing associations mobilized to create a basin consortium to address the collapse of the lagoon systems (Bidegain and Pereira 2005). While the inaction of the local municipal governments was viewed as a reason for much of the problems, the consortium invited the local governments to be part of the structure. Hence, the consortium explicitly sought to be a forum for debate and action to address environmental problems (Interview, 2010). The leaders of the movement intentionally formed the consortium with a structure similar to a basin committee, comprising water users, civil society and public officials,

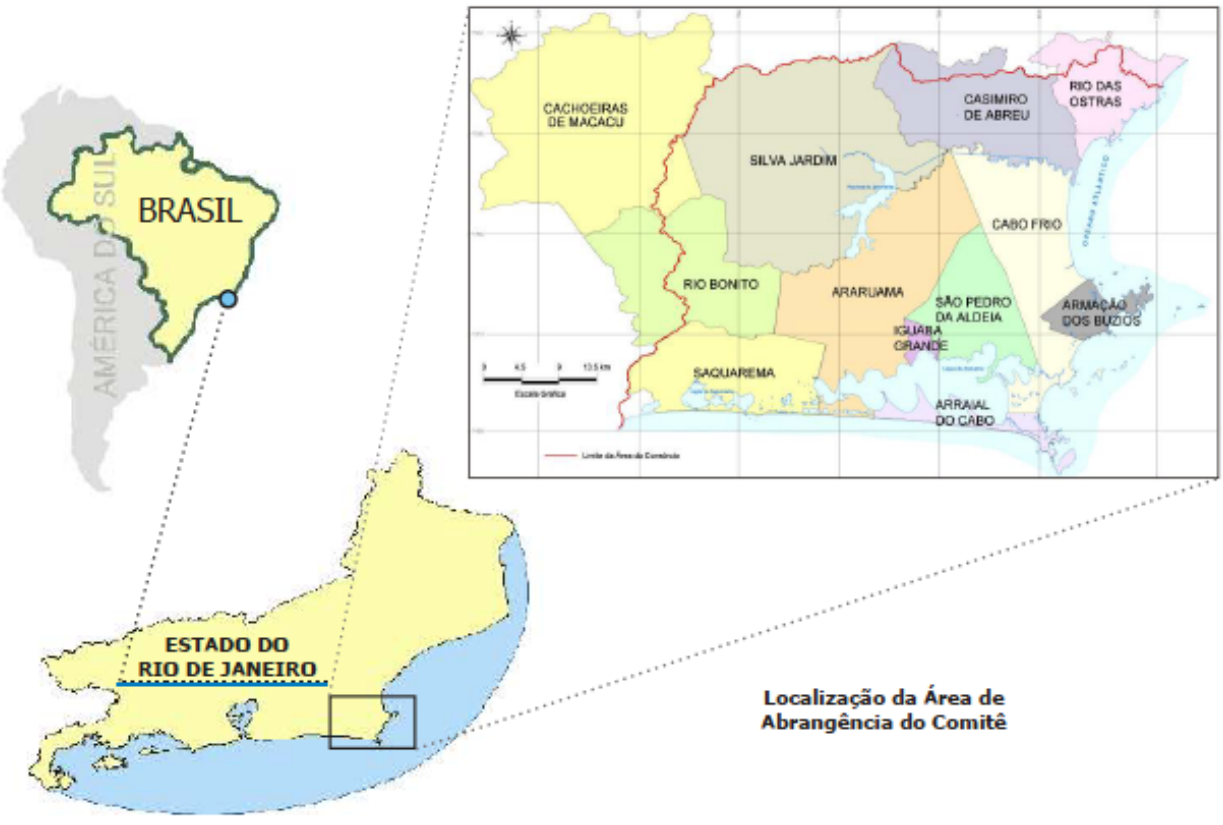



**Figure 5: Lagos São João Region (Source: Bidegain and Pereira, 2005)**

in order to pressure the state to implement a committee in the region with legal deliberative capacity. Figure 5 below shows the location of the basins.

The committee of the São João and lakes region was officially created in 2004 by state decree. Like other basin committees, there is a distribution of membership among civil society, water users and public agencies. The São João committee has 18 seats for each sector and thus has an egalitarian distribution. Much of the structure, action and members of the consortium were absorbed by the institutionalization of the committee, although the consortium continues to act independently as an organ of civil society within the committee (Interview, 2010). The committee's goals are to implement strategic planning for the region. It has developed basin plans, a system for registering water users and has implemented water charges in the region. The committee also has dedicated working groups to address environmental issues and technical chambers regarding environmental education, information systems, dredging operations and infrastructure maintenance. The major actions of the committee and consortium have been to develop an emergency plan to address the sanitation crisis. Working with the water companies in the region, Aguas de Juturnaíba and PROLAGOS, and the municipalities, they have created a system to collect sewage in rivers and drainage networks and pump it to sewage treatment plants before it reaches the lakes. While this is a provisional system, they are also planning a dedicated sewage collection network. Nonetheless, the actions have improved the water quality in the lake and have revitalized the fishing industry (Interview, 2010). The São João committee is small and has limited financial support, but is an effective actor in the community due to the grassroots mobilization and commitment of stakeholders to tackle shared problems of environmental degradation.

*ITAJAÍ*

The Itajaí valley is located in southern Brazil in the state of Santa Catarina. The basin occupies an area of 15,500 $km^2$ and has a population of 945,720, of which 76% is urban. The region is relatively wealthy compared to the rest of Brazil, and the basin contributes 28% of the GDP of the state with a large industrial sector centered around the textile and clothing sector (Mais 2003). The port of Itajaí and the city of Blumenau represent areas of extensive economic development. Water use in the basin is distributed relatively evenly among industrial, agricultural and urban use. The basin is associated with three micro-regions, the upper, middle

and mouth of the Itajaí Valley, each with a distinct socioeconomic profile (Itajaí 2010). Floods are the predominant problem in the basin, which have plagued the valley since its colonization in the 1850s. From 1850-2000, there were 67 major floods registered in Blumenau alone (Mais 2003). In 2008, a catastrophic flood killed hundreds in the region, and was unique due to the unprecedented incidence of landslides (Interview, 2010). The impact of floods has increased parallel to development in the region. Environmental degradation due to erosion and destruction of riparian wetlands has occurred as pasture, agriculture and unplanned urbanization have intensified deforestation, contributing to sediment pollution that exacerbates the impact of floods. Furthermore, there is a high degree of occupation in risk areas that increases the population's exposure and vulnerability to flood and landslide events. Industrial pollution and lack of adequate basic sanitation also contribute to water quality issues in the region (Mais 2003). Figure 6 shows the location of the basin in the state and highlights the major urban areas.

The establishment of a basin committee has roots in the experience with floods in the region. Despite investment in containment dams to control floods by the National Department of Sanitation Works (DNOS), floods continued to occur. A group of academics from the University of Blumenau (FURB) began to question the approach of DNOS in solely emphasizing infrastructure in protecting Blumenau from floods without considering the basin as a whole.


**Figure 6: Itajaí Basin. (Source: Fundação Agência de Água do Vale do Itajaí, 2010)**

This epistemic community conceptualized the basin in a holistic manner in order to frame the consequences of floods (Abers 2007). In 1990, the federal government dismantled DNOS, which marked the end of an era in water management in the state. The subsequent recurrence of floods presented a window of opportunity for the reform-minded network to expand their movement with a working group to address floods and eventually push for a basin-level organization. In 1994, the state passed a water law that called for the creation of basin committees. By 1996, on the eve of the federal water reform, the working group consisted of several universities, municipal associations and the state Secretaries of the Environment and of Urban Development (Mais 2003). The initial organization to address floods and create basin-level structures came from the perception by civil society of a common problem that the official public agencies were not adequately handling.

The creation of the work group marks the genesis of the committee. The state of Santa Catarina passed a law in 1997 establishing the Itajaí committee officially, with legal deliberative capacity at the basin level. The committee has 65 members, with a distribution of 40% for civil society and water users, and 20% for public agencies (Mais 2003). Hence, the Itajaí committee has fewer seats for government than most committees in Brazil. The first action of the committee was to create a framework to fill the vacuum left by the dissolution of DNOS. The committee created a workshop to develop an emergency flood prevention plan including improving flood infrastructure. There were also efforts to expand the vision of the problem of flooding to include soft measures for prevention, such as wetland restoration (Abers 2007). The committee is heavily involved in campaigns for environmental protection, environmental education and in organizing the public to participate in water resources issues through the creation of an annual Water Week. In 2001, a dedicated basin agency was created as a technical and administrative counterpart to the executive capacity of the committee. The committee has engaged in projects to develop long-term and strategic planning in the basin, including the completion of a basin plan in 2010 (Itajaí 2010).

# IV. METHODOLOGY AND FRAMEWORK

## RESEARCH METHODOLOGY

This study relies on three sets of data related to watershed management reform in Brazil. First, the Watermark survey from 2005 investigates the structure and behavior of 18 basin committees, with multiple respondents in each location. Questions relate to the background of individual members, their views on water management and their evaluation of the reform in the context of the committees. The structure of the 2005 survey is fixed multiple-choice response to 332 questions. Second, the 2008 Watermark key informant interviews elicited response from one or more high-level committee members in the same 18 basins. The key informant survey specifically inquires about the incidence of extreme climate events, the use of climate forecasting and projections and the activities of the committees in a semi-structured and multiple-choice format.

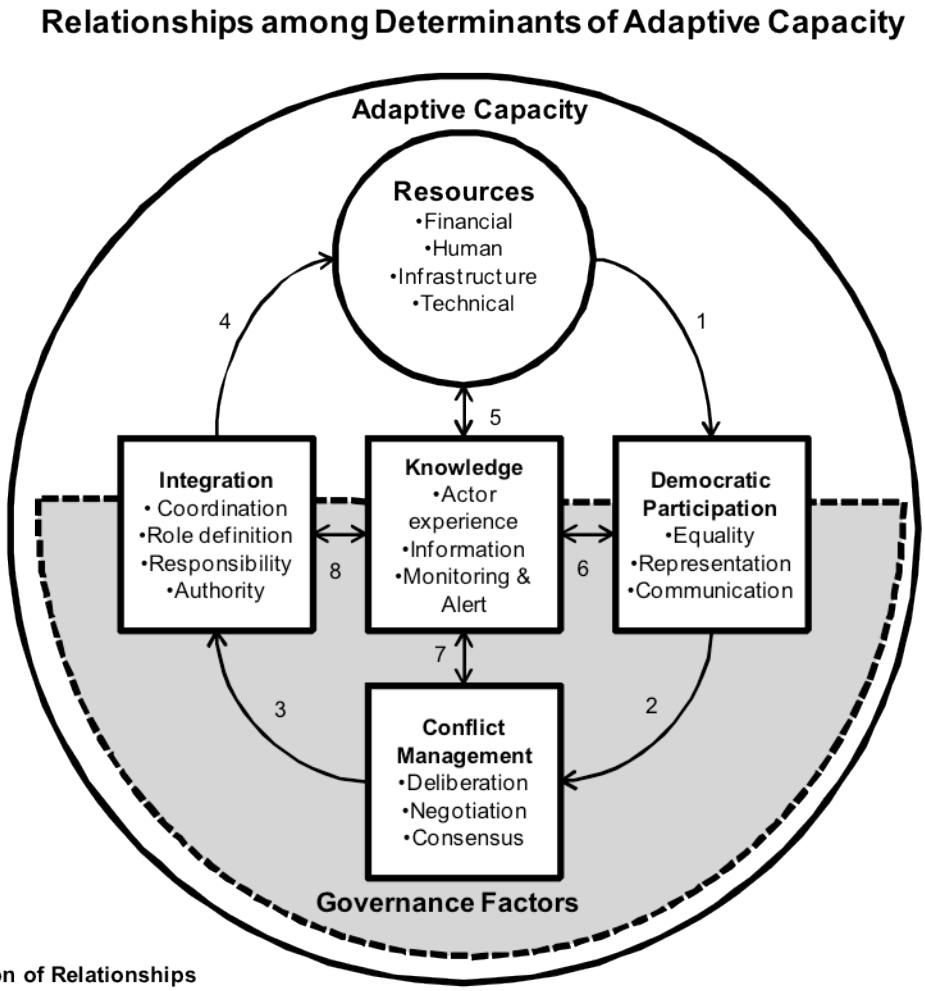
Finally, I administered the 2010 survey in three of the four basins of interest for this study. I trained a research assistant to administer the interviews in the Lower Jaguaribe case. This survey was largely qualitative semi-structured interviews with some multiple-choice and ranking questions. While the interview included 36 set questions, there were often probes or follow-ups to promote elaboration on interesting topics. The 2010 survey comprises the bulk of the data for this study. The interviews were with high-level officials related to water management and disaster relief in the four basins, including the committees. In each interview, I informed the interviewee of the confidential nature of the interview and solicited written consent. The content of the interviews focused on the experience with extreme events, an evaluation of the operation of the committees and the institutional relationships in the basin. I interviewed 10 officials in Itajaí; eight in Paraíba do Sul and five in Lagos São João. In about a third of the interviews, there were two officials present. The research assistant interviewed nine officials in the Lower Jaguaribe case. During the interviews, I took notes, and after each interview, I recorded my impressions and interpretation of the interview. I also conducted participant observation by attending committee meetings in each of the cases and by travelling around the study areas to observe some of the places and issues highlighted in the interviews. After returning to the US, I transcribed and translated the interviews from Portuguese. Afterwards, I organized and coded the transcriptions according to the research questions for analysis.

## CONCEPTUAL AND ANALYTICAL FRAMEWORK

The main questions and hypotheses of this study are fundamentally concerned with understanding governance and its role in promoting adaptive capacity. By governance, I mean "interventions aiming at changes in environment related incentives, knowledge, institutions, decision making, and behaviors… [and] the set of regulatory processes, mechanisms and organizations through which political actors influence environmental actions and outcomes" (Lemos and Agrawal 2006). For the purposes of this study, governance factors were selected from the theoretical paradigms of IWRM, adaptive management and governance that appeared to be most prevalent in the content of the data and relevant to the cases. Many of the variables espoused by these theories are related or overlapping, and as indicators in this study, I have aggregated them into five distinct bundles of factors: knowledge and information, democratic participation, integration and coordination, conflict management and resources. Resources are not a function of governance in itself, but rather enable the interactions that make up governance. Figure 7 outlines the relationship among these bundles of factors and how they contribute to overall governance and potentially adaptive capacity in the context of an extreme event.

In this study, the overall performance of a system is used as one determinant in assessing the combined portrait of governance, which is composed of the different factors and enabled by resources. This assumes that systems that have effectively implemented the tenets of the water reform (including consideration of multiple use, water charges, water allocations and permits, water agency, basin plans, etc.) and have other planning mechanisms, such as municipal plans and contingency plans have higher levels of performance and hence governance. Together, performance contributes to governance in normal circumstances, which, I hypothesize in times of extreme events or stress translate to the adaptive capacity of the system. Knowledge and information include the use of monitoring and alert systems, the embedded experience and diverse backgrounds of the actors involved. These elements are important for providing the knowledge foundation to guide decision making and informing the participation of institutions and actors in interacting with the water system. Knowledge is mobilized in extreme events as data and experience with past events, hence contributing to adaptive capacity. Democratic participation involves the inclusion of actors and their participation in management through democratic means, including representation, fairness, transparency and equality. Democratic

participation contributes to governance by giving legitimacy and accountability to the system, in addition to promoting the interests of actors. Democratic participation can contribute to adaptive capacity by giving civil society a voice in management, which can minimize winners and losers in an extreme event and ensure that autonomous and planned adaptations are complementary. Conflict management relates to the processes and qualities that enable effective negotiation and




**Explanation of Relationships**

| | |
|---|---|
| 1 | Resources are necessary in order to have participation among actors (opportunity and transaction costs) |
| 2 | Representative participation enables negotiation among actors and conflict management |
| 3 | Mediated and negotiated goals promote integration of institutions and issues |
| 4 | Coordination of roles and responsibilities leads to working together on common goals, saving resources |
| 5 | Financial resources are necessary to develop knowledge, information and monitoring systems. Knowledge feeds back to strengthen human resources and better understanding of technical/infrastructure resources |
| 6 | Equal access to knowledge improves participation among actors. Active democratic participation expands the consideration of multiple types of knowledge. |
| 7 | Knowledge and information inform the negotiation process and managing conflict. The negotiation process can refine how different types of knowledge and information relate in order to develop shared views and social learning. |
| 8 | Integration of agencies allows for information sharing and diffusion. Knowledge and information are necessary to coordinate agency actions on various issues across scales. |

**Figure 7: Relationship among resources and governance factors contributing to adaptive capacity**

deliberation, which can lead to compromise, consensus, shared goals or social learning. Such mechanisms for ameliorating conflict are important for governance in that they allow the process to move forward in a way that balances interests, which ensures that conflict does not derail decision making. Integration and coordination relate to the cooperation among agencies, including defined institutional roles and responsibility, which allow different institutions to work together. Integration and coordination are important among policies and issues as well, in that coordinated policies are more effective and that the integration of issues, such as the multiple facets of water resources, leads to more sustainable and robust outcomes. Finally, resources include financial resources in addition to human, technical and infrastructure-based resources, all of which are necessary to have functional water governance. Each of these factors and the way they interact are important for effective governance in ordinary situations. In extreme events, both resources and these governance bundles should contribute to the ability to flexibly adapt management decisions and hence improve the system's adaptive capacity.

It is important to recognize some of the limitations of this methodology and the data. For one, the factors contributing to governance and performance are limited. In reality, both governance and adaptive capacity are amorphous concepts that are difficult to measure. The dependent variable as performance is an adequate proxy for governance in that we assume the output of robust policy implementation results from an effective governance process. I assume that in the case of an extreme event, this performance is mobilized as adaptive capacity or capacity to respond effectively. To assess adaptive capacity, I qualitatively analyze the response to specific climate events in the four cases. The independent variables used here are not exhaustive contributions to governance, but were selected based on the theories in the literature on governance and water resources management, in addition to the content and availability of the data. Furthermore, there may be errors or biases in the data. In the three data sources used for this study, participants may falsify or exaggerate responses. Nonetheless, the confidential nature of the survey minimizes this possibility.

# V. ASSESSMENT OF GOVERNANCE AND ADAPTIVE CAPACITY

## PARAIBA DO SUL

### *GOVERNANCE*

CEIVAP was the first committee to successfully implement water charges on a basin-scale, and since then charges have been implemented on a state level in Rio de Janeiro and São Paulo. As such, CEIVAP has the funding to develop and support a sophisticated organization, including the basin agency, AGEVAP, which executes the decisions of the committee and implements projects. 7.5% of the water charges are used to support the administration of the committee and the agency structures (Interview, 2010). In addition to providing an ample source of funding, the water charges have begun to shape public perception of the finite nature of water resources, leading to use that is more rational. Despite the relatively high financial capacity of CEIVAP, many of those questioned lamented the lack of resources to fully address the major problems in the basin, such as improving knowledge through monitoring, dealing with untreated sewage and water quality. The committee receives approximately R$10 million per year in charges (around $6.5 million). These funds are used to support projects in the basin, such as collecting and treating sewage, which many actors identify as the most pressing problem. Yet the cost of fully implementing treatment is estimated at R$6 billion, so "it would take 600 years to solve the problem at this rate…water charges alone are not enough," as one respondent remarked (Interview, AGEVAP, 2010). The committee and sub-committees work with other agencies, such as ANA and state secretaries to raise funding and implement cost sharing for investing in projects in the basin related to environmental degradation and pollution.

The lack of resources affects performance in that the committee is forced to prioritize different projects that communities bring to them, which can generate conflict and inhibit addressing problems in an integrated manner. In CEIVAP, 65% of committee members stated that lack of financial resources to apply to projects was the biggest problem in the committee's functioning (Watermark, 2005). Furthermore, the shortfall of public resources means that management agencies and the committee itself have trouble attracting the most talented technicians and workers due to low salaries (Interview, 2010). As a result, the most qualified candidates do not want to work for the public sector or the basin committees, highlighting the

relationship between financial and human resources. Resources are also important to enable the participation of committee members, with 15% of noting cost of transportation as the biggest difficulty in fulfilling their role, in addition to 35% citing the distance and time to travel to meetings as a factor.

Resources are imperative in developing the infrastructure and research to produce high quality knowledge that informs decision-making. CEIVAP has financed a number of basin plans and diagnostic studies, including funding of flood studies for risk areas in cooperation with the civil defense. The sub-committee in São Paulo has distributed resources to implement environmental restoration and improving the sub-basin's flood monitoring and alert system. Furthermore, while many agencies in the basin run sophisticated monitoring systems, several interviewees expressed the desire for the committee to conduct further studies to analyze climate phenomena, such as drought, flood and climate change, but complained of inadequate funding given the magnitude of more immediate issues (Interview, 2010).

Several agencies in the Paraiba do Sul are involved in collecting data and monitoring in order to aid decision-making and inform operations. INEA collects information on water quality and quantity, including a network of 20 stations to measuring rainfall and runoff for planning extreme events. INEA shares this information with local chapters of the civil defense. The water company in Rio de Janeiro also collects water quality data and works with INEA in the case of environmental disasters or extreme events. The National Operation System (ONS) that operates the reservoirs for hydroelectricity generation has a sophisticated information system to control infrastructure according to rainfall in order to mitigate floods. The role of high quality climate and stream flow data is extremely important for ONS given its primary role in operating infrastructure to control floods. In São Paulo, the environmental agencies DAEE and CETESB have monitoring and alert systems, including 4 telemetric weather stations to measure rainfall and stream flow to plan for floods and 26 water quality stations. São Paulo was the first state in Brazil to demand permits for industrial pollution via CETESB, and the agency excels at water quality monitoring. There is also a radar system used by the civil defense organizations in the states, but respondents pointed to the insufficient coverage of the equipment.

Given the multiple agencies that collect and analyze data relevant to water management and natural disasters, the perceived impediments to information diffusion are surprising. Often multiple agencies collect the same types of data, suggesting a lack of integration. A manager

from INEA regretted the lack of information sharing among agencies claiming, "many times data is put away and not shared…it is guarded as the property of the individual or office…sometimes people even expect you to pay for data" (Interview, INEA, 2010). Other interviewees confirmed this, pointing out that the water companies do not like to share raw data on water quality, because it might incriminate them. A committee member argued that the restrictions on sharing information were a problem for the civil defense in responding to disasters.

Often CEIVAP and the sub-committees act as important players in the production and diffusion of knowledge for water management and disasters. Members of the committee explained that in the event of a disaster, they often give advice to aid the civil defense and municipal response. While the committee as a unit does not make decisions in extreme events, individual members do according to their official roles, which has made the committee a de facto forum for disaster response through the integration of actors. CEIVAP is a major proponent for improving alert systems in the basin, in addition to developing flood studies and prevention plans. The committee is important in disseminating knowledge about water resources both among its members and externally via other official agencies. CEVIAP is often times a broker of information and has helped to improve information sharing among members and with the general population. Nonetheless, variable knowledge within the committee can affect democratic participation, as 64% of members stated unequal technical knowledge has hindered the democratic process. However, 64% of members also said there was easy access to technical information and 73% claimed technical information was presented in a manner that facilitated the understanding by all members.

Given the large size of the basin, the cross-state boundaries and the number of actors involved, democratic participation presents a challenge for CEVIAP and the institutions in Paraíba do Sul. Many respondents pointed to CEIVAP as the most important actor to promote participation and representation of diverse actors in water management through democratic decision making, which committee members view as imperative for the reform. CEIVAP is an arena for counterparts in different states to participate equally in basin-wide issues, as in the case of public water managers from the three states – DAEE, INEA and IGAM, who cited high levels of equality and participation. The reform and the creation of CEIVAP have led to greater representation of multiple actors, and less domination by technocrats and the hydroelectric sector in water management. Nonetheless, many institutional actors in the basin continue to

demonstrate command-and-control tendencies that run counter to the democratic principles of the reform.

The public water company in Rio de Janeiro is an important actor in water management as the one of the largest water users in the basin, but an official pointed to the rigid and hierarchical internal structure of the company (Interview, 2010). CEDAE's managers make decisions without consideration of other officials or the public. This limits democratic decision-making about water service and delivery in the state. Another example is ONS, which despite being a product of the reform exhibits opaque and authoritarian decision-making processes. ONS and ANA are both federal agencies that were created by the Water Law, with ONS designed to operate hydroelectric infrastructure and ANA to manage federal waters and multiple use. ONS makes all decisions about operating the water infrastructure in PDS without consultation with other agencies and is not a member of the committee. ONS is highly technocratic, insulated and centralized, and does not interact with municipal officials, despite making decisions that are directly relevant, in that ONS manages infrastructure to prevent floods. The construction of predominantly poor communities in areas along rivers leads contributes to flood vulnerability, a problem that falls under the jurisdiction of municipal land use, but is inextricably linked with ONS's management of the reservoirs. ONS officials pointed out the severity of this problem, but claimed they had no contact with municipal officials or the public regarding flood issues despite implicit conflict (Interview, 2010). Municipal leaders frequently blame ONS when flooding occurs, but ONS argues that the occupations are illegal and that the lack of municipal flood plain delineation complicates the operation of infrastructure.

Within the committee, the level of equal representation is also complicated by its structure. While many of those interviewed praised the committee for improving the democratic nature of water management, others were less sanguine. Members of the sub-committees argued that they were discouraged with the over-emphasis on administrative matters in meetings. They claimed that there was too much participation in decisions about budgetary and bureaucratic matters, and not enough focus on long-term basin-wide issues, which has led to disinterest and decreased commitment. Others suggested that CEIVAP should decentralize decision-making and participation further, giving more delegation and power to the sub-committees on local matters and leaving CEIVAP to integrate the sub-basins by "look[ing] at the big picture in the basin…and thinking in a more universal and broader way" (Interview, CBH-SP, 2010).

Members also said that CEIVAP's control over funding allocation and micro-managing small local projects was subject to political influence and lobbying, which would be more transparent and equitable if the process were a task of the sub-committees. Table 2 gives a summary of some measures of democratic decision-making in CEIVAP according to opinions of members in a 2005 survey. The data show that most members view CEIVAP as being democratic in the decision-making process with active attempts at promoting participation, despite a lower assessment of representing society's interests and the presence of powerful members that can reduce equality.

Disagreement over the role and function of CEIVAP has led to conflict among members in the different states. Members from the CBH-PS sub-committee in São Paulo stopped participating in 2006 over disagreements with the election process of committee leaders and the relationship between CEIVAP and the sub-basins, arguing that CEIVAP needs to be a central manager of the sub-committee and decentralize decision-making power. Since then, the conflict has been resolved, in part by improving transparency of election and voting procedures, and by developing an integration agreement that clarifies the role of the committee, the states and the sub-committees. Members of the sub-committee in São Paulo noted how the process of resolving this conflict has led to a greater maturity of the institution in the long-term and could lead to a stronger shared vision over the role of committee in the future (Interview, 2010).

The committee has also had conflict with CEDAE over paying water charges. The charges were implemented "overnight, without planning or participation," which made it "impossible" for the water company to comply without raising its tariffs (Interview, CEDAE, 2010). CEDAE was legally barred from raising its water rates, and refused to pay CEIVAP to avoid an operating loss. This issue was eventually resolved through negotiations with the

| Scale of 0-10, where 0 is terrible, 10 is excellent | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| How representative of society's interests is committee? | 0.0% | 1.5% | 3.0% | 6.1% | 4.5% | 18.2% | 12.1% | 22.7% | 15.2% | 9.1% | 7.6% | **6.4545** |
| How democratic is decision making? | 1.5% | 0.0% | 1.5% | 3.0% | 3.0% | 6.1% | 7.6% | 16.7% | 16.7% | 25.8% | 18.2% | **7.64** |
| The attempt to actively involve all members? | 1.5% | 1.5% | 0.0% | 1.5% | 6.1% | 7.6% | 18.2% | 16.7% | 18.2% | 18.2% | 10.6% | **7.1** |

*Percent of 66 respondents

| | Yes | No | Sometimes |
|---|---|---|---|
| Has unequal power impeded democracy? | 64.4% | 35.6% | - |
| Do members feel free to express themselves and discuss their opinions? | 83.1% | 3.4% | 13.6% |

**Table 2: Measures of participation in PDS**

committee, CEDAE and state officials, but dragged on for over a year. Eventually the committee was successful at changing the state law to allow CEDAE to adjust their rates to the water charges. CEDAE is now the largest contributor to water charges in the basin (Interview, 2010).

The committee is also successful at deliberating and managing conflict over water among its members. Disputes over water concessions between large users are managed in the committee. In addition, conflicts over water quality between NGOs, industry and the state water managers are settled in the committee (Interview, 2010). Yet, many interview participants highlighted the threat of growing conflict over water between metropolitan water users in Rio de Janeiro and São Paulo. The high rates of urban growth have led to a greater demand for water resources, which are constrained by the massive water transfer to supply the Rio metropolitan area. Negotiating the allocation of water will prove challenging in the future. Table 3 shows some measures of conflict in the committee, with members indicating that there is a moderate level of conflict, but also attempts to resolve conflict democratically.

Integration and coordination among actors and issues is essential in a three-state basin like PDS in order to successfully manage water and implement the reform measures. There is a high level of integration among the activities of the water companies, INEA and ANA in order to streamline the water charges, user registration and water allocation processes. This involves coordination of roles and information sharing, which contribute to common goals and mutual progress. The consideration of multiple uses in the water reform has further promoted integration among agencies and water uses. In Rio de Janeiro, the formation of INEA combined three separate agencies to create a single environmental manager, which has helped to integrate environmental issues. Also, INEA reported working together with its institutional counterparts in the other two states to coordinate water management and develop flood contingency plans. ANA has served as a bridging organization to bring together agencies to work on cross-border issues through work groups.

Nonetheless, the lack of coordination has made addressing complex problems difficult, especially the disorganized urban growth that leads to risk exposure. This issue involves multiple actors, including the environmental agencies, state secretaries and municipal organs,

| Scale of 0-10, where 0 is terrible, 10 is excellent | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level of conflict among members? | 0 | 0 | 1.7 | 10.2 | 13.6 | 22 | 22 | 20.3 | 6.8 | 0 | 3.4 | 5.61 |
| Attempt to negotiate conflict among members democratically? | 0 | 3.1 | 0 | 1.6 | 0 | 9.4 | 12.5 | 31.3 | 25 | 6.3 | 10.9 | 7.1406 |

*percent of 64 and 59 respondents, respectively

**Table 3: Measures of conflict and negotiation**

and actions have not been coordinated. In Rio de Janeiro, INEA oversees the Forest Law, which prohibits construction within 30 meters of rivers, but the growth of slums and settlements is legally the responsibility of municipal director plans. Thus, there are limitations in defining responsibility among laws and agencies, which precludes effective resettlement away from riparian areas. In interviews, many actors expressed frustration over the poor coordination among institutional actions and policies in addressing this problem and water resources in general, given a lack of consideration of water resources in other policy areas (Interview, 2010).

The interviews suggest a mixed assessment of integration achieved through the reform. Ideally, the committee should act as a boundary organization, promoting integration among the various actors in the basin, but some reported that the integration was mostly comprised of informal personal contacts among committee members, as opposed to true institutional integration. However, many institutions work with the committee to implement projects and plans, including ANA, INEA, CEDAE, CETESB and DAEE. The creation of a basin plan brought together different institutions and the sub-basins, which was essential for implementing the water charges. However, some have criticized the plan for simply being an amalgamation of the various sub-basin plans, rather than an example of truly integrated planning at the basin-scale. There is also a disconnection among the committees and the technical arm of the committee in different states. In Rio de Janeiro, AGEVAP is the dedicated administrative agency, but in São Paulo, the state laws give this role to DAEE, the state's Department of Water and Energy. In Minas Gerais, there is no agency whatsoever. To improve integration, CEIVAP has an Institutional Integration workgroup that seeks to harmonize sub-basin activities and plans, and there are efforts to revise the basin plan. Table 4 shows the level of integration between the institutions interviewed and other institutions at different levels. It suggests that there are moderate levels of integration, mostly with official agencies and the committee.

Overall, the experience of the Paraíba do Sul basin and CEIVAP has demonstrated good performance, suggesting effective governance, although there are difficulties and a tendency towards excessive bureaucracy. The committee has successfully implemented water charges and created a basin agency, increasing participation, integration and consideration of multiple water use. In the interviews, each respondent rated the success of the committee in a variety of areas,

| Federal | State | Municipal | Civil Soc./ NGO | Committee | Agriculture | Industry | Hydroelec. | Average |
|---|---|---|---|---|---|---|---|---|
| 8.00 | 8.14 | 6.92 | 6.64 | 7.10 | 3.43 | 5.29 | 9.75 | **6.91** |

*of 8 surveyed institutions

**Table 4: Level of integration and cooperation among actors in PDS, with zero as no interaction and 10 meaning very close coordination**

which are summarized in table 5. Despite the tendency to point out the flaws of the committee and water reform, most interviewees qualified such statements with positive assessments, as table 5 shows. Overall, the committee received 9 out of 10 for general importance, with high scores for cooperation and improving management. The committee is not viewed as relevant for climate change, since it lacks the resources to develop this issue, or has more pressing short-term issues that dominate its time, according to members (Interview, 2010). Nonetheless, with respect to adaptive capacity, many actors noted the lack of preparation to respond to extreme events and highlighted the failure to adequately deal with the occupation of risk areas.

### *ADAPTIVE CAPACITY*

Good governance and availability of resources are important contributions to disaster response and adaptive capacity in PDS as the discussions of a drought event in 2003 and a flood in 2010 will show. For one, mobilizing resources is an important component of flexibility, which in turn increases adaptive capacity in extreme situations. In the case of a disaster, the federal and state governments can disburse discretionary funding. CEIVAP has been effective at brokering this emergency money, helping municipalities to receive the funding for rebuilding purposes. In extreme situations, such as the 2010 flood that is discussed below, many agencies in the basin, including the water company and the environmental agencies reported donating their equipment and workers to help aid the response and reconstruction.

Information, monitoring and alert systems are important components for planning and responding to extreme events. This is complemented by knowledge and experience with events that increase the capacity to respond based on past occurrences, which was cited as a factor in the region of the basin in São Paulo that has common flooding episodes (Interview, 2010). In the case of a disaster, state agencies give information to civil defense to guide actions in response. In São Paulo, the dissemination of alert information is formalized through the Integrated Emergency Network (RINEM), which aggregates information from different public and private sources and transmits the alerts via radio. The water companies and ONS use climate forecasts to anticipate drought and flood, based on cyclical occurrences in the case of droughts. When

| In general | Water use mgmt | Cooperation | Rational Water Use | Innovation/ Mgmt improvement | Communication / Info sharing | Climate Change | Average |
|---|---|---|---|---|---|---|---|
| 9.00 | 8.33 | 9.17 | 7.33 | 9.50 | 7.58 | 5.00 | 7.99 |

*of 8 surveyed institutions

**Table 5: Importance of CEIVAP (0 unimportant, 10 very important)**

events occur, ONS and the water companies share reports of the events with the state environmental agencies and civil defense, which use the assessments to update plans and inform future interventions. However, the capacity to evaluate events in PDS is inadequate, as many of the informants suggested, and rather than actual policy changes to prevent future incidences, many agencies call for more studies and data as a way to justify their inaction. Multiple actors stated information and studies were a factor in preparing for or responding to extreme events. Improving the quality of monitoring systems is viewed as a primary need for future water management.

The quality of democratic participation is important for adaptive capacity in giving actors access to the decision-making process, which can improve consideration of the public in an official disaster response. The major actors in a disaster are the civil defense and municipal authorities. In interviews with the civil defense, officials claimed that the level of participation between local communities and the municipal-level of civil defense was inadequate. The lack of participation in the community for disaster planning parallels the low levels of risk perception among the population, which contributes to occupation of risk areas. Oftentimes, this is political as officials do not want to invest in costly relocation, but instead provide residents with public services to gain votes, which legitimizes and reinforces the population of risk areas. Furthermore, there is little participation of the civil defense within the committee. Officials from the civil defense argued that they should be more involved in the committees, given the relationship of water resources and natural disasters (Interview, 2010).

Coordination among agencies in managing water resources to consider disaster was thought to be important in responding to extreme events by every institution interviewed. The committee should be a regular actor in flood and drought management with ANA, ONS and other agencies, but there is a lack of integration in normal situations. The absence of coordinated roles and plans for emergencies was cited as a shortcoming of planning on behalf of institutions. Often, the committee has helped to develop contingency plans with other actors, but only after an event has spurred evaluation and action. The civil defense is supposed to coordinate disaster response, yet it is weak, disorganized or non-existent in many municipalities, which can lead to an official vacuum when events do occur. This can detract from adaptive capacity and leads to responses that are disorganized.

From 1998-2004, there was a drought in the region that peaked in intensity in 2002 and 2003. The major reservoirs in the state of São Paulo had almost completely emptied with only 1-2% capacity, reaching some of the lowest levels ever recorded. This event presented serious challenges to supplying water to urban centers, especially for the city of Rio de Janeiro, which receives all of its water via the inter-basin transfer. The shortages in the reservoir threatened to collapse the regulated stream flow system managed with the basin's infrastructure. Furthermore, the low water levels exacerbated poor water quality, given the higher concentration of pollution with low levels of dilution. The drought also coincided with an industrial accident, in which 1.2 billion liters of toxic effluent from a paper production facility was accidentally released into the river, and much of the already critical water reserves had to be released to dilute the concentration of the pollutant. The drought presented a challenge to state agencies and water managers, requiring adaptation in order to effectively manage the extreme event.

The drought inevitably contributed to high levels of water conflict as water supplies dwindled and city managers in Rio wanted to maintain the quantity of its water supplies. Managers from ONS and ANA decided to reduce the flow from the reservoirs and prioritized the use of water for human consumption. In response to the crisis, CEIVAP created a work group to monitor the impact of the drought, mitigate conflicts and work with ONS and ANA to manage water supplies. The severity of the crisis and the need to make quick decisions made it unfeasible for the entire committee to handle the negotiation and operation of this issue through normal channels. The work group effectively integrated the actions of the committee with ONS and ANA to manage the crisis, by maintaining constant dialogue with municipal officials to prioritize water use and identify areas where the water supply could be reduced. The work group also collaborated with ONS and ANA to generate models and planning for the drought. While there were fears that the water transfer would have to be reduced and Rio de Janeiro would have to implement water rationing, ultimately the participatory management scheme avoided such drastic measures.

The drought event demonstrates how the water reform and management by CEIVAP have increased the adaptive capacity of the water management system through enhanced governance. Rather than succumbing to paralysis in this situation, CEIVAP demonstrated flexibility by creating the work group, thus maintaining the participation of the committee in managing the response to the drought, while limiting decisions to a smaller number of actors.

This intervention incorporated knowledge, democratic participation and conflict management tools through integration of the committee to handle the situation. Furthermore, actors suggested that the drought promoted an evaluation of the fragility of the water transfer to Rio and the creation of a shared view that alternatives were necessary. The reform's stipulation that water use be prioritized for human supply was also important in this event, since it forced ONS and ANA to manage the water shortage to maintain water supplies for the cities.

In 2010, there was intense rain that caused a severe flood event in the São Paulo portion of the basin, affecting the municipality of São Luis Paraitinga. The 500-year rain was surpassed the expectations of a region that experiences periodic flooding. After several days of intense rain, there was 200mm of rainfall in a single day. The river runs through the city center, where the water level reached 12m. The event caused the destruction of 300 bridges in rural areas and the interruption of agricultural industries, including the collapse of the dairy industry. The flood also paralyzed the tourist industry, which is an important sector for attracting income to the historic town. The Paraibuna dam downstream from São Luis Paraitinga was critical for containing the floodwaters to prevent further impact. In the city, 80% of the population was displaced and the flooding destroyed multiple homes, businesses and a historic church. Months after the flood 150 local families were still homeless and rebuilding was incomplete, suggesting the magnitude of the impact. Despite the dramatic impacts, there was only one fatality, which occurred outside the urban area due to a landslide. This is due to the local population's experience with frequent flood events, which has imbued the residents with a high level of autonomous adaptive capacity, including preemptive evacuation and seeking higher ground. A local rafting company was instrumental in saving people stranded on rooftops during the flood. During the flood, DAEE worked with ONS and ANA to facilitate monitoring and alert, which interviews suggested was precarious (Interview, 2010). In the aftermath, the city was inaccessible given the destruction of bridges and loss of essential services, such as electricity and telephone.

In response, many agencies were involved, including the state and municipal civil defense, DAEE, CETESB, water companies, the sub-basin committee and local universities. The mayor and municipal authorities took leadership over the response and coordinated the work of different institutions. Many institutions that have no formal jurisdiction over disaster response, such as CETESB, contributed equipment for road reconstruction, supplies and

technicians to aid the response and restore the city by removing debris. CETESB also oversaw the environmental impact of reconstruction and provided equipment to build emergency housing for the displaced population. DAEE technicians contributed to the response by studying the impact of the event, implementing projects on environmental restoration of riparian areas, and updating the monitoring and alert system. The studies included hydraulic and hydrological analysis of the event, with plans to create a drainage study for the sub-basin. Members of the sub-committee worked closely with the other agencies and created a work group to monitor and evaluate the impacts, together with the National Spatial Research Institute (INPE), the civil defense and DAEE. The committee worked closely with DAEE (which doubles as the executive agency for the committee in São Paulo) and other agencies, including the mayor's office, and contributed almost R$2 million for enhancing the alert system and environmental restoration of the headwaters. The committee did not make executive decisions in the response, but provided planning advice and information to the municipal authorities coordinating the official rescue. Reconstruction of the city has considered the high water level in 2010 to anticipate future events, but much of the construction is in the same vulnerable places, since the river runs through downtown São Luis Paraitinga.

In terms of adaptive capacity, much of the response was autonomous and drew upon the embedded experience and social capital of the residents. Interviews cited barriers to the response as insufficient resources to a more developed monitoring system and the institutional weakness of the municipal civil defense. The official response was integrated and organized due to the leadership of the mayor and the state civil defense, but there was poor advanced warning to the population due to the inadequate alert system. In many ways, the effective leadership of the municipal officials and the state civil defense made up for the weakness of the local civil defense. Overall, despite the failure of advance warning, the aggregate response of the official agencies and the population indicate a significant level of adaptive capacity. The sub-committee was effective at organizing plans for preventative measures for future events, improved monitoring, alert and communication systems. This includes an updated emergency plan that integrates the flood alert system, communication among relevant official agencies, and defines the institutional roles for future floods. The sub-committee has also worked with agencies and universities to develop studies for future infrastructure projects upstream from the city, including flood retention dams and canals. In addition, the environmental managers and the sub-

committee have redoubled efforts to decrease sediment pollution and land degradation, which contribute to flooding, with dredging and environmental restoration. Nonetheless, sediment pollution in the river is a result of ingrained land practices by the rural agricultural population, such as clearing land for pasture, slash and burn agriculture, and inadequate rural road construction. The committee pointed out that it lacked resources to fully address this problem. In interviews, local officials suggested that actors sought to learn from the event and applied their experience in the implementation of the emergency plan to further refine roles and coordination (Interview, 2010). Thus, the role of the committee and other agencies suggests an ability to mobilize and learn from the opportunity presented by the negative impact, indicating adaptive capacity that should improve in the future through evaluation.

## LAGOS SÃO JOÃO

### *GOVERNANCE*

The Lagos São João case illustrates how effective governance and innovation can occur despite scarce resources. While water charges fund part of the operation of the LSJ committee, members stated that resources were insufficient to address the major problems in the basin. In order to develop projects, the committee has been successful at attracting external funding, including money from the World Wildlife Foundation to develop climate vulnerability assessments. The shortage of resources also limits the production of scientific knowledge by the committee, which instead depends much more on common and local knowledge of its members. Seventy percent of committee members claimed that the lack of financial resources to apply to projects was the main problem for the functioning of the committee. Furthermore, the committee lamented how the state government often neglects the region for projects such as environmental restoration and controlling sediment pollution to prevent floods, given that the low population decreases its priority vis-à-vis other parts of the state. The committee has been creative in overcoming the lack of resources by creating partnerships and mobilizing the capacity of its members to maintain effective governance and water management.

Physical resources in the form of infrastructure also affect water management in the region. The water distribution in LSJ is complicated given that the coastal area where the population is concentrated has low annual rainfall, requiring water to be transported from a reservoir in an adjacent sub-basin. Due to the flat terrain of the coastal region, transferring water

requires a complex pumping system. The two water companies in the region – Águas Juturnaíba and PROLAGOS – explained that the precarious nature of this pumping system can constrain water delivery (Interview, 2010). In addition, the region has seen explosive growth in the past decades, with the population increasing from 50,000 in 1980 to over 400,000 in 2000. Since the beaches are a popular vacation destination, the population can balloon in the summers, attracting up to two million tourists each year. This seasonal population spike adds pressure to the water system. The growing population requires investment in infrastructure improvement, which has led to disagreements between the private water concessions and the municipal authorities. These questions are effectively negotiated in the committee.

The limited financial capacity of the committee constrains the production of scientific studies, data and monitoring. Often, the committee has access to information, but does not have the technical capability to analyze data and turn it into usable information. There is no alert system in the region to warn of extreme events and the municipal civil defense agencies are deficient in terms of communication and information sharing. Yet, the committee does collect information from other agencies, including water quality data from INEA and the water companies, in addition to climate, stream flow and oceanic data. Nonetheless, many actors have placed the inadequate monitoring systems on the agenda of the committee, which has attempted to pressure the official agencies to invest in more sophisticated data collection (Interview, 2010). There have been conflicts within the committee regarding the implementation of projects by municipalities without prior study or impact assessment, notably with the dredging of canals, which has focus attention on the need for better knowledge production for environmental assessment and monitoring.

Increasingly, the committee has mobilized the local population and civil society, including the rural population and fishing communities, to provide informal monitoring and oversight of environmental conditions. The committee cites this local knowledge as important to overcome the limitations of technical information. As one committee member remarked, "you need money to have good information, so if you don't have money you need to seek the commitment of the population" (Interview, CILSJ, 2010). Within the committee, participation of the local population helps to disseminate knowledge of environmental and climatic conditions. In one case, the committee used 10 years of rainfall measurements, observations and advice from a rural worker to inform a project to contain runoff and improve flood control in the rural area.

This local knowledge of flood dynamics and community participation allowed for an effective place-based solution to flooding in the absence of technical data or scientific studies. In general, local knowledge and participation in the LSJ committee help to reduce uncertainty and increase preparation for extreme events through communication and observation.

Members of the committee are important sources of knowledge and technical expertise, especially in the technical chambers, where they provide evaluations and recommendations for decision-making. In the interviews, committee members noted that the participation of actors from a wide variety of sectors and educational levels contributes to diverse knowledge that can have both positive and negative effects. This diversity of knowledge is good for providing multiple views, enabling the fusion of technical expertise and local knowledge, which through participation can result in social learning. Yet, knowledge gaps can often constrain decision-making or slow down the process of deliberation, as some actors do not have an understanding of the issue at hand, or others may have a myopic and inflexible view of an issue based on their educational, technical or career background. This indicates the compromise between broad participation of heterogeneous actors and the ability to make quick decisions through technical deliberation. To promote knowledge diffusion, the committee has organized a number of workshops and training course for its members in order to increase the understanding of water management and climate change. Overall, only 44% of committee members said that unequal knowledge among members hurt the democratic process. All surveyed members claimed there was easy access and availability of technical information for members, and that this information was presented in a way that facilitated understanding. This emphasis on local knowledge parallels the quality of democratic participation in LSJ.

All of the actors interviewed enthusiastically praised the quality of democratic participation fostered by the committee and its leadership, citing high levels of inclusion in decision-making. The commitment to participatory management and the broad inclusion of civil society have roots in the genesis of the committee. The organization of the consortium, which was the precursor to the committee, derives from the mobilization of civil society and officials in the region to confront poor environmental management. The legal establishment of the committee absorbed the structure of the consortium and its members, who retained their commitment to democratic mobilization. Hence, the participatory nature of the committee results from the self-organization among regional actors, which has matured over time with

sustained commitment to the organization. In interviews, respondents noted that the committee was an impartial forum that recognized the opinions of all members. The leadership of both the consortium and the committee was dedicated to participatory management, and "helped to alleviate the fears of those who were not used to talking, while making people who accustomed to talk a lot stop and listen" (Interview, CILSJ, 2010). The impartial nature of leadership has gone beyond improving negotiation to generate a shared perception of problems and social learning. It has also prevented the proliferation of extreme views or forced opinions on other members. As such, the interviews noted that there is little dominance, self-interest or political influence in the committee as all members have equal access to present their opinions with respect.

The commitment to democratic participation in the committee and the perception of equality has produced a favorable image of the institution in the region. As a result, the active participation and deliberation in the committee confers legitimacy on basin actors and their decisions, even those external to the committee. The manager of PROLAGOS illustrated this by stating, "I would go beyond saying that I simply consider the actions of the committee; I insist on consulting with the committee and getting its approval before I make any big decision" (Interview, PROLAGOS, 2010). Table 6 outlines some measures of democratic participation in the basin. Overall, the committee and consortium members gave high ratings for the representativeness of society's interests, democratic decision-making and involvement of members. While 44% of respondents said that unequal power impeded democratic decision-making, the lowest among all of the investigated cases, 94% said members felt free to express themselves.

| Scale of 0-10, where 0 is terrible, 10 is excellent | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| interests is committee? | 0 | 0 | 0 | 0 | 0 | 5.9 | 11.8 | 5.9 | 17.6 | 23.5 | 35.3 | **8.47** |
| making? | 0 | 0 | 0 | 0 | 0 | 5.9 | 5.9 | 0 | 11.8 | 11.8 | 64.7 | **9.12** |
| The attempt to actively involve all members? | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11.8 | 23.5 | 5.9 | 58.8 | **9.12** |

| | Yes | No | Sometimes |
|---|---|---|---|
| Has unequal power impeded democracy? | 43.8 | 56.3 | 0 |
| Do members feel free to express themselves and discuss their opinions? | 93.8 | 0 | 6.3 |

*Percent of 17 respondents

**Table 6: Measures of Participation in LSJ**

The mobilization of multiple actors has facilitated the participatory creation of innovative solutions, especially the shared problem of pollution in the Araruama Lake. Within the consortium, a plan was proposed to address the lack of sewage treatment, which accounted for the primary source of pollution causing hypoxia and eutrophication in the lake. In 1998, the municipalities signed a concession agreement with the two water companies to provide services, including sewage collection and treatment. This plan required the water companies to build sewage collection networks, hitherto nonexistent, starting in 2008. This timeline would have delayed action on mitigating the primary stressor to the Lake by at least a decade. In the consortium and later the committee, actors negotiated with the cities and water companies to accelerate the recovery of the lake by investing in an emergency plan to treat sewage first rather than a separate collection network. Since sewage was disposed and reached the lake via the urban drainage networks and rivers, the actors negotiated to use the money earmarked for the sewage network and instead invest in a containment belt around the lake. By collecting the sewage and pumping it to treatment stations, the network impeded the sewage from entering the lake. This represents a temporary solution to the problem by leapfrogging over the construction of dedicated sewage collection networks, which would have taken substantial time and resources before positive effects would have been seen in the lake. However, the palliative infrastructure is controversial since it does not function when the rain fills the drainage networks and treatment is interrupted. Nonetheless, these measures have successfully revitalized the lake by reducing the amount of pollutants. The consortium and committee enabled the development of this innovative solution by involving multiple actors in a participatory discussion of the shared problem. This process allowed a renegotiation of the water concession contracts between the municipal governments and the water companies.

Despite the effectiveness of the committee to infuse water management with participation and democratic principles, other important factors detract from these qualities. For one, there is a serious problem with water theft in the region, with houses and businesses illegally connecting to the water network. This contributes to high levels of inefficiency in the water system, including 32% water loss given the improvised connections. The municipal authorities seem to tolerate this activity, doing little to enforce laws and punish violators. Similarly, there is a problem with poor enforcement of zoning and land planning, which exacerbates environmental damages and vulnerability. There is a high level of development and land speculation in the

region, in which housing projects are built in wetland and other protected areas. The municipal authorities tolerate these infractions, and issue permits in corrupt ways for their own political or economic gain. The lack of integrity of the municipal officials and failure of the rule of law detract from the accountability of governance in the region and contribute to land use problems that exacerbate vulnerability.

Committee members have lamented the lack of participation of the municipal and city officials in the reform process. While the committee generally attracts high levels of participation, the inactivity of important actors at the municipal level sometimes makes it difficult to make decisions. The committee hopes to increase participation further, by including small-scale actors at the community level. Other actors have argued that maintaining the commitment of members to participate is a future challenge, especially as progress is made in achieving the goals of restoring the lake. Without this mobilizing issue, interest in the committee could wane or lead to diverging interests.

Part of the success of the LSJ system has been to operationalize democratic participation to promote conflict management and the elaboration of shared views through consensus. Interviews pointed to the excellent role of the committee in providing impartial mediation to resolve conflicts. As one interviewee expressed, "the success of the committee results from its capacity to mediate conflict and not take positions…Other committees don't mediate; they have formed positions, but here [leaders] view their role as promoting mediation and not ecological activism" (Interview, PROLAGOS, 2010). Settling disputes within the committee helps to foster an integrated view of problems in the basin and promotes the coordination of institutional actors. Table 7 presents some indicators of conflict and negotiation, with members giving a moderate assessment of the level of conflict and a very high assessment of the level of democratic negotiation.

The negotiation of the sewage system illustrates the ability of the committee to deliberate to solve problems. The process of developing this system sought to mitigate conflict between the

| **Scale of 0-10, where 0 is low and 10 is high** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **Avg** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level of conflict among members? | 6.3 | 6.3 | 0 | 31.3 | 6.3 | 18.8 | 6.3 | 6.3 | 18.8 | 0 | 0 | **4.5** |
| Attempt to negotiate conflict among members democratically? | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14.3 | 14.3 | 14.3 | 57.1 | **9.14** |
| | | | | | | | | | | | | |

*percent of 16 and 14 respondents, respectively

**Table 7: Measures of conflict and negotiation in LSJ**

municipal authorities, civil society and the water companies regarding the toxicity of the lake. The decision to pursue the provisional system resulted from a thorough consideration and negotiation of all options. The provisional system was technically illegal due to the strict environmental quality laws and the existing timeline in the contract with the water companies, but the committee was able to negotiate to circumvent the laws for the emergency system, demonstrating flexibility in deliberation and problem solving. "The process tries to hear all sides and put all of the opinions on the table without getting totally caught in legalities, because, in Brazil, if you are overly legalistic, nothing happens…The sewage capture points were illegal so we had to convince the courts that they were a viable solution " (Interview, CILSJ, 2010). Nonetheless, there was widespread conflict over this issue, since many criticized the system's inability to function in the rainy season. The committee was unable to develop consensus on the issue, but had majority approval.

The committee is an effective forum for managing conflict among its members. In one circumstance, there was conflict between the fishing communities and the water companies, with the former accusing the latter of the incidence of high fish mortality rates. The fishing community accused PROLAGOS of not doing enough to prevent pollution from killing the fish. The committee brought the parties together and ordered a study of the issue, including asking the water companies to fund a project to monitor phytoplankton. Ultimately, the technical chambers found that the high incidence of rain had altered the salinity of the lake, contributing to the fish die-off, rather than pollution. The mediation with the fishing communities improved both the consideration of their interests and the knowledge of lake dynamics. Another conflict occurred with companies that engage in commercial sand extraction for construction materials. Since these companies' activities caused high levels of environmental degradation, including sediment pollution and erosion, the committee worked to make further extraction illegal in the region. Furthermore, they negotiated with the extraction companies and INEA to pay for dredging the rivers to mitigate the environmental damage, with the stipulation that the companies could sell the dredged sand. Thereby the committee was successful at preventing further environmental damage and negotiated cleaning up sediment pollution, which was a responsibility of INEA in preventing floods that was unfulfilled given scarce resources.

The success of negotiation and mediation through democratic participation has contributed to the committee's effectiveness as a forum for enabling integration and coordination

among the various actors in the region. The initial motivation to create the consortium was to tackle escalating environmental issues by integrating various actors. While the leadership of the movement viewed the public agencies as the source of inaction, they intentionally encouraged the participation of official organs in the nascent institution. In creating the consortium one respondent remarked, "Civil society was tired of screaming and not having anyone to kick…NGOs [created the structure] not to fight with the city governments, but to permit their presence and incentivize their action, knowing that public officials were not committed to environmental action, but perceiving that it was important to have them in the organization" (Interview, CILSJ, 2010). Consequently, the structure of consortium and committee promoted integration and coordination among actors on regional issues, such as sewage and environmental protection. The committee allows actors to make decisions on water management in tandem, such as the two water companies that work together closely within the committee. A representative from INEA stated that their integration with other official agencies occurs through the committee, not externally, thus the committee gives regional stability to environmental policy and integration through basin-level water management. Table 8 gives an outline of how the agencies interviewed assessed their levels of coordination with other agencies. It suggests that there is a moderate level of integration, especially with local-level government. The respondents all gave a rating of 10 to the integration with the committee, highlighting its importance in bringing actors together.

In addition to promoting integration and coordination among actors, the committee has been successful at integrating policies and issues. The development of a basin plan brought together regional actors to create goals for integrated projects on water and the environment. Furthermore, the committee has worked at mobilizing the municipal officials to tackle shared issues, including sanitation, trash control and environmental education of the population. Members of the committee note that their goals are to manage not only water, but also its surroundings, including wetlands and forest. This vision has led to projects in rural areas to instill best practices for land management to improve water quality and prevent floods. The combination of this integrative approach with democratic participation and deliberation has prevented the view of the committee as an activist organization.

| Federal | State | Municipal | Civil Soc./ NGO | Committee | Agriculture | Industry | Fishing | Average |
|---|---|---|---|---|---|---|---|---|
| 4.19 | 6.31 | 8.88 | 8.50 | 10.00 | 4.75 | 3.00 | 6.67 | 6.54 |
| | *of 5 surveyed institutions | | | | | | | |

**Table 8: Level of integration and cooperation among actors in LSJ, with zero as no interaction and 10 meaning very close coordination**

Nonetheless, there are shortcomings to the general success of integration in the region. For one, table 8 indicates lower levels of integration among actors with state and federal institutions. A state official from INEA in the region indicated that despite their natural fit to work with the committee, they have little integration with the actions of other state agencies, namely health and education. The committee also pointed to the poor coordination of policies with city and municipal governments as a future challenge, especially related to disaster management. With respect to infrastructure resources, the reservoir that supplies water to the region was constructed by the federal government, which abandoned its jurisdiction over the dam and hence resources to maintain it. While the state is attempting to negotiate a transfer of control, the state is also reluctant to accept the burden of maintaining the infrastructure. In this respect, defined responsibility is ambiguous, which complicates effective infrastructure management. The local water companies have filled this void by providing the minimum necessary maintenance and work with the committee in participatory operation of the reservoir through a technical chamber. In this case, the committee has been important in compensating the poor definition of institutional roles and responsibility.

In sum, the LSJ case seems to represent a success story in the implementation of the reform given the commitment of the committee to democratic participation and conflict management, which has positively affected integration and coordination among actors. These governance factors have given the committee a high level of respect and influence among actors, which has contributed to the high performance of the reforms. Actors gave the committee a perfect rating for its importance in general, as table 9 shows, with high scores for innovation, communication and cooperation in particular. However, there are obvious limitations given the poor quality of knowledge and resources in the region. The system seems to have overcome these shortcomings by improving coordination to capture resources through cost sharing and grants. With respect to knowledge, the broad participation and commitment of local civil society has contributed to a high level of local knowledge and social learning. However, the lack of monitoring, information systems and technical capacity can contribute to poor decision-making. The smaller size of the LSJ case and the existence of a palpable shared issue inevitably play a

| In general | Water use mgmt | Cooperation | Rational Water Use | Innovation/ Mgmt improvement | Communication / Info sharing | Climate Change | Average |
|---|---|---|---|---|---|---|---|
| 10.00 | 9.40 | 9.40 | 7.60 | 9.20 | 8.40 | 5.70 | 8.53 |
| | *of 5 surveyed institutions | | | | | | |

**Table 9: Assessment of LSJ committee (with 10 being high and 0 low)**

role in the long-term commitment and participation of actors. Most importantly, the consortium and later the committee were instrumental in mobilizing actors to force a solution to the collapse of the region's lakes. This required innovation, conflict negotiation, integration among actors and changing laws in the region. The actions are arguably a less than ideal solution, given the ineffectiveness of the system during rains, but the project has been successful at improving the quality of the lakes several years sooner than the original plan. However, committee members have observed a trend of increasing rains in the region, which threaten the long-term effectiveness of the sewage system. The development of basin plans also represents a success of the committee in negotiating and planning for long-term water management in an integrated manner. Furthermore, the performance of the committee has been important to raise awareness of environmental and water resources issues by both public officials and the local population.

### *Adaptive Capacity*

The effective governance instilled by the reform should lead to adaptive capacity, despite a relative lack of knowledge and resources. The region has low rainfall and a low incidence of extreme events, but floods have occurred with unprecedented intensity in the past few years. The limited experience with flood means that both the population and the agencies tasked with response have low levels of knowledge that detracts from their adaptive capacity. In addition, the civil defense agencies do not share information with other organs or with their counterparts in neighboring municipalities, which leads to a lack of preparation and coordination. The weakness of the civil defense is compounded by the lack of formal information or alert system to give anticipation to the population with respect to extreme events. The committee has begun to collect data and study climate change vulnerability, which could be an effective source of knowledge to enhance adaptive capacity in the future, but such efforts are in preliminary stages. The committee's mobilization of local knowledge and monitoring is important to counteract the paucity of technical information.

Inadequate coordination and integration of municipal authorities and civil defense limit the effective mobilization of adaptive capacity in emergencies. Many interviews highlighted that there is no preparation to respond to floods and a failure to develop contingency plans by the municipal governments. In many cases, the relevant civil defense agencies are weak or non-existent. This leads to responses that are ad hoc and disorganized. Furthermore, there is no

evaluation, formal or otherwise, of the occurrence of disasters and the subsequent response. A coordinated effort to address the occupation of risk areas could help to decrease vulnerability, but the inaction of the government to control land use and urban growth instead perpetuates vulnerability. The committee has recognized the perceived increase in rainfall intensity and the lack of integration among disaster response to argue for greater risk reduction and disaster management efforts, but responsibility ultimately lies with the municipal and city authorities. To further progress this issue, the committee intends to include disaster management and climate vulnerability in the next iteration of the basin plan.

In April 2010, a flood event affected the region especially in the municipalities of Araruama and Saquarema. The intense rains, including a 24-hour accumulation of 220 mm (more than the historical average for the entire month of April), were a historical aberration from the arid tendency in the region. High tides compounded the flood by preventing the runoff from reaching the ocean, leading to rapid overflowing of lakes and rivers, which reached levels of up to two meters. Because of the negligence of state and local officials in dredging the rivers and drainage systems in the coastal areas, the floodwaters had a much greater impact. The waterways were clogged with plant debris and trash, which resulted from the inadequate basic sanitation and trash collection in the region. The flood was one of the most intense ever recorded in the region, causing landslides, the destruction of roads and houses. The landslides severed the major highway in the region, contributing to isolation and complicating the response. Hundreds of people were displaced or made homeless, while many others were trapped as the water took several days to recede. In response, the affected municipalities declared situations of public emergency. The rains also had dramatic impacts in the Rio de Janeiro metropolitan area, causing over 150 deaths, which detracted from the attention given to the LSJ region on behalf of state officials. The two municipalities requested state financing and support for rebuilding in response to the declarations of emergency.

In response the civil defense and fire departments attempted to rescue those who were trapped by the rising waters with rafts and boats. Displaced families were taken to schools and churches that served as shelters until they could return to their homes. People that were living in risk areas were encouraged to leave their homes and go to the shelters, but many were reluctant to leave their belongings. Nonetheless, there were perceptions that the civil defense and the city authorities were poorly prepared for the response (Interview, 2010). The federal Department of

Roads responded by clearing the major road artery in the region to free trapped motorists and aid the response. However much of the response was autonomous, with the local population doing what they could to survive by themselves and with neighbors. While the local population coped with the floods, the local authorities were meeting in the capital trying to define the emergency measures and secure funding from the federal government. This process was slow given the severe impacts of the rains in the Rio de Janeiro area. Further complicating the immediate response was the impact on public organs themselves, including the evacuation of the hospital, which was subsequently inoperative, and the flooding of local police headquarters and other government buildings in Araruama.

The local water companies ceded employees and heavy equipment to help the rescue and rebuilding efforts. There were fears that the landslides had broken waterlines, letting rainwater and sewage into the potable water supply. As a result, Aguas Juturnaiba stopped the water supply and fixed the problem. In addition, technicians from INEA came to the region to measure how high the water level had reached in different areas and where the most affected regions were in order to evaluate the flood. The committee leadership supported INEA's actions, accompanying the technicians studying the flood area and helping to interpret the results. The committee members noted that they attempted to identify the risk areas impacted by this flood to highlight the inaction of the municipal authorities in allowing construction in low-lying areas.

The local authorities and the civil defense coordinated the response to the rains in April 2010, but actions were overwhelmingly impromptu. Authorities were able to attend to the victims in a relatively organized manner, despite some complaints of neglect of certain areas and disorganization. The inexperience with flood limited both the autonomous response of the population and the official response. Yet, most importantly, the flood revealed the absence of preventative measures and the inattention to issues that exacerbate the magnitude of such events. For one, the failure to maintain drainage systems and dredge rivers by municipal officials made the water level rise higher that it otherwise would have. In addition, the incomplete coverage of trash collection in the region, in addition to the inadequate management of landfills impeded runoff, as channels and drainage canals filled with debris. Finally, not only do the local authorities ignore the settlement of risk areas, including impoverished neighborhoods that are below sea level or adjacent to rivers, but they condone large housing developments in areas of

delicate wetlands. Altogether, the neglect of urban planning intensifies the impact of flood and the absence of flood preparation or contingency plans limits the effectiveness of the response.

In this case, the water reform and the committee's role had limited direct influence in increasing the adaptive capacity to floods. The committee used the 2010 event to illustrate the need for further planning, and supported INEA in its evaluation efforts, but otherwise did not play a role. The committee has also pressured the local governments to focus more on flood prevention and planning. Nonetheless, the closer relationship between the municipal authorities and the water companies allowed for better integration, which is enhanced by active participation within the consortium and committee.

In 2009, there was also an incidence of heavy rain, which had adverse flood impacts in the rural areas inland from the coast and negative effects on the Araruama Lake ecosystem. After several days of rain, 340 mm fell in the rural inland region in one day, flooding the municipalities of Casimiro de Abreu, Silva Jardim and Rio das Ostras. The local governments declared states of emergency given the intensity of the events. Since the area is predominantly rural and agrarian, the effect on the population was lower. Nonetheless, the flood affected approximately 3,800 people, with 300 families displaced due to flood-damaged houses and at least 100 families made homeless. The rains damaged a bridge on a major federal highway in addition to destroying many smaller bridges, which caused disorder in the region's transportation. Floods caused the destruction of entire crops in the rural areas, given that much of the region was underwater for almost 30 days. The Juturnaiba reservoir, which is located in the municipality of Silva Jardim, filled up rapidly and PROLAGOS had to operate the floodgates to prevent even worse flooding of the town upstream from the dam. The committee worked with PROLAGOS to monitor the event, communicate with the affected municipalities and mediate conflict over managing the floodgates for flood control. This involved a tradeoff, since downstream from the reservoir were two agrarian reform settlements of landless workers that were settled by the National Institute of Colonization and Agrarian Reform (INCRA). The water company had to manage the floodgates in an emergency capacity to mitigate the damage to the two settlements, but in the end, both had to be completely evacuated.

As a member of the committee described the response, "it was everyone for themselves" (Interview, CILSJ, 2010). In the immediate aftermath, the local government and civil defense were overwhelmed and lacked the organizational capacity or equipment to effectively respond.

Eventually, the authorities were able to provide shelter for displaced families as local businesses donated heavy machinery to reach the victims. Local authorities also worked to allocate state money to reconstruction of bridges and houses. The committee, the state civil defense and local NGOs also cooperated in the response.

The 2009 event also caused secondary damages, including massive environmental destruction and fish mortality downstream in the Araruama Lake. The downpour caused landslides and sediment pollution of the river channels, much of which accumulated in the reservoir. In response, INEA and the committee worked with the local governments to assess the damages and to reconstruct the drainage networks. This involved digging out smaller drainage canals, collecting debris and dredging the main river channels. The spike in freshwater that entered the Araruama Lake suddenly lowered the salinity level. Since the shared sewage pumping system was inoperable due to the high amounts of runoff, sewage also entered the lake during this instance. The combination of factors led to a sudden shock to the ecosystem, resulting in high mortality of aquatic species. This dramatic event led to a prolonged period of conflict among fishing communities and the water companies, which the committee helped to mediate.

The water reform and the interaction of the committee in the process of response and recovery seems to be more important for adaptive capacity in the 2009 flood than in 2010. For one, the committee had long been involved with cooperating with the rural workers in the region to negotiate with INCRA to find better locations for their settlements. Before the event in 2009, the committee highlighted their vulnerability due to the settlement's proximity to the reservoir. After the event, the committee worked with the residents to force INCRA to do suitability studies of the soil and analyses of risk, which ultimately led to an agreement to find a more adequate settlement area. The committee was also important in working with PROLAGOS to manage the dam within the technical chambers, which infuses elements of participation in both water management and flood control. In the aftermath of the events, the committee worked with NGOs and the local governments to identify areas of environmental damage, which guided INEA in undertaking the dredging process. This reconstruction and removal of sediment in 2009 mitigated flooding in the inland region in the 2010 event. Finally, the committee was an important actor in managing conflict with respect to the agrarian communities and resettlement, in addition to the protest of the fishing community. While the committee played a limited role in

enhancing the response to the floods overall, the governance improvements likely contribute to latent capacity that may prove instrumental in the future. The response to the floods indicates only moderate adaptive capacity, which further integration among municipalities, planning and alert systems would improve.

## ITAJAÍ

### *GOVERNANCE*

The Itajaí committee is one of the oldest and most developed of basin entities in the state of Santa Catarina. Nonetheless, the committee has only recently begun to discuss the implementation of water charges. While water charges face opposition from powerful sectors in the basin, especially the textile industry and agroindustry, implementation would finance expanded activities. In order to maintain itself financially and implement projects, the committee leadership has been successful at soliciting money from state and local governments, in addition to securing partnerships on projects. In the early days of the committee, insufficient financing and technical support limited decision-making and concrete projects on water management. In 2005, 71% of members said that lack of financial resources for projects was the biggest problem in the committee's operation. In recent years, the committee has received more funding from government sources, especially the state Secretary of Sustainable Development (SDS) to support its operation. The committee leadership noted that more resources would be necessary to improve the technical capacity of its members, especially those from rural areas (Interview, 2010). For specific projects, the committee has financial partnerships with Petrobras, the national oil company, and JICA, the Japanese International Cooperation Agency. The scarcity of public funds detracts from the organizational capacity of municipal-level agencies as well, which limits effective water and disaster management. SDS has attempted to improve water management by funding municipal governments to help them produce director plans. The Santa Catarina Foundation for Research and Innovation Support (FAPESC) has been important to promote the development of scientific knowledge to improve management, including funding initiatives to bring organizations together to create integrated information systems.

Physical resources are also important for water and disaster management in the basin. Three flood control dams in the Itajaí valley are operated by the State Infrastructure Department (DEINFRA). Many interviewees argued that the current water infrastructure was insufficient

and more investment was necessary, but the committee has long sought to move beyond infrastructure as a solution to flood (Interview, 2010). The JICA project focuses on flood prevention in the basin, which was elaborated with strong participation of the committee. The committee was initially dissatisfied with the project's emphasis on infrastructure alone in preventing floods and took the project to the state legislative assembly to present their views. The presentation effectively persuaded state officials, and led to changes in the project to include land use and environmental planning to complement infrastructure investments.

Given the history of flood in the region and the prevalence of agriculture in rural areas, the production of climate information is sophisticated in the Itajaí basin. Many agencies are involved in collecting, analyzing and distributing information for different purposes. The Agricultural Research and Rural Extension Company (EPAGRI) has a sub-agency, the Center for Environmental and Hydrologic Resources Information (CIRAM), which has a highly regarded capacity for providing meteorological data at the state level. In Itajaí, the Alert System Operation Center (CEOPS) monitors river levels to warn of floods in the basin. CIRAM and CEOPS are the most important actors in Itajaí for producing information, which is used by multiple agencies to guide decisions and produce secondary evaluations. SDS also monitors rainfall and surface water conditions, which it combines with geologic data to plan for new infrastructure and to implement policy. The agency also produces aerial maps and cartography for the state. FATMA collects water quality data in order to monitor pollution levels and allocate permits to agriculture and industry. DEINFRA disseminates information on the conditions of the water infrastructure with other agencies and the public, including dam capacity levels. The civil defense agencies conduct studies of risk areas and analyze the impacts of flood and landslides.

Yet, in the interviews, many pointed to limitations in using information. While there is an abundance of climate information, often there is not enough anticipation for the information to be usable by policymakers. "We don't have the right timing for forecasts…Even when information comes, it's right on top of the event, or comes in an incomplete and poorly-presented way (Interview, FAPESC, 2010). Other times, technicians worry about the accuracy of their hydrologic models to predict flood rather than focusing on informing the public, in part because of the politicization of flood prediction. The respondent from CEOPS noted, "we have high quality information, but how managers use this information is out of our control" (Interview,

CEOPS, 2010). Other actors echoed this, arguing that the sophisticated production of knowledge is irrelevant without effective institutions and organizational relationships that can operationalize information and respond to stressors.

Given the devotion of several institutions to produce information on climate and water resources, information sharing and diffusion are important for enabling the application of knowledge in the region. Both EPAGRI-CIRAM and CEOPS disseminate information for use by civil defense agencies, which then communicate with the population in the event of climatic extremes. SDS works with EPAGRI to strengthen the alert systems in the state and supplement them with hydrogeological data and aerial photography to identify risk areas. FAPESC is attempting to intervene through the committee to promote greater integration among information systems. All of these agencies communicate this information with the public thorough websites. Yet, beyond raw data, the poor coordination of information among institutions can limit performance. For example, CEOPS is mandated to focus on the entire basin, yet it emphasizes the city of Blumenau, and often fails to share information with upstream areas. There is also a lack of integration and information sharing between EPAGRI and CEOPS, despite their complementary roles, which leads to overlap rather than specialization (Interview, 2010). Furthermore, the interviews suggest that there is a marked sense of protection over the role of producing information among agencies. SDS has experienced conflict with both EPAGRI and CEOPS over operating information systems. EPAGRI is the premier producer of forecasts in the state and has considerable power, but since it has an agricultural focus, it is criticized for having a rural bias that limits the ability to inform urban disaster planning. SDS attempted to subsume the office of CIRAM, which generated outright hostility among the agencies. In addition, SDS collaborated with CEOPS to modernize the alert system in Itajaí by funding new stations, which eventually became antagonistic and led to conflict when CEOPS did not meet the expectations of SDS. The prestige of climate knowledge in the basin seems to have led to a desire to control information among bureaucracies, which has produced rivalries and mistrust, limiting the effectiveness of knowledge use.

The committee plays an important role in the diffusion of information. There is a close relationship between CEOPS, which is based in the University of Blumenau (FURB), and the committee, which has many members and leaders associated with FURB. The committee has a technical chamber for disaster prevention, of which CEOPS is an integral part, to discuss

forecasts and disaster prevention. The creation of an integrated information system for the basin in partnership with ANA and FAPESC was a major accomplishment after the 2008 flood, but the committee was unable to secure participation of some actors, such as DEINFRA. The civil defense in Blumenau has a close relationship with the committee, and views its role as important in providing information to members. The committee is important for expanding monitoring beyond to municipal level to consider the entire basin. Yet, many interviews were critical of the committee and the dominance of certain actors due to unequal knowledge. One respondent argued, "We need participatory processes, but there needs to be access to information for all participants…to avoid technocratic or excessive academic control in the committee" (Interview, SDS, 2010). In fact, 76% of committee members said that disparate technical information constrained the democratic nature of the committee. Yet, 67% said that there was access to information in the committee and 78% said it was presented in a way that promoted understanding.

Thus, the role of information and the technical capacity of committee members influence the quality of democratic participation in the case of Itajaí. There is a perception among many actors that the committee leadership stifles true democratic representation by controlling the agenda and dominating decision-making given their influence over the information utilized in the process. Several actors viewed the committee as fulfilling an activist role, rather than truly representing the interests in the basin, by promoting unyielding environmentalism and lacking a pragmatic vision. As one official described, "the committee has important role and can't be an NGO; it can't work for the interests of certain water users. It has to have the vision of the system as a whole, and to make multiple use of water viable... Environmental dogma isn't the function of the committee or the state" (Interview, SDS, 2010). These allegations reflect the origins of Itajaí committee, which was formed and led primarily by academics that have retained influence over the activities and path of the committee, accounting for the strong relationship between the committee and university-based CEOPS. Since its genesis, an undercurrent of the work of the committee has been to ameliorate the environmental issues in the basin and balance the dominance of hydraulic engineering as the predominant logic of flood and water management. Furthermore, civil society is the most important sector in the committee structure, with 40% water users, 40% civil society and only 20% public agencies, which may contribute to the prevalence of social and environmental issues and the lack of integration with official agencies.

Many public officials interviewed saw the committee as being subjective and imposing its will, instead of being an impartial arena for participatory management. They criticized the committee as being controlled by a cadre of members that constantly rotate among leadership positions and maneuver the decisions given their personal ideological views (Interview, 2010).

Yet, the committee has taken several actions that should improve the democratic participation in the basin and the state. For one, the Itajaí committee created a statewide river basin committee forum. This was part of the committee's efforts to reform the state's water resources policy. In interviews, committee leaders were proud of the progress the committee members had made by improving their knowledge of water resources over the years. Over time, there has been greater communication among members and an attempt to develop a convergence of views. Yet the concerted effort by members to fully understand issues can slow down the decision-making process due to intensive deliberation (Interview, 2010). Other interviewees viewed the committee is the most important actor in representing community interests, but antagonistic relationships between the leadership and other agencies pose a barrier. As some suggested, this animosity might be due to bureaucratic and personal territoriality, or rather, "disputes of vanity, since each side wants to appear more important than the other" (Interview, FATMA, 2010). In interviews, it became clear that there was antagonism among the committee, SDS, the state Civil Defense and DEINFRA. Table 10 presents indicators of democratic participation by committee members. It suggests that the committee is moderately high in representing society's interests and democratic decision making, but that power has significantly impeded democracy. While this suggests that there is indeed democratic participation internally within the committee, the leadership and agenda of the committee have undeniably produced

| Scale of 0-10, where 0 is terrible, 10 is excellent | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| How representative of society's interests is committee? | 0 | 0 | 0 | 7.1 | 4.3 | 10 | 7.1 | 22.9 | 27.1 | 12.9 | 8.6 | **7.1** |
| How democratic is decision making? | 1.5 | 0 | 1.5 | 4.4 | 4.4 | 17.6 | 7.4 | 10.3 | 25 | 19.1 | 8.8 | **6.99** |
| The attempt to actively involve all members? | 0 | 0 | 0 | 4.3 | 5.7 | 8.6 | 2.9 | 25.7 | 14.3 | 21.4 | 17.1 | **7.54** |

| | Yes | No | Sometimes |
|---|---|---|---|
| Has unequal power impeded democracy? | 75.9 | 22.4 | |
| Do members feel free to express themselves and discuss their opinions? | 70.2 | 7 | 22.8 |

*Percent of 70 respondents

**Table 10: Levels of democratic participation in Itajaí**

rancor in its relationship with state agencies. Thus, it is unclear and difficult to separate whether the committee leadership genuinely impedes democratic participation, or if rival officials simply disagree with the output and activities of the committee. Regardless, these rivalries affect the quality of relationships with the committee and official agencies, which in turn indirectly harm the participation of such agencies within the committee structure. This has limited the performance of the reforms.

In many regards, the friction surrounding the committee could be construed as a microcosm for democratic governance in the state and the Itajaí basin. There seems to be pervasive influence in official agencies that bleed into water and environmental management. The committee was involved in attempting to counter the revision of the state's environmental code that relaxed or removed many provisions for environmental protection. According to the committee, this was an initiative of the rural and agricultural lobby in the state, which wanted to weaken the laws over preservation areas and land management to further the interests of large-scale agriculture. The committee allied with universities and state representatives from the left-of-center Worker's Party in a campaign to maintain the state's environmental code. Such alliances inevitably contribute to the perception that the committee exhibits ideological bents rather than being objective. Yet, the prominence of rural organizations and their influence over lawmakers represent limitations of democratic governance that directly affect water management. Furthermore, the prowess of hydroelectric companies has held back the reforms by weakening the law to require environmental assessment of new large-scale facilities, hence making the majority of hydroelectric plants exempt from licensing requirements (Interview, 2010). The committee has also mobilized to counter hydroelectric development, which subjects it to allegations that it undermines the doctrine of multiple uses.

Instead of being a forum for managing conflict, the actions of the committee have polarized the institutions engaged in water management, making the committee a direct player in conflicts. For one, the cooperation between SDS and CEOPS to modernize the alert system in the basin generated conflict, as SDS was unhappy with the implementation the project. When the flood occurred in 2008, the blame over the monitoring system sparked conflict involving the committee, which publically blamed SDS. This has further eroded the working relationship of the committee and SDS. Similarly, the committee has publically traded criticisms with DEINFRA, over its refusal to let the committee participate in operating and monitoring the dams.

There is also discord between the city of Blumenau and the committee over a basin drainage project. To receive federal funding on the project, there is a stipulation that the city must receive the committee's approval on the plan, which the committee refuses to give over disagreements. With respect to water users, the committee has attempted to limit the expansion of hydroelectricity in the basin, leading to direct conflict with FATMA over issuing the required permits. The committee has accused FATMA of approving the projects without consulting other actors. The state civil defense was upset when the committee excluded it from disaster preparation trainings, despite its official responsibility (Interview, 2010). Overall, this antagonism derives from the view that the committee seeks to dominate water management in the basin, infringing upon competencies beyond its perceived responsibility without forming partnerships.

Nonetheless, the committee has successfully developed deliberative processes that are useful in managing conflict internally. In developing a basin plan, the committee has engaged in consensus building through several iterations of the plan; a process that has taken over five years. This includes the future implementation of water charges, which led to hostility with the textile industry that was effectively resolved through deliberation. In addition, the revision of the JICA project to include environmental management upset many within the committee that protested the delay of the project to negotiate consensus. In this case, FAPESC worked with the committee to negotiate the project among actors. Table 11 gives assessment of the levels of internal conflict in the committee by its members. It suggests that there are moderate levels of conflict and relatively high attempts to manage this conflict democratically.

In the Itajaí basin, the tendency towards bureaucratic rivalry extends beyond the committee and detracts from integration. The competition between CEOPS and EPAGRI over controlling the production of climate data in the basin has damaged the ability of the two agencies to cooperate. Furthermore, SDS wants to take over the role of EPAGRI-CIRAM through an attempt to create a new institution, CLIMESC. This has generated hostility within the state government over control of climate information. In Blumenau, the civil defense has

| **Scale of 0-10, where 0 is low and 10 is high** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **Avg** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level of conflict among members? | 3.4 | 1.7 | 8.6 | 8.6 | 5.2 | 27.6 | 12.1 | 22.4 | 5.2 | 5.2 | 0 | **5.21** |
| Attempt to negotiate conflict among members democratically? | 0 | 0 | 1.6 | 4.8 | 0 | 14.3 | 12.7 | 23.8 | 20.6 | 12.7 | 9.5 | **7.06** |
| *percent of 58 and 63 respondents, respectively | | | | | | | | | | | | |

**Table 11: Measures of conflict in the Itajaí committee**

come into conflict with the Secretary of Housing, which approves construction projects without consulting the civil defense, due in part to overlapping laws that delineate responsibility. To resolve these legal disparities, the civil defense has worked to clarify the laws, which will eventually increase disaster preparation through improved zoning. Finally, FATMA has managed conflict over the multiple use of water, which in other cases lies within the purview of the committee. FATMA has played a larger role than the committee in managing the disputes between water users given its role in distributing permits, which can generate conflict, namely among agriculture users and between tourism and hydroelectric.

The high level of bureaucratic conflict and personal-self interest has undermined the integration among actors in Itajaí, in part due to the failure to define and agree upon responsibilities. Instead of promoting integration, the committee has been embroiled in the competition over information and responsibility that contributes to isolation and fragmentation. For one, the committee has been criticized for being overbearing and going beyond its role, for example by seeking to be involved in managing the reservoirs or controlling information systems. SDS has been active in attempting to clarify the role of the state's committees. After the 2008 flood, there have been attempts to improve integration through a basin information system, which brings together multiple institutions. Furthermore, FAPESC created the Techno-Scientific Group (GTC), which brings together multiple institutions to promote disaster planning and integration, including SDS, EPAGRI and the committee. Table 12 indicates that there are not very high levels of integration among actors. While the highest integration is with state institutions, there is low integration with the committee and with civil society.

There has been a failure to integrate water management issues in the basin as well. For one, FATMA representatives expressed discouragement over the lack of integrated basin planning in that water and land use conflicts are not adequately managed. For example, environmental assessments of agriculture and hydroelectricity relate to individual projects, but not the collective impact of development in the basin. The committee has attempted to improve this through the basin plan to promote a more holistic view of the watershed that includes disaster management as part of the reform, instead of focusing only on water quality and

| Federal | State | Municipal | Civil Soc./ NGO | Committee | Agriculture | Industry | Average |
|---|---|---|---|---|---|---|---|
| 6.75 | 7.75 | 6.71 | 4.00 | 5.86 | 5.00 | 5.13 | **5.89** |
| | *of 10 surveyed institutions | | | | | | |

**Table 12: Levels of interaction among organizations in Itajaí (with 10 being high and 0 low)**

quantity. The lack of integrated basin planning has led to unintended consequences, such as the construction of an overflow canal in the Brusque municipality, which resulted in flooding downstream and destroyed beaches. The committee also helped to promote integrated water management in the JICA project, by emphasizing land use and environmental management. Given that the committee's focus on integrating environmental issues has contributed to disagreements with other agencies, there appears to be difficulties in pursing both integration of water resources and the institutional coordination of actors with diverse mandates.

Overall, the reform experience in Itajaí has been mixed. The committee has developed a basin plan, but this took over five years to elaborate. It has only recently begun steps to implement water charges. While the committee has improved the role of civil society in water management, the conflict and polarization surrounding the committee has prevented closer relationships with important institutional actors, which limits the deepening of the reform and precludes successful integration. The committee has promoted environmental stewardship, which contributes to better integration of water resources, but not in a manner that builds consensus or shared vision with other actors. The view that the committee is an activist organization that does not actually make pragmatic solutions to water management, but instead perpetuates long-winded environmental discourse further detracts from its efficacy. As many interviews suggested, the committee leadership has alienated other actors by controlling the internal agenda of the committee and purportedly taking strong external positions instead of being an objective forum. Table 13 summarizes the assessment of the committee by the organizations interviewed. The results suggest that the committee is important in general, but has been less successful at fostering cooperation, which limits integration. The committee has attempted to play a greater role in diffusing the high-quality knowledge that is available in the state, but given the controversy surrounding the leadership, has been unable to do so efficiently. The institutional rivalries in the case of Itajaí hold back the success of the water reforms and weaken good governance.

| In general | Water use mgmt | Cooperation | Rational Water Use | Innovation/ Mgmt improvement | Communication / Info sharing | Climate Change | Average |
|---|---|---|---|---|---|---|---|
| 8.29 | 8.13 | 5.50 | 6.75 | 6.00 | 6.86 | 2.43 | **6.28** |

*of 10 surveyed institutions

**Table 13: Assessment of the Itajaí committee (with 10 being high and 0 low)**

*ADAPTIVE CAPACITY*

The history of the Itajaí basin is marked by periodic extreme floods, which has contributed to the preparation of the population and official institutions through experience. Before the water reform, the last major flood was in 1983 and resulted in 49 deaths. Like most major disasters, the 1983 event pushed disaster preparation and flood control onto the political agenda and extensive resources flowed into efforts to reduce vulnerability. Consonant with this history, there are many institutions in Itajaí that excel at producing high-quality information that should contribute to the adaptive capacity of actors in the basin, such as EPAGRI, CEOPS, SDS and the committee. While there are multiple alert systems, information as currently produced is poorly integrated among different social actors and has had relatively limited effect on mitigating vulnerability to extreme events. The failure to define roles and responsibilities among agencies limits the coordination required to effectively share information and collectively plan a response. The committee's attempt at improving the integration of information occurred only after the major flood in 2008, and still does not have complete support from all information producers and users. Resources are also necessary to have effective institutional capacity for response. The aftermath of an extreme event brings an influx of financial and material resources, but adequate and flexible funding before an event is necessary to enable latent adaptive capacity. In many smaller municipalities in Itajaí, institutions like the civil defense or fire department are poorly funded, making preparation and response difficult.

The state civil defense has worked to expand beyond a reactive role by engaging in innovative preparation measures. After the 2008 flood, the agency implemented a program to make disaster preparation more participatory through community involvement. The campaign works with communities to increase risk perception and disaster preparedness by attempting to promote community solidarity in the case of disaster. Mobilization involves training community leaders in the response protocol of the civil defense agencies to bring the agency closer to the communities. Community integration increases the legitimacy of the civil defense by making preparation participatory rather than top-down. In time, this attempt to improve the democratic participation in disaster preparation is likely not only to increase adaptive capacity but also to complement the official response to disaster. In addition, the state civil defense has a disaster plan that outlines the role of each agency and their role under its coordination.

The 2008 flood in the Itajaí basin was a catastrophe that affected nearly 1.5 million people, with 135 deaths and 80,0000 left homeless or displaced. While there is a long history of living with floods in the Itajaí basin, the 2008 event was significant due to the magnitude of the rains and the massive impact of flash floods and landslides. In 2008, it was exceedingly rainy, with a period of 14 weeks with rain in the region. In November, the total rainfall was 1000 mm of which 700 mm fell in a 48-hour period. To understand the intensity of this rain, the average annual rainfall is between 1800-2000 mm in the basin, thus one third of the average yearly precipitation fell in only 2 days. Given the prolonged period of rain, the soil was already completely saturated, which compounded flash floods and contributed to landslides. The aftermath lasted over two weeks as new landslides occurred after the rains had stopped and the water subsided. In total, there were over 3,000 landslides that most contributed to the loss of life and property. The impact extended over the entire basin and 14 municipalities declared a state of public calamity, in addition to the state government. In rural municipalities, the impact was most dramatic, especially in Ilhota, Luis Alves and Gaspar, where insufficient public funding contributed to the poor organization of disaster response by the official agencies.

Usually with flood events, decision makers expect a six-hour window that allows officials to prepare the population, but in 2008, there was no advance warning. The event was irregular, with a very high rainfall intensity concentrated over a small area. Due to the localized nature of the rains, the flood control dams were of little use, since much of the rain fell beyond the dam catchment areas. As the radar run by CEOPS was not calibrated to detect this type of event, the system only indicated an anomaly immediately before it started. When CEOPS finally detected and warned about the event, it was too late to formulate a preventative response, in part due to the disorganization of the governmental organizations expected to respond. At the state level, the civil defense released general warnings that November would have high amounts of rain, and the week of the flood, they issued an alert that the rains would be above average. However, this general warning did not adequately capture the catastrophic nature of the rains and did not catalyze an official intervention to warn and prepare the population. As a result, public officials were caught almost completely off guard.

The unprecedented intensity of the rains paralyzed the immediate local response as many agency officials had also been personally affected by the event. In the capital, the state civil defense quickly mobilized in response, including support from the federal government and other

states. The state rescue effort included the mobilization of the largest air operation in Brazilian history, with 24 helicopters and 6 planes, with support from the air force. Yet, the destruction of infrastructure and the saturation of the topsoil made it difficult to take off and land. As one civil defense leader described, "we had food, we had clothes, we had blankets, all of the necessities, but we didn't have conditions to take them to the affected people" (Interview, Defesa Civil-SC, 2010). As a result, there was isolation of the most impacted regions, where the first response depended on local authorities and there were delays in opening shelters for displaced families. In Blumenau, the well-developed emergency agencies (including the civil defense, military, police and fire departments) had a much greater capacity than the smaller municipalities in rural areas that only had support of volunteer fire departments, such as Luis Alvez and Ilhota. In the valley, the emergency response structure that gives support to the smaller municipalities is centered in Blumenau, but much of the efforts favored Blumenau rather than the rural areas. It took nearly 3 days for the emergency team to reach Blumenau, and full access took almost a week. There were 23 major roads destroyed, including the most important artery in the state, BR-470. While the response of emergency officials in Blumenau focused on attending to the city, they sent reinforcements to the rural areas after 36 hours.

The state civil defense attempted to coordinate the response of the multiple organizations involved. They directed state and local agencies in reconstruction and distributed resources. Many entities provided equipment and provided employees for the response, such as SDS, FATMA and EPAGRI. DEINFRA was tasked with dredging rivers, rebuilding bridges and roads. The environmental impact of the disaster was monitored by FATMA, which streamlined the process of obtaining the necessary environmental licenses for reconstruction. EPAGRI was the only institution that had detailed maps of the rural areas and was involved by informing the locations where rural inhabitants lived, but few people in government knew that EPAGRI had such information. Many institutions that sought to help that were not officially coordinated by the state, leading to some confusion. Complicating the response, there was conflict and politicization among agencies that undermined the coordination of the state civil defense. The authorities in Blumenau did not cooperate well with the state and wanted to appear to have self-sufficiency, limiting communication with the state and putting institutional concerns before community interest. There was also a tendency for institutions to blame one another, as in the case of the dispute between CEOPS, the committee and SDS over the perceived failure of the

disaster alert system. Many lawmakers also used the disaster to blame the outgoing political party. While there was minimum coordination at the state level, overall, the response was fragmented among the municipalities, which did not cooperate with one another.

In Blumenau, the local civil defense had mapped out risk areas before the event that accurately indicated the areas that were most impacted by landslides. While this mapping did help the responders decide where to send help, the information did not lead to a preventive evacuation. Eventually, the city opened 64 shelters to attend to the displaced population. Yet, when victims complained of the poor quality and treatment in the shelters, they were deliberately ignored, leading to controversy and allegations of official mismanagement. Many of the victims mobilized to protest the failure of the city to provide suitable shelter. The biggest problem was the reconstruction of housing and infrastructure. Two years after the event, many families were still in shelters or provisional housing and the destruction of the city's infrastructure took more than six months to reconstruct to a minimum level. The disaster refocused the government's efforts to reduce future vulnerability by taking adequate land use measures. The civil defense required people to have structural assessments in order to return to their houses, and many areas were condemned. Since the floods, the civil defense has enforced zoning laws that forbid people from building in risk areas, and created a specific sector for monitoring constructions. Furthermore, there is an effort to relocate people that live in 37 risk areas identified by geologic mapping. While laws controlling construction in risk areas existed before the event, their enforcement has improved with the renewed pressure from the civil defense.

The delay in the initial response and the long period of reconstruction and resettlement suggest that there was low adaptive capacity in light of the magnitude of the event. In response to the disaster, the government undertook several initiatives to improve future capacity. The governor of the state created the Reaction Group designed to integrate the reconstruction efforts and improve institutional capacity to prevent future impacts. This group brought together multiple state secretaries (including SDS, EPAGRI, DEINFRA, etc.), water companies and civil defense. After the disaster, FAPESC implemented a number of initiatives to fund research on disaster response, improving information collection and diffusion through the Technical-Scientific Group, which provided information to the Reaction Group. These efforts have included strengthening the institutional capacity of the civil defense in smaller municipalities. In addition, there has been investment into improving the assessment of risk areas, with aerial

mapping and geologic studies. Overall, the aftermath of the 2008 event exposed the inability of the state to respond, which resulted in multiple efforts to improve this disaster relief by supporting institutional capacity, improving knowledge of risk areas and enforcing land use control. While these actions are reactive, they should improve future adaptive capacity.

The role of the committee in the immediate response was limited. Two weeks after the impact, the committee organized to pressure the government to include environmental provisions in the reconstruction funding by sending letters to the National Water Resources Council. The committee attempted to focus on the role of water resources management in disaster prevention and bring the issue to the national agenda. In doing so, the committee lambasted the state Water Resource Council for inaction that contributed to the disaster, which generated controversy and eroded the opportunity for cooperation. These actions fueled accusations that the committee leaders sought political glory and attention from the disaster. The committee also worked to improve the integration of information through the alert system, with limited success given the fractious relationship among institutions. Finally, the committee also engaged in the revision of the JICA project to include land and environmental management into the conceptualization of disaster management, which occurred after the 2008 impact.

In 2010, a minor flood event in Blumenau demonstrated the improvements in adaptive capacity. In five days, it rained an amount comparable to the flood event in 1983, but the management of the event mitigated the impact. Some of those interviewed suggested that the heightened awareness after the 2008 event resulted in an exaggerated response and that the rain barely classified as an extreme event. In this case, the dams controlled most of the flood, but one overflowed causing panic in the nearby community. DEINFRA managed the infrastructure to dampen the impact in Blumenau while providing constant communication to communities near the dam. CEOPS effectively issued a warning and the civil defense mobilized to evacuate risk areas before the event. The impact in Blumenau included the destruction of nine roads and the evacuation of 24 families, which officials promptly and effectively addressed. The minor amount of people who were evacuated reflects the progress made at reducing the population's vulnerability through effective planning. While the event paled in comparison to 2008, the quick and effective response shows how subsequent initiatives have increased response capacity. In order to ensure an adequate level of adaptive capacity to withstand another event comparable to

the 2008 flood, agencies must maintain the efforts made to improve land use, institutional capacity and disaster planning.

## LOWER JAGUARIBE

### *GOVERNANCE*

The state of Ceará was a pioneer in implementing water reform prior to the federal law, yet the implementation of reform has followed a different path than other states, given the centralized role of the Water Resources Management Company (COGERH). The committees were created later to comply with the federal law, but COGERH is by far the most important institution to emerge from the reform. The state was the first to implement bulk water charges, which has increased the capacity for COGERH to act and implement projects. Yet, few of these funds go to support the participatory management in the committee and user commissions, which has limited the success of the reform (Interview, 2010). The committees in the state have pleaded for COGERH to increase financial and administrative support, as COGERH acts as their administrative arm. The financial dependence of the committees on COGERH constrains the ability to increase participation and elaborate local projects, limiting the influence of the committees. Committee leaders themselves perceived their role as unimportant, in large part due to the failure to have greater financial support and decision-making capacity (Interview, 2010). In Lower Jaguaribe, there was an attempt by the Water Resources Secretary (SRH) to extend the water charges to irrigation, but this was poorly communicated and explained to water user leading many to not comply. It also led to conflict among producers and tarnished the progress made on bulk water allocation in general.

The distribution of resources to agricultural producers in the basin is a long-standing practice that helps to minimize the impact of drought. The Secretary of Agricultural Development (SDA) works to build the capacity of farmers to improve their adaptive capacity, in part by adopting new cultivars and diversifying production. Financial support also includes crop insurance programs, in addition to funding technological interventions, such as water capture and storage. Other programs focus on improving irrigation practices and promoting environmental

preservation through water and soil management. However, SDA complained that the amount of available resources was deficient. Greater investment could decrease farmers' vulnerability to drought through improved infrastructure, education and agricultural extension to broadly disseminate new cultures. In the Lower Jaguaribe, the government has invested in irrigated cooperatives, but the committee complained that there is little parallel funding for agricultural extension. The Secretary of Water Resources (SRH) and the Ceará Foundation for Water Resources and Meteorology (FUNCEME) have collaborated on a project to decrease evapotranspiration rates through small infrastructure projects. While resources are important for increasing the resilience of farmers to extreme events, the lack of funding for the committee has detracted from improving locally informed projects and strengthening the governance factors that promote adaptive capacity.

Hydraulic infrastructure historically constitutes the dominant resource in water management in northeastern Brazil. The Jaguaribe basin has three major dams (Orós, Banabuiú and Castanhão) that allow year-round regulated water flow in the main river channel, in addition to 37 strategic dams that guarantee local water use outside of the regulated valley. In addition, over the last 100 years, thousands of smaller reservoirs were built to make subsistence agriculture viable in the semi-arid climate. In 2004, the Castanhão dam was completed, which improved flood control in the basin. The operation of dams and other hydraulic infrastructure is shared by National Department for Drought Works (DNOCS), which officially manages the large federal dams, and COGERH, which oversees the smaller state-built reservoirs and some federal ones according to agreements with DNOCS. These agencies use precipitation forecasts from FUNCEME to develop criteria for operation of the infrastructure to mitigate extreme events. The 37 user commissions annually negotiate allocation of water from the smaller reservoirs and for the regulated valley. Since the user commissions are organized around reservoirs, they do not represent actual basin-level management. In theory, the committee has broader water management competency and jurisdiction over the commissions, setting guidelines and creating basin plans. Within the Lower Jaguaribe, there is one strategic reservoir, Santo Antônio de Russas that has a related user commission. The strategic reservoirs are designed to hold water for three years to mitigate potential drought, but before 1993 there was no monitoring of the water levels in tandem with climate forecasts, so often this water would run out. DNOCS now works with the commissions to inform water management, which has been an improvement

implemented by the reform. The construction of Castanhão represents the last viable large-scale dam project for the basin. Yet, due to water transfers from the basin to attend to demand of the capital, Fortaleza, water managers hope to implement a massive water transfer from the São Francisco basin, a project that would be expensive and is controversial due to the potential environmental impacts. In the interviews with water managers, the importance given to infrastructure as the primary tool in drought mitigation was unambiguous. Thus, despite the reform and its attempt to move beyond the legacy of the 'hydraulic solution' for drought (Tompkins, Lemos et al. 2008), infrastructure remains a vital resource for water management in Jaguaribe that shapes the scope of participatory governance.

Knowledge in the form of climate forecasts and projections is an important component in water management in Ceará given the legacy of investment in drought prediction. FUNCEME is the primary actor in producing and disseminating climate related knowledge to other agencies, while DNOCS and COGERH are involved in operationalizing these climate predictions to manage the water stock in the reservoirs in dry periods. COGERH also has a system of stations to measure stream flow in the state. The Federal University of Ceará (UFC) is also involved in climate modeling for seasonal forecasts and the creation of a risk analysis and decision support tool with COGERH to further inform the operation of reservoirs in the face of climatic uncertainty. UFC conducts studies of climate variability and change as well, which is a concern among institutional actors. To inform decision making, each year FUNCEME issues preliminary scenarios for the rainy season to relevant agencies in December. In January, FUNCEME meets again with state and federal agencies to give the final forecast, which informs planning and reservoir operation. COGERH shares this information with the committee and commissions for the purpose of allocation negotiation.

Yet, there are inevitable limitations on the usefulness of such data. Uncertainty is a major problem, given the rainfall dynamics of the region – there is general certainty that it will be dry for 9 months, with various scenarios for the rainy period. There are multiple climatic phenomena that mediate rainfall, including fluctuations in the inter-tropical convergence zone and El Niño oscillations. Given the high level of uncertainty, FUNCEME no longer makes deterministic forecasts, and instead gives decision makers a probability that they must consider based on risk. Most farmers consider the margin of error of the forecasts too high to inform crop decisions, and instead base their actions on life experience and local knowledge. As one

interviewee suggested, “for the population, when a forecast by FUNCEME is released it is a source of mockery and laughter, so if FUNCEME says its going to rain tomorrow, you can leave the house comfortable that it won’t rain” (Interview, SRH, 2010). There is a challenge to transform climate forecasts into usable information by policymakers and the local population.

Other important uses of knowledge are the growing need to address water quality, environmental impacts and to prepare for the increasing prevalence of flood and landslide events. The Ceará Environmental Secretary (SEMACE) monitors water quality and grants permits for pollution. Yet, quality has been a neglected problem given the pervasive concern of water quantity. UFC also works to develop studies on sanitation projects and water quality. The civil defense works to develop risk maps for flood and landslide vulnerability, which are used to inform preparation and response to extreme events. However, the civil defense highlighted the need for better information for technical preparation, in addition to increased articulation with local communities to promote risk perception. The SRH uses studies of the basin to inform planning for infrastructure, working closely with SEMACE on environmental impacts of projects.

Despite the prevalence of information produced in managing water resources, many interviews suggested that there is still technocratic command over knowledge and barriers to information diffusion. While the reform has improved institutional coordination of information that enhances response to extreme events, there is a continued disconnection among institutions. The diffusion of information beyond technicians is a problem, since production of climate information is opaque to society and the communication with the population is inadequate. FUNCEME and COGERH overvalue highly technical assessments that do not consider local knowledge or popular wisdom, which makes the information incompatible with the realities of small producers. For water allocation, the forecasts are given to the committees and commissions to negotiate among users, but the committee expressed dismay that they play no role in preparing for flood events. Greater education of the population with respect to water resources is necessary to couple information with adequate practice. There is a perception that, “climate change and water shortages are going to happen, but they are already happening in our daily lives, but we keep on delaying action. We can’t do this” (Interview, SEMACE, 2010). The committee is the most important actor to increase local knowledge in decision-making and to share information with users, but this role has not fully matured. In sum, 79% of members in the

Lower Jaguaribe said that unequal knowledge hindered democratic participation. Furthermore, only 31% replied that there was easy access to technical information in the committee, yet of the information available 86% said it was presented in an understandable manner.

The quality of democratic participation in the Lower Jaguaribe is most prevalent in the annual negotiated allocation of water via the commission and committee. In the case of the Lower Jaguaribe, there are two relevant commissions. The committee participates with the commission to negotiate allocation of water from the one isolated strategic dam in the Lower Jaguaribe sub-basin, the Santo Antônio de Russas dam, and in the larger user commission that is involved in the negotiation of the waterway regulated by the three major dams in the Jaguaribe system. This negotiation has increased transparency and equality in water distribution since the reform, when water was distributed to favor irrigation. "Before there was a favored minority, but now there is transparent and fair water distribution for rich and poor alike," as one interview explained (Interview, SEMACE, 2010). While greater equity has improved the capacity to respond to drought, other users still feel excluded from the process. The committee is generally involved in the process and is a forum for conflict negotiation, but it does not play a formal role in the allocation, which is the responsibility of the commissions. The committees play a weak role in basin-level activities such as long-term planning and creating a basin plan with democratic participation. In the Lower Jaguaribe, the committee has increased participation of the basin population through environmental education efforts to improve understanding of local land and water issues. Despite shortcomings, many of the interviewed agencies expressed that the committee was the strongest entity for participatory management.

The peculiarities of the reform in Ceará with the centralized control of COGERH influence the character of democratic participation and the role of the committee, which is less central than in other states. As the interview with COGERH suggested, the Lower Jaguaribe committee is not playing enough of a role in deliberation or long-term planning in the basin, which would prevent the bureaucratic rigidity of water management through democratic participation (Interview, 2010). Other organizations involved in water management, including the committee, suggested the committee is indeed becoming more bureaucratic as it lacks a clear role outlining the means to sustain participation and construct an agenda, largely due to the prominence of COGERH. Often the committee will vote and make decisions on an issue, but if the decision does not conform to the desires of COGERH or other government agencies (which

are often members on the committee), it is ignored. This occurred with the implementation of water charges for agriculture in the basin, which the committee wanted to install over a longer period. "The government negotiates well when the position of the committee is not contrary to the position of the government…if there is government interest and the committee is against it, the decision is blocked for not having consensus and the government imposes its opinion" (Interview, CSBH-BJ 2010). Thus, especially on controversial or important issues, the committee lacks decision-making power given the unspoken veto power of COGERH and the State Water Resources Council that circumvents the democratic process. This perceived lack of decision-making power contributes to a vicious cycle that suppresses democratic participation in the committee. As one member described, "the committee can only propose… the power is totally within the government sphere... Many people have stopped participating because they realized the decision-making power is not in the sphere of the committee" (ibid). The committee leadership suggested that centralized agencies want to maintain their power over certain activities that should be a capability of the committee, such as issuing charges, permits and allocation. However, other interviews argued that within the committee, the leadership controls the agenda and other members wait for the secretary's orders, reducing the democratic participation of the committee.

The interviews paint a complex portrait of democratic participation. While COGERH argues the committees are not fulfilling their roles, the committee accuses COGERH of being over-bearing. Overall, the existence of the commissions and the centralized role of COGERH leave the committees without a viable role. Hence, the Lower Jaguaribe committee does much less in comparison to its counterparts in the other case studies, sometimes only meeting once a

| Scale of 0-10, where 0 is terrible, 10 is excellent | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| How representative of society's interests is committee? | 2.4 | 0 | 0 | 0 | 4.9 | 12.2 | 17.1 | 17.1 | 17.1 | 9.8 | 19.5 | **7.22** |
| How democratic is decision making? | 2.5 | 0 | 0 | 5 | 0 | 5 | 7.5 | 20 | 25 | 17.5 | 17.5 | **7.58** |
| The attempt to actively involve all members? | 0 | 0 | 0 | 2.5 | 2.5 | 5 | 7.5 | 22.5 | 30 | 12.5 | 17.5 | **7.73** |

| | Yes | No | Sometimes |
|---|---|---|---|
| Has unequal power impeded democracy? | 62.1 | 37.9 | |
| Do members feel free to express themselves and discuss their opinions? | 75.9 | 10.3 | 13.8 |

*Percent of 40 respondents

**Table 14: Measures of democratic participation in the Lower Jaguaribe**

year. Table 14 illustrates that there is moderate to high levels of democratic decision-making within the committee according to its members, but that unequal power has limited democratic participation. This suggests that internally there is democratic participation, but obscures the external role of non-committee members, like COGERH in forcing decisions or ignoring the deliberations of the committee, thereby reducing the authority of the democratic decision-making by the committee.

Conflict in the Lower Jaguaribe, and in Ceará more generally, concerns the allocation of water in times of scarcity, especially in prolonged drought. In this regard, the reform in Ceará has been enormously successful given the transparent and negotiated system of water allocation among users, which consequently contributes to adaptive capacity in times of drought. Nonetheless, there has been conflict with the role of the committee and the centralized power of COGERH when the decisions of the committee are ignored, as described above. Yet the committee has also effectively resolved conflict among users in the Lower Jaguaribe basin, also related to water use. For example, in the Aracati municipality, there was a concern by the residents that the groundwater was being overused, especially with the development of shrimp aquaculture in the area. The community worked with the committee and COGERH to develop studies regarding the amount of water in the wells and allegations of salinization. When there were violent conflicts with workers from the shrimp farms and the community, the committee intervened with law enforcement to make the operation comply to maintain water quality and quantity standards. These conflicts are ongoing, and the committee remains involved in the resolution process. Table 15 suggests that within the committee, there are relatively low levels of conflict and that there are high levels of democratic deliberation among members. This implies that the primary source of conflict, water scarcity and allocation, is adequately addressed via the commissions.

The centralized nature of the reforms in Ceará and the long history of drought intervention have led to a clear delineation of roles and responsibilities among agencies that facilitates integration. Key institutional players include COGERH, SRH, FUNCEME and DNOCS, which work together and form the bulk of decision-making power in managing water

| Scale of 0-10, where 0 is low and 10 is high | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level of conflict among members? | 17.2 | 3.4 | 10.3 | 20.7 | 3.4 | 3.4 | 6.9 | 10.3 | 13.8 | 3.4 | 6.9 | **4.41** |
| Attempt to negotiate conflict among members democratically? | 0 | 0 | 0 | 3 | 0 | 6.1 | 6.1 | 21.2 | 42.2 | 9.1 | 12.1 | **7.67** |

*percent of 29 and 33 respondents, respectively



**Table 15: Indicators of conflict in the Lower Jaguaribe**

resources. Initially after the reform, there were growing pains in COGERH exercising its new role due to bureaucratic competition with DNOCS, which resisted its loss of power over operating infrastructure (Formiga-Johnsson and Kemper 2005). Yet, over time, COGERH and DNOCS developed a new working relationship that contributes to the healthy integration and coordination that exists today. The interviews suggest that there is clear understanding and good working relationships among institutional actors, with FUNCEME informing decisions with technical information; SRH coordinating management and issuing permits; COGERH managing much of the infrastructure, overseeing water charges and allocation, and acting as an intermediary with the committee and user commissions; and, DNOCS cooperating with COGERH to manage federal infrastructure. Part of the success of integration seems to come from the level of centralized control, which conflicts with the principles of decentralization embodied in the reforms, pitting the committees against COGERH in a tenuous institutional balance. COGERH has attempted to improve downward accountability by establishing seven regional offices, including one in the Lower Jaguaribe. As table 16 shows, there were low to moderate levels of interaction among the nine agencies interviewed, with the highest articulation at the committee and state levels. This may suggest that integration does not extend beyond the key actors mentioned. The close relationship of the water management organs results from the clearly defined goal of managing water quantity and drought in the reform, but this has perpetuated the centralized and hierarchical relationships among institutions and has not contributed to more generalized governance improvements.

The biggest obstacle to integration and coordination is the ambiguous role of the committee in the ambit of the water reform. The reforms have instituted equitable management of water allocation, but not necessarily participatory management. As the committee leadership explained, "In the committee there is already integration of the different entities, for example civil society, public power and users, but what is lacking is decision-making power…[without] this integrated management doesn't exist" (Interview, CSBH-BJ, 2010). Instead, COGERH fills the role that is held by the committee in other cases, constraining the integration of civil society and users into the decision-making process in an operational manner. Hence, the committee –

| Federal | State | Municipal | Civil Soc./ NGO | Committee | Agriculture | Industry | Other | Average |
|---|---|---|---|---|---|---|---|---|
| 5.38 | 6.13 | 4.63 | 5.25 | 6.14 | 4.88 | 4.63 | 5.75 | 5.35 |
| | *of 9 surveyed institutions | | | | | | | |

**Table 16: Level of Integration in Lower Jaguaribe (with 10 being high and 0 low)**

the only basin-level actor – is left without a clear mandate or role. While table 16 indicates that the committee has the highest level of interaction with other agencies, this is merely a consultative role among institutional members. In addition, there is a blurring of boundaries between the committee and the user commissions in their role over water negotiations. The interview with COGERH admitted these shortcomings, "all the time we are pushed by the committee and commissions, demanding a more qualified effort for technical, administrative and financial support to strengthen participatory management" (Interview, COGERH, 2010). Hence, in the case of Ceará and the Lower Jaguaribe, integration and coordination of action results from a top-down imposition of roles prescribed by the water reform, rather than a self-organized and bottom-up approach that brings actors together through basin-level participation.

Integration among water management, land and environmental issues is incomplete in the Ceará reform. While the reform has integrated users and multiple uses into the negotiation process, the pervasive emphasis on water quantity almost completely ignores water quality. In interviews, both COGERH and DNOCS cited water quality and environmental degradation as pressing future problems, but dismissed the issues as outside of their jurisdiction. This reflects the logic of the reform's focus on quantity and the role of COGERH, rather than the environmental organ as the primary water manager. SEMACE and SRH work with the committees and municipalities to develop plans for basic sanitation and pollution plans, but this is secondary to water quantity issues.

The case of Ceará and the Lower Jaguaribe is unique when compared to the other cases. The role of the state government is dominant in the reform, with the primary role of COGERH, which makes the discussion of basin-level reform less appropriate. The committee plays a supporting role to the reforms, but is much less prominent than in other parts of Brazil. In large part, this is due to the dependence on hydraulic infrastructure for water management, which detracts from the natural basin as a relevant unit. This has led to a conflicting and nebulous distinction in the roles of the commissions, which are organized around regional reservoirs, and the basin-level committees. Table 17 indicates that the committee is still viewed as relatively important, especially with respect to water use management (which is actually more a role of the

| In general | Water use mgmt | Cooperation | Rational Water Use | Innovation/ Mgmt improvement | Communication / Info sharing | Climate Change | Average |
|---|---|---|---|---|---|---|---|
| 6.75 | 7.00 | 6.38 | 6.63 | 6.38 | 6.50 | 5.13 | **6.39** |
| | *of 9 surveyed institutions | | | | | | |

**Table 17: Assessment of Lower Jaguaribe committee (with 10 being high and 0 low)**

water commission), despite its mere consultative role. Many interviews lamented the inability of the committee to achieve more importance, but still noted its relevance as a basin-level forum and actor. In the case of the Lower Jaguaribe, it makes sense to analyze the reform overall, rather than focusing on the committee as the sole actor in the process.

In this respect, the combined roles of COGERH, the user commissions and the committee have made remarkable progress in water management. The negotiated allocation of water has reduced conflict among users, increased equality and legitimacy. Effective implementation of water charges by COGERH has increased the rational use of water in a drought-prone region. Furthermore, successful protection of the multiple use of water that prioritizes human consumption in drought has improved equity from the historical practice of giving preference to irrigation and local elites. All of these mechanisms indicate the high levels of performance in the reform of the water system, which also increase the adaptive capacity in he case of drought by distributing water transparently. Yet, despite the success of the reform to enable equity in water allocation, it has taken a centralized form, which limits democratic participation and basin-level integration. The same is true for knowledge, which despite the high capacity for information production, is often dominated by technocrats and gives little attention to the needs of the local population. Hence, the success of the reform in this case illustrates a tradeoff between the centralization of authority with managed negotiation versus true democratic participation in management. In many ways, this system gives flexibility and effectively solves the problems the reform sought to achieve, but it deviates from the tenets of the federal law and IWRM. This poses unique questions for the role of governance in the reforms

### *Adaptive Capacity*

With respect to adaptive capacity, knowledge plays a large role in Ceará and the Lower Jaguaribe. The effective production and communication of climate information informs the drought planning process each year, but does little to influence the water allocation process, which occurs after the rainy season. This indicates a disconnection between knowledge, conflict management and democratic participation with respect to adaptive capacity. While users and the local population benefit from the official knowledge production by FUNCEME, COGERH and DNOCS in theory, there is less emphasis on the dissemination of information in a usable format to the local population, limiting individual decision-making and autonomous adaptation. In

addition, with respect to floods, there is less experience among actors, which limits adaptive capacity. The region lacks an official flood monitoring or warning system, given the traditional focus on drought. COGERH indicated that it was unprepared to deal with the growing tendency for flood in the basin. Yet integrating knowledge is important to anticipate for both flood and drought, since there is a tradeoff between releasing water from reservoirs to allow capacity for flood control and retaining water in case of drought. Furthermore, there is an inextricable relationship between the effective management of physical infrastructure resources and knowledge in the form of climate forecasts and hydraulic models. The effectiveness of knowledge in promoting adaptive capacity depends on diffusion though the integration of public organs.

With respect to drought, the combination of technical expertise and the improvements of the reform have contributed to institutional integration that promotes effective response. However, the official institutions have less experience with the growing prevalence of flood events. After being caught off guard in flood events, COGERH, DNOCS, FUNCEME and the civil defense worked with SRH to develop flood plans. These plans include clear institutional responsibility among agencies and guidelines to follow in the case of flood, which has improved integration and the subsequent response capacity. However, as in other cases, the absence of municipal plans to delineate flood plains and enforce zoning detracts from the progress made in institutional integration. In addition, flood control is largely institutionalized among the main players. The committee played a consultative role in the development of the contingency plans, but the final decision has remained with the government. The committee expressed a desire to play a larger role in creating disaster management plans that are informed by local knowledge and hydrographic realities. While drought and flood control has improved with greater experience, knowledge and integration, there has been less success in promoting democratic participation, especially with flood.

Starting in 2001, there were a series of low rainfall years that constituted a major drought in the greater Jaguaribe basin. The reservoirs reached critically low levels, making it impossible to guarantee water for all uses. As a result, there were severe conflicts over water that could not be resolved by negotiated allocation, given the scarcity of water. The water reform required the prioritization of water for human consumption, especially to provide the capital, Fortaleza, hence requiring some agricultural producers to go without water. In the yearly allocation meetings

with the commissions and the committee, COGERH told the producers they needed to reduce irrigation by 50%, which would have jeopardized perennial crops. Through discussions among government agencies, there was a decision that allocations should go to permanent crops, namely fruit trees, over seasonal cultures such as rice, which use a much higher quantity of water. This decision was made in part given the long-term investment in fruit trees, as opposed to the single year loss that rice producers would have to endure. The result of this decision was the *Águas do Vale*, or Waters of the Valley program, which sought to overcome the drought by purchasing water allocations from the irrigated rice producers to prioritize human supply and minimize damages to the agricultural sector.

This plan involved a clear outline of institutional roles, which facilitated the coordinated response among actors. The National Water Agency (ANA) would fund the payments given to producers, but conditionally stipulated that irrigation charges would be implemented during the same period, which was undertaken by COGERH and SRH. COGERH used data from previous years to calculate the amount of water necessary for the number of producers and then managed the water allocations. The Secretary of Irrigated Agriculture distributed the funds to rice producers after technicians from SDA met with the farmers to confirm they met the criteria. However, there was broad resistance by the rice farmers to the plan. With participation of the committee and COGERH, the situation was explained to the farmers and the committee acted as a forum for justifying the action in the context of multiple uses. Despite initial rejection of the plan, those compensated ultimately reached an understanding. Rice farmers were also counseled on the disadvantages of focusing on a crop that required so much water, and were given technical training and investment opportunities in hopes to promote their transition to longer-cycle fruit crops. The plan was successful at preventing the collapse of agriculture during the drought, especially among the long-term fruit crops that had been promoted by the government.

While the Waters of the Valley program averted disaster and demonstrated the adaptive capacity of official institutions, there were limitations. For one, the committee was not supportive of the implementation of water charges simultaneously, and resented not being involved in the creation of the plan. The choice to implement water charges at that time weakened the system overall, as many producers refused to pay without penalty in the confusion. This impunity restricted the success of expanding water charges in future years and made producers suspicious of the reform. The committee also questioned the government's vilification

of the rice producers. Despite the unsuitable nature of planting rice in a semi-arid region, given the wasteful method of flood irrigation, SEAGRI and SDA were previously complicit in promoting the maladapted rice cultivation through official programs. Furthermore, the plan did little to integrate assistance and promote adaptation of rain fed subsistence agriculture. In this case, the civil defense responded by dispatching water cars and organizing work fronts to provide jobs to those who had lost their crops. In addition, the civil defense created a registration of families who had lost their crops, which subsequently received food baskets. These short-term measures were complemented by projects with the SDA to improve water retention infrastructure for subsistence farmers. Overall, there were imperfections in the response, but the modification of allocation in the reform through the Waters of the Valley program (including water charges and priority water use) represents an innovative mechanism to promote adaptive capacity. The consultation with farmers to move away from rice farming and the intervention of market-based signals on water use engendered adaptation in the agricultural sector. Nonetheless, the primary intervention for subsistence agriculture focusing on hand outs represents a coping response, given the short-term nature of the solution, but also fit within longer-term initiatives to improve technological capacity.

In 2004 and 2009, there were flood events in the region that challenged actors, given the proclivity to respond to drought. The 2004 event was atypical, because there were intense pre-season rains, but then a drought during the expected rainy season. The flood validated the construction of the Castanhão dam, which was completed in that year, since it was crucial in containing the floodwaters. Many technicians had derided the construction as foolish and claimed it would take a decade to fill up. While the infrastructure helped to dampen the impact of the flood, there were still damages to the communities downstream in the Lower Jaguaribe, especially those residing near the margins of the river that had to evacuate. FUNCEME had predicted lower than average rainfall in that year, so there was little advance preparation for a flood event. However, immediately before the heavy rains, FUNCEME gave warnings to the civil defense, which allowed for evacuation that prevented injury and death. The heavy rains caused 27 small dams in rural areas to burst, which led to flash floods and the destruction of bridges and other constructions. The greatest economic impacts were losses in the cattle industry. During the flood, there was cooperation among COGERH, DNOCS and civil defense to control the floodgates and limit the flood damages. The civil defense worked individually

with the affected municipalities, but there was little integration in rescuing the population. After this event, there were efforts to improve institutional preparation for floods through planning and integration. There were studies and the creation of preliminary flood contingency and control plans that sought to define infrastructure operation in the case of flood. In the 2004 event, the construction of infrastructure limited the impact, but the response was mostly technical.

In 2009, FUNCEME predicted well in advance the possibility of intense precipitation, which allowed for planning and preparation. There was anticipatory participation among COGERH, DNOCS, FUNCEME and the civil defense following the plans and experience gained from the 2004 event. The agencies met in advance to monitor the rainy period and to establish guidelines. However FUNCEME had predicted that the rains would subside, so COGERH kept the levels in the reservoir higher to retain water for the dry period. When the rains suddenly returned against expectations, two of the three major dams filled up almost to capacity and there was a need to operate the floodgates in an emergency fashion to prevent an overflow, which exacerbated the flood impact downstream. Since the rains were not completely controlled by the infrastructure, there were severe flood damages, especially among areas near the Lower Jaguaribe where houses, roads and other infrastructure were destroyed. The greatest impact was downstream from Castanhão in the Lower Jaguaribe, including the municipalities of Limoeiro do Norte, Aracati and Itaiçaba. These municipalities are in the river delta, but construction of houses has neglected the threat of flood due to the infrequency of risk. There was a flood containment dike in Aracati to protect the downtown center, but the city was nonetheless completely submerged under the floodwaters. Several municipalities had displaced populations that were relocated into emergency shelters. As a result, 134 municipalities declared a state of emergency and received money from both the state and the federal government for reconstruction.

To respond to the event, there was collaboration between the municipalities, the civil defense, COGERH, DNOCS and the state secretaries. There were also adverse impacts on agriculture, with many crops destroyed by the floods. The predominant worry over drought has led farmers to emphasize irrigation over drainage in their fields, but the floods in 2009 led to waterlogging due to the poor drainage planning. The committee worked with DNOCS and the farmers to institute emergency drainage measures to save the perennial fruit trees through pumping. The first time the Secretary of Agricultural Development distributed crop insurance

funds related to a flood event was in 2009. The flood led institutional actors to further refine their flood operation and contingency plans, resulting in an official policy approved by the State Water Resources Council. This involved developing guidelines to operate the floodgates according to climate projections and the existing water volume in order to balance the need to have volume to control floods and reserves to distribute in the dry season. The 2009 event also expanded on the purely technocratic response in 2004 by attempting to involve the committees in the discussions of elaborating the flood contingency plans and the guidelines for managing the volume of the reservoirs. Hence, the planning and coordination that occurred in response to the 2004 event improved the response in the case of 2009, which suggests a higher adaptive capacity to floods given a comparable intensity in the two floods. Overall, the high levels of knowledge, authority and integration in the Lower Jaguaribe have contributed to high adaptive capacity to drought, and a moderate, but improving capacity for flood.

# VI. Discussion and Conclusion

## Assessment of Reform Implementation and Effects on Governance

How has the implementation of water reform in the four cases varied in terms of governance and performance? The results given in the previous chapter give a profile of governance based on the interviews with officials in the basin and existing surveys in terms of key themes: resources, knowledge, democratic participation, conflict management and integration. These governance themes, while difficult to distinguish and measure in practice, are heralded in the literature on IWRM and adaptive paradigms of management as key components of sustainable water resources management that should subsequently improve the capacity to embrace change and recover from extreme events. These governance components also broadly encompass the goals of the 1997 Brazilian water law, which to review has the following guiding principles: the watershed as management unit, decentralized and integrated management with user participation, multiple use of water with economic valuation and priority to human consumption (especially in times of shortage). The technical, institutional and economic tools of the reform include: basin committee with conflict management; the integration of public officials, civil society and water users; water resources and basin plans; water permits; information systems; and water charges (ANA 2002). The results of the cases reveal differences in the implementation of the reform and measures of governance.

Achieving the reform's principles and implementing the requisite management tools constitute a measure of the performance of the basins. This performance indicates higher overall governance, which the interviews sought to examine in-depth. Table 18 summarizes the success of achieving the reform principles, in addition to a summary of indicators of the different governance bundles. It is important to note that this study cannot rank the different basins based on any concrete quantitative measure, but the analysis of performance allows for a qualitative comparison among cases when assessing the overall makeup of governance and success of the reform. This section will evaluate and compare the cases according to the principles of the reform and the related governance factors.

In terms of the basin as management unit, LSJ and Itajaí have been effective at acting at the basin scale by organizing actors and issues, whereas PDS has had complications given the fractured nature of the multi-state basin and ambiguity over the relative role of sub-basin and

basin organizations. In the Lower Jaguaribe case, the basin unit is less germane, given the authority held in state-level institutions and the primary integration of users in the commissions organized around infrastructure. In the Lower Jaguaribe case, the basin-level committee plays a weak role in water management. The level of decentralization parallels the assessment of the basin as the predominant unit of action, as LSJ and Itajaí have effectively promoted

| | | PDS | LSJ | Itajaí | L Jag. |
|---|---|---|---|---|---|
| Reform Principle | Basin as management unit | medium | high | high | low |
| | Decentralization | medium | high | high | low |
| | User participation | medium | high | medium | low |
| | Multiple water use | high | high | medium | high |
| | Water charges | medium | high | low | medium |
| | Priority to human consumption | high | high | high | high |
| | Information systems | medium | low | high | high |
| | Basin plan | high | high | medium | low |
| | Water permits | high | high | high | medium |
| | **Qualitative assessment by author* | | | | |
| Resources | Percent responding lack of resources for projects is the principal difficulty in the committee | 65.2 | 70.6 | 71.4 | 73.2 |
| Knowledge | Percent responding unequal technical knowledge impeded democratic decision-making | 64.4 | 43.8 | 75.9 | 79.3 |
| | Percent responding technical information is easily available to all members | 64.4 | 100 | 67.2 | 31 |
| Democratic Participation | How representative of society's interests (from 0-10, with 10 being very high, average of all responses) | 6.46 | 8.47 | 7.1 | 7.22 |
| | How democratic is decision-making (from 0-10, with 10 being very high, average of all responses) | 7.64 | 9.12 | 6.99 | 7.58 |
| Conflict Management | Level of conflict (from 0-10, with 10 being very high, average of all responses) | 5.61 | 4.5 | 5.21 | 4.41 |
| | Attempt to resolve conflict democratically (from 0-10, with 10 being very high, average of all responses) | 7.14 | 9.14 | 7.06 | 7.67 |
| Integration | Interaction and cooperation with committee (from 0-10, with 10 being very high, average of all responses) | 7.1 | 10 | 5.86 | 6.14 |
| | Overall interaction and cooperation (from 0-10, with 10 being very high, average of all responses) | 6.91 | 6.54 | 5.89 | 5.35 |
| Committee Rating | Average rating of committee (from 0-10, with 10 being very high, average of all responses) | 7.99 | 8.53 | 6.28 | 6.39 |

**Table 18: Summary of performance and governance indicators among basins**

decentralization, whereas PDS is mired in power relationships between the centralized CEIVAP and the sub-basins. In the Lower Jaguaribe, COGERH has retained centralized management at the state level as the committees and commissions have limited decision-making power.

Overall, the reform has increased the participation of users and civil society, but with varying quality. User participation is most effective in the LSJ case with an active effort to promote inclusion by the leadership, with Jaguaribe the least, given the lack of decision-making power of the deliberative body, which has contributed to disinterest. The other two cases have effective user participation, but not at the level of LSJ. Respect for multiple water use is high in PDS and LSJ, but there were barriers in the Lower Jaguaribe given the continued dominance of large agricultural users. In Itajaí, there have been conflicts over how to reconcile hydroelectric use in a democratic manner. LSJ was the only basin to fully implement bulk water charges, which are currently non-existent in Itajaí, implemented in only some states in PDS, and incompletely covering agriculture in the Lower Jaguaribe. The system of drought planning and negotiated allocation gives Jaguaribe an effective system of prioritizing human consumption, which favors urban supply first. Whereas the other cases also showed the capacity to prioritize water use, the process is less systematic than in Jaguaribe. With respect to information systems, Jaguaribe and Itajaí have sophisticated systems to monitor water resources and climate for planning purposes. PDS also has information systems, but they have sporadic coverage, whereas LSJ lacks a sufficient system altogether. Bureaucratic rivalries and attempts to control information in Itajaí limit the efficient use of knowledge, whereas the effective integration in the Lower Jaguaribe and PDS enable the usability of information. Both PDS and LSJ have developed basin plans consistent with the reform, albeit with limitations, yet Itajaí has only recently elaborated a basin plan after five years of development. The Lower Jaguaribe has not created a basin plan that involves local participation, however COGERH created a plan for the entire macro-basin. Finally, all of the cases have implemented water allocation permits, yet Jaguaribe has had some problems reconciling permits with the system of negotiated allocation, especially in the irrigated agriculture sector.

Comparing the uptake of the reform elements suggests a variation in the success of the different cases. On a purely qualitative level, it appears that LSJ has most closely followed the federal stipulations for reform, which in many ways seems to be a result of the commitment among actors and its small size that facilitates user participation and decentralization. Jaguaribe

has conformed least to the federal model, mainly due to the centralized control of the water agency COGERH and the dependence on hydraulic infrastructure, which limits the effectiveness of basin-level organization. PDS and Itajaí conform in some measures, but less in others. In the PDS case, the large size and three state coverage has made it difficult to balance decentralization with basin-level management, which has affected the implementation of technical tools, such as charges and information systems that depend on different state rules and management agencies. Itajaí has been slow to implement the tools of the reform, including charges and a basin plan. It is interesting to note that while Jaguaribe has least followed the guidance of the federal reforms, it has a very high level of performance in managing drought in an equitable manner, which accounts for a dramatic change from the pre-reform system. Comparing the cases in terms of resources and specific elements of governance contained in the interviews gives a deeper understanding of how the reform has contributed to performance and governance.

Resources are necessary for enabling the effective functioning of institutions for good governance. Water charges are a mechanism of the reform that both induce perception of the economic value of water and support the operation of basin-level management through the committees. In the interviews, all of the cases suggested that resources were a problem that limited the functioning of water management, especially with the committees. CEIVAP and the sub-basins take in the most resources from water charges and from state governments, allowing for the development of sanitation and environmental preservation projects. The Lower Jaguaribe has the most constrained actions due to lack of resources, given the dependence on COGERH for financial support, which parallels the low level of democratic participation given the inability to execute and make decisions. Both LSJ and Itajaí overcame insufficient resources by collaborating with actors not officially involved in the water resources arena. Infrastructure represents a physical resource that was most influential in the case of Jaguaribe, due to the dependence on reservoirs for water regulation. In LSJ, the aging infrastructure and its mismanagement by the state and federal government are problems that limit effective water management. The ability of the committee to effectively integrate the regional water companies has helped to cope with this shortcoming, which has also enabled the provisional sewage retention infrastructure that was innovative in restoring the Araruama Lake ecosystem. While financial and infrastructure resources are an important precursor to effective governance, none of the cases seemed paralyzed due to insufficient resources.

Knowledge is important for informing decision-making by officials. It is also correlated with the level of democratic participation in that proper information diffusion improves equitable representation among actors, whereas barriers to dissemination can limit democratization. There is also a relationship between knowledge and integration as sharing information improves institutional coordination and vice versa. LSJ has the least developed system of technical information, but is also the case with the most democratic diffusion of information. In fact, through encouraging active involvement of all of its members, the LSJ committee ameliorated the paucity of technical information by using the working knowledge of institutional actors and local knowledge from farmers, fishing communities, etc. The Lower Jaguaribe case demonstrates the opposite – despite having the most developed information system of all the cases via FUNCEME, technical information was least available to the committee members and knowledge disparity had the largest impact on participation. This stems from the continued dominance of technocrats in Ceará and the incomplete devolution of decision-making power to lower scales. The path-dependency of the prominent drought bureaucracy has placed a premium on knowledge production and control in centralized institutions, which consequently maintained elements of command-and-control after the reform, limiting both equitable knowledge and democratic participation.

Similarly, in Itajaí there is also a well-established information bureaucracy, yet which is more heterogeneous and less centralized than in Ceará, leading to conflict among agencies over information control, including SDS, CEOPS and EPAGRI. Committee members reported that information inequality hinders democratic participation, and Itajaí had the lowest score for democratic decision-making. In this case, the interviews suggest that the strong role of academics from FURB (and their relationship with CEOPS) has dominated the agenda and deliberation process in the committee, thus limiting democratic processes. In PDS, CEIVAP acts as a forum for sharing information and there is more equal information access and use among members. While the interviews suggest that sharing technical data among water management institutions is often problematic, there is less institutionalized competition and control over knowledge than in Itajaí, but also incomplete coverage. The case studies present interesting findings on the role of knowledge in that advanced technical information is not sufficient to enable good decision-making and governance, and can often become a source of contention.

Furthermore, the cases suggest a correlation between information diffusion and democratic participation.

Democratic participation is a multifarious concept that in this study includes representation, equality, transparency and rule of law, which in turn depends on leadership and commitment. In terms of the reform, the committee is the most important arena to foster democratic participation, but the relationship among external organizations also shapes democratic participation. In addition to the relationship between knowledge and democratic participation, there is also a connection with conflict management, which reinforces democratic participation. Again, the LSJ committee has the highest level of democratic participation among all of the cases, and a strong commitment to conflict mediation. Interviews highlighted the dedication of leaders in the basin to promote participation in an objective fashion, deliberately encouraging debate and nurturing a social learning process. On the contrary, the interviews suggest that the leaders of the Itajaí committee tended to influence the other members and incited polarization, which limited both democratic participation and conflict resolution. In fact, in the Itajaí case, the perceived activism of the committee and the overbearing tendency of the committee leadership (or perception thereof) stalled integration with other institutions as conflict spilled out of the committee arena, becoming institutionalized.

The cumbersome organizational structure in PDS has made democratic participation difficult as CEIVAP's actions are often far removed from local realities. The multiple actors across states and sub-basins have led to clashes over resource allocation and the macro-level vision of the organization. Yet, among the cases, the breadth of CEIVAP has enabled wide integration of actors and issues, which inevitably comes with high levels of conflict. The experience of CEIVAP best illustrates the question of scale in democratic participation and the tradeoffs between too much democratic participation at a macro-scale, which can lead to fatigue and conflict among actors, and decentralization to sub-basins, which can detract from integration. The Lower Jaguaribe presents the most interesting case in terms of democratic participation in the limited, but crucial role of negotiated allocations. This infusion of controlled democratization is contrasted with the centralized role of COGERH, which hampers a wider role of the committees in decision-making. Nonetheless, the transparency and equality in the water allocation process represents perhaps one of the most effective features of reform out of all of the cases. Given the magnitude of water scarcity in the region, this process is crucial in contributing

to low levels of conflict and adaptive capacity. Comparing the cases suggests that effective democratic participation can be limited at larger scales. The PDS and Jaguaribe cases indicate that there might be a role for centralization in actually promoting democratic participation at lower scales, but this requires a complex and concerted effort to balance institutional scales and responsibilities. The smaller geographic bounds of LSJ enhance the high levels of democratic participation, as there is greater interaction and intimacy among actors. In addition, the quality of leadership is an important element for maintaining democratic participation through guiding impartial conflict resolution as the diverging experiences of Itajaí and LSJ suggest.

In addition to mere cooperation, integration among institutional or sectoral actors includes mutual relationships, defined roles and responsibilities, and ideally goal alignment to promote policy and topical integration. The reform process should lead to integration through interaction with the committee and the promotion of multiple water use. Ironically, the ambiguous role of the committee often was the primary reason for poor integration. In the PDS case, CEIVAP has contributed to bringing a broad range of institutional actors together better than the other cases with close working relationships among ANA, water companies and managers in the three states. Surprisingly, there is no participation of ONS, the private company that manages federal reservoirs, which despite being a result of the reform and an instrumental player in flood control, does not align with the institutional arena. There were also problems in defining the role of the committee in different states given disparate laws, which establish the prominent role of DAEE in São Paulo as the administrative arm of the sub-committee, limiting the actions of AGEVAP, the basin agency of CEIVAP. The LSJ case also demonstrated effectiveness at integrating actors to tackle shared regional problems, notably sewage treatment, with the committee forging mutual relationships. Yet in both the LSJ and the PDS cases, disaster planning and land use were not integrated into broader water resources management, which limits governance with respect to extreme events. The weak rule of law regarding construction in risk areas results from incomplete integration that increases vulnerability.

In Itajaí, there are also problems with occupation in risk areas, but this is better integrated into land use and flood control policy, given the history of floods, and especially the major flood in 2008. Nonetheless, in Itajaí the institutional competition over roles and responsibilities has exacerbated conflict and stifled integration due to bureaucratic infighting. The committee's attempt to play a larger role in management and defining environmental standards through water

resources has alienated other actors. Thus, while this actually represents an attempt by the committee to integrate issues, it conflicts with institutional integration, which illustrates the connections between integration and conflict management. In the Lower Jaguaribe case, there is clear role definition among the major actors, including FUNCEME, COGERH, DNOCS and SRH, which contribute to effective decision-making and an integration of drought and water resources planning. This is due to the centralization of the reform, which gives clear authority to different players. However, the integration does not extend beyond water issues and there are problems with land use planning and flood as well. In addition, while in other cases the committee holds a central position, in the Ceará case of the reform the committee holds an ambiguous role and responsibility, especially since the user commissions are the natural arenas for most community participation. The centralization of the reform promotes effective institutional integration, but has limited democratic participation through the committee, suggesting a need to balance the centralization of authority with wider democratic inclusion.

Overall, each case of the reform is unique and presents areas of both success and failure, highlighting the need to understand governance processes in context. With respect to achieving the tenets of the federal reform, LSJ represents the most idealized case. The assessment of the committee and the interviews confirm this as LSJ received the highest ranking overall in the assessment of the committee and qualitatively in terms of governance. The success of LSJ comes from its high levels of democratic participation, deliberation and consensus building, bolstered by an inspiring and objective leadership. The interviews conveyed an enthusiasm and reverence for the committee that was absent in the other cases. While LSJ lacks resources and technical knowledge, the committee members were able to compensate these deficits with social capital and learning. CEIVAP received the second highest self-assessment, demonstrating an ability to integrate multiple actors at several jurisdictional scales. However, there are issues regarding integration, democratic participation and centralization that CEIVAP must balance. For one, the spatial scale makes is unlikely that CEIVAP could achieve the level of democratic inclusion that LSJ displays. Instead, CEIVAP must strike a balance between its role and those of the sub-committees, which it is slowly achieving. CEIVAP should provide support to the sub-committees, where a smaller scale and local knowledge can foster deeper democratic participation, and instead strive to be a democratic forum for macro-basin issues through integration. The Ceará case presents similarities with PDS in the centralized role of COGERH

and CEIVAP. However, the democratic latitude in Ceará is much more limited than in PDS. The Lower Jaguaribe received lower scores on its overall performance, in part because it lacks decision-making power and hence a cohesive mandate. Notwithstanding, the reform in Ceará has been one of the success stories in terms of actually achieving change, but the idiosyncratic balance of centralization and participation limits the maturation of the committees. Hence, while the Lower Jaguaribe may fail in following the institutional model of the federal reform (and the tenets of IWRM) in terms decentralization and the role of the committee, the centralization of COGERH has actually been highly effective at managing water resources leading to perhaps the most dramatic improvements among the cases with respect to outcomes. Finally, while the purpose is not to rank the cases, Itajaí has the lowest score, undoubtedly due in part to the explicit contempt some interviewees held for the committee and its leaders. Itajaí seems to present a case of best intentions gone awry, given a committed leadership that forged the reform process and sought to integrate flood and environmental issues into water management. However, while maintaining democratic participation, the influence of the committee leadership veered from objective commitment by shaping the internal deliberation process, which has led to entanglement in political issues external to the committee. The shortcoming of the democratic process and leadership in Itajaí strangled the committee's ability to forge integration, hence reducing its influence and performance.

## Assessment of Adaptive Capacity and the Role of Governance

The increasing impact of natural disasters in Brazil is projected on a terrain of existing problems, including socio-economic inequality, maturing democratic institutions, and massive unplanned growth. All of these phenomena affect adaptive capacity—the latent ability to modulate risk exposure, dampen shocks, recover from losses and readily incorporate change in the case of an extreme event. While the Brazilian water reform does not explicitly seek to temper adaptive capacity, the evolution of institutional arrangements and the seemingly innovative treatment of water resources have inevitably affected adaptive capacity, given the relationship of water to the predominant climatic disturbances in Brazil – flood, drought and landslides. The effective uptake of the governance reforms should also contribute to greater adaptive capacity. How does adaptive capacity vary in the four cases and what role has the reform played in enhancing or detracting from this capacity? While it is difficult to measure

adaptive capacity given its latency and the dynamic and complex suite of factors involved, evaluating the response to events sheds light on this capacity. In the four cases investigated here, this research focused on governance and the impact and response to extreme events, which helps to develop a portrait to compare adaptive capacity in the cases and the relationship with governance.

In the Paraíba do Sul case, the drought event in 2003 and the flood in 2010 mobilized institutional responses in a manner that show the strengths and weaknesses of the reform. The events show how the reform and basin committee have contributed to governance improvements that shape adaptive capacity in PDS, but there are existing problems that have not been resolved. For one, the integration of agencies for disaster response was effective when confronting sudden impact events such as the 2010 flood, despite shortcomings in the capacity of local agencies. This is in part due to the planning and evaluation to improve response, but also due to institutional coordination. The institutional roles in the response were led by the mayor of São Luis Paraitinga and the state civil defense, which compensated for the weakness of the municipal civil defense agency. While the rebuilding process has been slow, suggesting some limitations of adaptive capacity, the city is recovering and providing housing to families displaced by the event.

Furthermore, insufficient resources to address problems that exacerbate flood made the subsequent impact more severe in São Luis Paraitinga, including failures in targeting land degradation, sediment pollution and disorganized occupation, despite knowledge that these problems existed. These shortcomings also represent a failure of integrating broader issues into policies, especially water management. Knowledge in the form of monitoring and alert were insufficient to adequately mobilize an official response in advance of the 2010 event, and efforts to improve these systems occurred only after the event. However, the Paraibuna dam did minimize the flood impact in downstream areas, indicating the positive contribution of physical resources. While CEIVAP was not involved in the reaction to the flood, the local sub-committee worked with DAEE to evaluate the impact and to help improve the alert system ex post. The local community displayed solidarity in the autonomous response and a history of experience with floods in the region limited casualties, since residents knew to seek higher ground. The official institutional response helped to complement this community flexibility. Hence, overall, the committee and the reform seem to have played a minor role in the 2010 flood. The sub-

committee should act as a forum for integrating issues and institutions, including flood planning and forging closer ties with civil defense agencies, which would improve future adaptive capacity. A major barrier to preventing flood disasters is the inadequate planning and enforcement of land use by municipalities that is integrated into water management. While this is true in all four of the cases, it was most pronounced in PDS. The failure to integrate land planning exacerbates flood impacts given the large population living in risk areas. Interviews were quick to point to the lack of institutional coordination and the tendency of agencies to blame others or eschew responsibility for this problem. This issue should play a larger role in the actions of CEIVAP and the sub-committees.

The drought in 2003 represents an even bigger success story in terms of the reform and the committee in enabling adaptive capacity. Faced with a looming crisis, the creation of a small work group maintained coordinated participatory involvement of the committee with water managers to mitigate conflict and negotiate water use. The work group allowed decision-making in a more flexible manner than including the entire committee apparatus, despite limiting the deliberative process and curtailing full democratic participation. The committee worked with ONS and ANA to analyze simulations of models to inform water management during this critical period. In addition, the work group was an arena for communicating with municipal authorities and water companies over the situation, and helped to prioritize water use. The work group acted as a bridge with the sub-committee in São Paulo and the neighboring Guandú basin, which receives the water transfer supplying Rio de Janeiro. Hence, the coordinated role of CEIVAP, ANA and ONS allowed participatory management of the scarce water resources in the reservoir in nimble manner that adapted predefined management guidelines to prevent draconian water rationing. This event mobilized the elements of reform stipulating multiple use, priority for human consumption and participatory management. The role of the committee in participating with ONS and ANA illustrates how integration facilitated an effective response that managed conflict and involved participation, rather than a purely technical response.

The 2003 drought displays a more robust adaptation than the 2010 flood, which illustrates the disparate challenges in sudden impact and slow-onset type events, with sudden impact events like flood depending more on long-term planning and integration. The deficiency in the advanced warning system and the weak mobilization of the local civil defense in the 2010 flood is contrasted by the effective ability of CEIVAP to coordinate the response with the federal water

agencies and infrastructure operators in the drought event. As such, weak institutions or poor integration can paralyze and delay the response to a sudden impact like flood, especially in the case where there is little or no anticipation. Slow-onset events like drought can mobilize flexibility after the event has begun and give a longer time horizon for planning a response. The integration of the committee with ONS and ANA represents a response to the drought that did not normally occur otherwise. Furthermore, the operation of the work group curtailed the democratic participation and conflict resolution process of the entire committee in order to make quick decisions, illustrating the potential compromise of democratic participation for enhanced flexibility in the case of an extreme event. Overall, the case of PDS shows how governance factors improved adaptive capacity in the two events, but there are still limitations in promoting institutional and policy integration to respond, especially to sudden impact flood events.

In assessing the effect of the reform in the Lagos São João region, there have been positive outcomes with respect to governance through the interventions of the committee and consortium, which in theory should contribute to higher adaptive capacity. Yet, the region is bereft of monitoring and alert systems beyond weather forecasts to warn of floods, in part because flooding has not traditionally been a concern. This is also due to the limited resources of both the committee and the official agencies to elaborate knowledge and projects that foster integration of environmental issues. Most importantly, the municipal officials have not developed emergency plans to guide disaster preparation and response that define institutional coordination. Disarticulation among the municipalities and the local civil defense agencies limits responses, with the closest working relationship occurring in the committee with respect to managing water supply and sanitation. Nonetheless, while the response to the floods in 2009 and 2010 proceeded in a disorganized manner, it did show a capacity of agencies to effectively mobilize in an emergency and recover from damages in a timely manner. This moderate adaptive capacity could be improved in the case of further integration and planning among municipalities and the civil defense. The committee has been a driving force in highlighting the need for such information and planning, including long-term studies of climatic vulnerability. These measures, combined with further participation of civil defense and municipal managers in the committee to integrate disaster and water resources management would enhance regional resilience.

High levels of active participation by organizational and community actors in the committee and consortium increase the experience and knowledge of climatic impacts in LSJ. This participation contributes to closer relationships among institutional actors and ultimately integration, which is mobilized in the instance of extreme events. In the aftermath of the 2009 event, the committee worked with INEA to restore the river channels and wetlands, which likely mitigated the impact of the 2010 flood in the coastal region. In addition, the committee's participation in discussions of infrastructure management was important for instilling a sense of accountability and legitimacy in the water companies' flood control capacity. The close working relationship between the committee and the water companies allowed for participatory management of the reservoir in 2009 in order to manage the floodwaters in the least destructive manner, despite inevitable impacts on rural areas near the dam. The committee had addressed the issue of the vulnerable communities settled near the dam with federal authorities before the flood to no avail, and helped to negotiate resettlement options with the federal government in response. The mutual commitment of the committee, INEA and the water companies to the reform has promoted the creation of shared goals and social capital. This was evident in the cases of both floods, where agencies worked together to recover, donating equipment and workers to supplement the tenuous municipal response. The broad participation of actors has also provided a forum to discuss extreme events on a regional scale that pressures governments to be more accountable. In the two events discussed, the committee helped to evaluate the repercussions, which is an important element for future preparation.

Encouraging the participation of multiple actors combined with conflict management leads to a greater convergence of goals and communication, which is important for regional integration on common problems. This has occurred in the LSJ region, especially when considering the successful negotiation of a solution to the collapse of the Araruama Lake ecosystem. The management of this environmental disaster illustrates the adaptive capacity of the committee to a slow-onset anthropogenic stressor. While not a climatic event, the rampant sewage of the lake threatened the region's primary natural asset that supports fishing communities and draws tourism to the region. The committee's ability to work with multiple levels of government, private companies and civil society illustrates how efforts to promote democratic participation, integration and conflict management led to the resolution of this complex socio-environmental problem. This process also engendered social learning.

Nonetheless, in LSJ and the other cases, the role of the reform and the gains from better governance can only go so far. The failure of local authorities to manage land use and create municipal plans hamstrings any broader governance advantages resulting from the committee's engagement. While the committee has pressured authorities to address these issues and to take a more proactive role in disaster planning, ultimately this requires actions by the municipal government. Overall, the LSJ case demonstrates an average adaptive capacity with respect to the 2009 and 2010 events, which is not consistent with the glowing outcome of the reform on governance. However, the excellent result of committee's raison d'être to improve sanitation and restore ecosystem health does indicate high adaptive capacity. Further integration of municipal and civil defense authorities through a concerted effort to extend these governance dimensions to cover extreme events would bolster adaptive capacity.

In the case of Itajaí, the impact of the 2008 floods revealed low adaptive capacity in the basin. A history of flood instilled both an institutional and social proclivity to cope, but the magnitude of the 2008 flood surpassed any advantages gained through ingrained experiential and organizational knowledge. The severity of the disaster in part justifies the initial confusion and paralysis of the response, but the slow recovery and bureaucratic infighting in the aftermath (especially as people remained homeless two years later) suggests a shallow resilience. The sophisticated information systems failed to anticipate the severity of the disaster, and the only alerts were cursory warnings of high potential rainfall by the state civil defense. This failed to instigate a preemptive response. The civil defense already had detailed maps of risk areas before the event that accurately predicted the very regions with the most severe landslides, but this information was not used to relocate residents or prevent new constructions until disaster struck. The state response involved adequate coordination given the logistical complexity of the rescue and recovery, but there were difficulties in cooperation with local authorities, especially in Blumenau. The emergency response apparatus for the mostly rural basin is centered in Blumenau, where the rescue efforts were focused. Rural areas were most affected given the vacuum of local emergency relief agencies and the neglect from regional authorities. The slow rebuilding process and the failure to house victims in part results from the politicization of the event as officials sought to use the disaster to gain prestige or spent political capital to counter negative allegations. In the 2008 flood, the lack of preparation and difficulty in reacting to the disaster, in part due to conflict and controversy, illustrate the low levels of adaptive capacity.

Not surprisingly, the dramatic impact of the floods and the poor response catalyzed initiatives to improve the official preparation, which may contribute to greater capacity in the future. The most important changes have been the emphasis placed on enforcing land planning by the civil defense and municipal governments, improving the usability of information and strengthening organizational capacity in rural areas. The attitude towards urban planning changed after 2008, with an active engagement of the state in zoning and land use, which should decrease future vulnerability. There have also been efforts to integrate disaster management at the state and basin level and an influx of resources for information systems and studies. The event in 2010, while comparatively minor, did exhibit greater coordination and anticipated action, suggesting possible improvements in preparedness.

Overall, the water reform seems to have played little role in enhancing adaptive capacity in Itajaí. While the committee was involved in initiatives to integrate information systems, in sum the water reform has not contributed to improve disaster preparation in the basin. Ironically, unlike the other cases, the committee in Itajaí explicitly sought to address extreme events with the operation of a flood prevention work group, but the actions of the committee to make meaningful changes has been disappointing. In fact, the contention in the water reform process in Itajaí has detracted from good governance through erosion of connections among crucial institutional actors. This results from the failure of the reform in inducing constructive collaboration and shared goals among actors. The perceived lack of democratic participation within the committee has detracted from its legitimacy, which has stymied integration among management agencies. Despite efforts by the committee to increase environmental management that could help dampen the impact of floods, the ideological nature of the leadership and propensity to blame other institutions has led to alienation rather than partnerships. Beyond the committee, bureaucratic infighting over defined responsibilities and the competition over controlling information systems have led to fragmentation and mutual distrust among organizations involved in water resources. These tensions also illuminate the high premium placed on technical information in the basin, which is emphasized over improving institutional organization and capacity to respond to events. Contrary to the goals of the reform, the competition among agencies in the Itajaí case reduces the ability to make the coordinated planning and response that are intrinsic to adaptive capacity.

In fact, the 2008 event further estranged relationships among key players in water management. The committee's first action in response to the event was an appeal to the federal government decrying the failure of the State Water Resource Council that stifled any potential opportunity for future collaboration with state officials. The committee leadership was also embroiled in passing blame over the failure of the warning system though a series of interviews with newspapers leading to hostility with institutional counterparts. These arguments have limited the role of the committee in encouraging greater integration among agencies, as evidenced by the refusal of some agencies to contribute to its basin alert system. The view of the committee as controlled by a politicized and vainglorious leadership has hurt its ability to enhance governance. The committee should be a forum to increase democratic participation to improve integration of agencies and water resource management, which helps to promote adaptive capacity, but it has failed in this respect.

In the Lower Jaguaribe case, the drought of 2001 and the floods in 2004 and 2009 are events that demonstrate the capacity of actors to effectively respond to multiple stressors. The water reform has contributed to adaptive capacity, especially in the case of drought, where mechanisms such as priority use, allocations and bulk charges have conditioned agricultural producers to accept negotiation and use water more sensibly. The reform has made vast improvements from the corrupt and clientilistic manner drought and water management proceeded in the past. The Waters of the Valley program illustrates the institutional adaptive capacity to quickly respond to drought through a coordinated multi-agency response. The clearly defined institutional roles complemented the efforts of the user commission and committee in managing the high levels of conflict among agricultural producers. The program helped to avert disaster and built on the negotiated allocations that have improved democratic distribution of water. Compensating rice producers for their water allocations and promoting investment into new crop technologies allowed producers to cope, yet also gave an incentive for long-term adaptation through training and extension. The response for rain-fed agriculture was also effective, but nonetheless prioritized short-term coping. Ironically, this plan failed to achieve its goal of making water charges viable in agriculture and instead delayed progress on this subject due to poor implementation. This failure results from the deficient levels of democratic participation in the reform; if the committee and the local population had greater authority, the water charges could have followed a more feasible timeline that allowed deliberation, as the

committee had proposed. Hence, while the reform enabled the effective integration among institutional actors that is necessary for inducing an effective response, the frailty of democratic participation precluded sufficient local stakeholder engagement to promote commitment and legitimacy. This in turn reveals a tradeoff between centralization and democratization, in that the centralized structure of the reform has afforded the key institutional actors with authority that enables flexible decision-making and integration via clearly defined responsibilities. Nonetheless, the constrained level of democratic participation reduces local perspectives in the management process, which decreases the commitment of the population and ultimately the efficacy of decisions.

The flood events demonstrate the important role of infrastructure resources in enabling flexibility, given the dichotomy between flood control and drought preparation in reservoir operation. Again, the integration among official actors fostered information diffusion and cooperation to mitigate the floods through an authoritative technical response, with COGERH playing a prominent part. In 2004, there was little advanced warning of the coming flood and the response was poorly coordinated. The historical emphasis on drought planning overshadowed the institutional focus to cope with sudden impact events like flood. However, there was an evaluation process and successive attempts to refine flood control policy after the 2004 event and again after the 2009 event. Information systems adequately warned of the 2009 event in advance and led to a more coherent rescue intervention. The cooperation of DNOCS, COGERH, FUNCEME and the civil defense improved in the case of 2009, illustrating the gains made in adaptive capacity with concerted preparation and evaluation. The committee played a minor role in the 2009 flood, working with the affected farmers to salvage crops, but also consulted on the development of flood control measures. While the reform has intrinsically involved democratic participation in the context of water scarcity, this function has yet to achieve maturity with flood preparation.

Overall, in the case of Ceará and the Lower Jaguaribe, the institutional sophistication to address drought and the gains in governance due to the reform have promoted relatively high levels of adaptive capacity, especially with drought. The 2001 event illustrates the role of institutional coordination and conflict management in informing an innovative response. The flood in 2004 shows a low level of adaptive capacity to flood events, which markedly improved in the 2009 event with planning and evaluation. However, there is ample room for maturation of

the reform to bolster adaptive capacity in the case of Ceará and the Lower Jaguaribe. For one, the centralized nature of the reform has included only limited democratic participation. This contrasts with institutional integration that allows for rapid technical decision-making that has improved governance and disaster response. Additional democratic openness in a manner that does not erode integration or paralyze decision-making, such as giving a greater deliberative capacity to the committees, would contribute to deeper governance reforms by contextualizing decision making at a lower scale. It would also help to diffuse climate information to a lower level by empowering agricultural producers through deeper collaboration. Clarifying the role of the committee is the crucial challenge for reform in Ceará in order to balance centralized institutional authority with local participation at the scale of the hydrographic basin. This will further improve adaptive capacity by giving greater legitimacy to official interventions and improving the integration of local knowledge.

These case studies show variable adaptive capacity among basins. Table 19 summarizes the opportunities and constraints in the four cases in terms of governance and adaptive capacity. The highest levels of adaptive capacity were in the cases of drought response in PDS and the Lower Jaguaribe, both of which exhibited a lower capacity to manage flood events. In fact, none

| Basin | Opportunities | Constraints |
|---|---|---|
| **Paraíba do Sul** | Strong integration of institutions at basin level; high technical capacity; revenue allows investment in projects | High level of disorganized occupation in risk areas; unclear delineation of responsibility among committees and sub-committees |
| **Lagos São João** | High level of commitment to democratic participation among leaders and members; construction of shared goals; committee action on climate change and vulnerability | Poor information system; lack of resources and aging infrastructure; incomplete participation of municipal authorities; low technical capacity |
| **Itajaí** | Good information system; high technical capacity; concerted disaster planning | Poor integration and high level of conflict among institutional actors; controversial committee leadership; disagreement over role of committee |
| **Lower Jaguaribe** | Good information system; negotiated water allocation; technical drought management expertise | Limited democratic participation and incomplete decentralization; unclear role of committee; emphasis on infrastructure over watershed |

**Table 19: Opportunities and constraints in governance and adaptive capacity**

of the cases showed a remarkable resiliency to sudden impact floods, although this capacity was arguably least in the case of Itajaí, and increasingly better with LSJ, Lower Jaguaribe and then PDS. The 2010 flood in PDS indeed showed a positive role of the reform in contributing to disaster response. The Lower Jaguaribe case illustrated how improving coordination and information use through planning increased response to flood over time. However, despite showing the highest promise in the governance performance of the reform, LSJ seems to have only a moderate capacity to respond to flood, but showed extensive capability in managing the slow-onset pollution of the lake. This shows that high levels of democratic participation and conflict management, while good for governance, are ineffective without resources and information that contribute to the capacity of municipal and civil defense agencies.

The results suggest a difference in the dynamic of slow and sudden onset events. The tenets of the reform in managing water are more effective in cases of water scarcity, giving a natural role of committees and agencies in managing drought. Furthermore, the slow onset allows for effective mobilization of actors with a greater lead-time than a sudden event. In the case of flood, clear integration and planning (along with effective resources to support institutional capacity) must be in place before an event. Flood events seem to present a less natural opportunity for intervention by the committee, since it falls beyond the conceptualization of water management envisioned by the reform, being more about disaster than water resources. Hence, one clear lesson from this case study is the need for explicit integration of civil defense agencies within the ambit of the committee and a better articulation of flood control within the scope of the water management reform. The limited participation of civil defense agencies in the committees represents a missed opportunity of the reform, given the importance of basin-level management in regards to flood. All of the committees talked about the need for better flood planning, but few saw this as one of their primary roles or were actively engaged in such pursuits that involved the civil defense. Furthermore, while beyond the scope of this analysis, these cases suggest that a major barrier to improving adaptive capacity in Brazil is the structure and ethos of the civil defense, given the lamentable patchwork of local coverage and the overwhelming focus on reaction rather than preparation.

In all of the cases, integration – the coordination of institutional roles, a clear delineation of authority and the confluence of complementary policies – was identified as a crucial component of adaptive capacity. Integration allows for effective communication and knowledge

diffusion, which is important for informing events and engaging in subsequent evaluation. The water reform should improve integration through participation within the committee structure, bringing actors together to deliberate, manage conflict and forge mutual decisions. The LSJ case shows how democratic participation can foster effective integration among actors. However, integration relates in some respect to centralization and authority as Ceará best illustrates, which intuitively runs counter to the reform. The case studies show how integration that maintains some semblance of central authority to define roles often facilitates a flexible response to extreme events. Hence, there is a clear need to balance democratic participation and deliberation with institutional integration. The performance of the work group in the case of drought in PDS and the effective coordination among official actors in Ceará highlight the need to have effective integration. While democratic participation confers legitimacy and commitment, it can offset the gains made by clear delineation and coordination of authority by involving multiple competing interests and views that can stall flexible action. In this respect, conflict management that promotes a convergence of interests is essential to complement democratic participation and integration. The equilibrium between centralized integration and democratic participation involves the question of scale, in that democratic participation becomes more challenging at progressively larger spatial scales and requires some centralization. The smallest basin, LSJ, was most effective at engaging members democratically, while the largest, PDS, had trouble relegating the role of CEIVAP and the sub-basins.

The integration of issues is also an important element for adaptive capacity, as echoed by the discussion of fitting flood control within the context of water management. Perhaps the most prominent issue that is neglected in Brazil in the context of disaster is the occupation of risk areas along rivers and degraded hillsides, especially by informal slum settlements. This issue came up repeatedly in interviews. Despite progressive environmental laws that make such occupations illegal, the law collides with the socio-economic realities of Brazil and the inability of public agencies to address such a rampant problem without adequately solving entrenched poverty. Yet integrating land use, disaster and water management within the water reform presents a chance to effect change in a manner that contextualizes the problem and improves adaptive capacity. Of all of the cases, only post-disaster Itajaí made actual inroads to overcome the problem of disorganized occupation.

Overall, the complexity of governance makes it difficult to isolate factors that contribute to adaptive capacity. While this study reveals that integration is paramount to an effective disaster response, the success of integration is intrinsically tied to other governance factors. Democratic participation is also important to confer legitimacy and infuse management with knowledge and insight that captures the reality of the local actors, giving them access to shaping decisions. Democratic participation balances the official institutional integration of roles and responsibilities with local participation, effectively reconciling scales and allowing for official flexibility in responding to extreme events that involves actors on the ground. Knowledge is an essential component of promoting adaptive capacity, but is largely irrelevant without effective integration that is complemented with democratic participation as Itajaí shows. Conflict management is a function of both democratic participation and effective integration, and is important for fostering deliberation and creating shared goals. The inability to manage conflict among official agencies harms the integration process, as Itajaí's experience has illustrated. Furthermore, inadequate resources are a limiting factor in translating the gains from governance into actual decisions that improve adaptive capacity. Institutional weakness limits integration, especially in the case of the municipal-level agencies and the civil defense, and is largely a function of scarce resources. Hence, the water management reform in Brazil has made some progress at increasing integration of actors through the democratic participation in the committee, and improving the integration of issues. These changes have influenced the capacity to respond to extreme events, as the cases have highlighted. However to fully realize the potential of the reform to enhance adaptive capacity, greater efforts must be made to contextualize disaster management (especially sudden impact events) within the scope of water management.

## Lessons for Water Resources Management and Adaptive Capacity

This study adds to the literature on adaptive capacity and water management by taking a case study approach to qualitatively analyze the specific role of water resources governance in adaptive capacity. Many authors have highlighted the theoretical importance of effective institutions and governance in promoting adaptive capacity (Folke, Carpenter et al. 2002; Brooks, Neil Adger et al. 2005). This case study builds on Engle and Lemos (2010) in moving beyond the theoretical discussion to an actual evaluation of the role of different relationships

among governance factors in adaptive capacity. Furthermore, theories abound in the growing tendency to tout water management as an instrument for improving adaptive capacity (Pahl-Wostl 2007; Medema, McIntosh et al. 2008). This study has built upon the paradigms of adaptive and integrated paradigms of water management to illustrate to role of water management in adaptive capacity. This study identifies that integration is a key component of governance to promote adaptive capacity and is complemented by democratic participation, conflict management and knowledge. Furthermore, the results of this study reveal a couple of key points that merit further investigation and research.

First, it is important to elaborate on prescriptive theories of water management in a manner that contextualizes management blueprints with actual realities. The flexibility of the Brazilian reform has led to variations that seem to counter theoretical assumptions. For one, the tenets of both IWRM and adaptive forms of governance focus on decentralization as an important element of reform. The Brazilian cases suggest that while decentralization and democratization are important for adaptive capacity, this needs to be contextual. For one, at larger scales, the maintenance of some centralization promotes integration. In addition, integration that clearly defines authority is important for making flexible decisions in the instance of extreme events. Additionally, in many ways it is important to tailor prescriptive theories with a consideration of existing institutions and local realities, rather than starting over with a completely different management model. Hence, further research into actual cases of water management should illuminate the variation in governance in different contexts to give deeper insight into management prescriptions.

Second, this study has identified the variation in the adaptive capacity of water management institutions to respond to slow-onset and sudden impact events. This suggests that different types of impacts require unique governance considerations to mobilize adaptive capacity. Flood and drought seem to involve different institutional domains in Brazil, limiting the ability of water managers to profit from the reform's governance improvements in the case of sudden impact events. The different elements of governance that are useful in slow-onset and sudden impact events has received some attention in the literature, namely with respect to disaster-induced human migration (Warner 2010). There is comparatively little investigation into how governance promotes adaptive capacity in different types of events. Further research

could help to identify governance elements that promote greater synergy in adaptive capacity to both types of events.

## CONCLUSION

Understanding the particular elements of governance that promote adaptive capacity is an important endeavor for climate change research. This study has investigated the role of water management reform in Brazil in four cases with respect to governance and adaptive capacity in order to build on management prescriptions and theories. The Brazilian case provides a unique opportunity to investigate these relationships given the national water reform that induced governance changes, but gave wide latitude to state and local actors to implement these institutional changes. Hence, the variation in the reform allows for comparison of the different factors that contribute to success. In addition, the range of climate phenomena in Brazil, including the drought-prone northeast and the prevalence of floods in the south, provide analogues for investigating the governance of adaptation to multiple stressors.

Specifically, I have attempted to answer what factors contribute to the success of reform implementation in terms of governance. Also, I investigated how adaptive capacity to specific events varies in the different cases and how governance contributes to adaptive capacity. I predicted that the reform and the uptake of institutional changes would be more successful in cases where changes have effectively contributed to equality, legitimacy, participation and so on, in a manner that navigates existing power relationships and bureaucracies. I also hypothesized that successful implementation of the reform should contribute to greater adaptive capacity in the basins. Overall, the analysis of interviews seems to suggest that the reform was more effective in the cases that have higher-quality governance, given that the influence of the committee depends on its ability to confer legitimacy and promote cooperation among actors. In addition, the reform seems to have improved the adaptive capacity, but less so than expected in the incidence of flood. Governance was an important factor for promoting adaptive capacity, especially with respect to integration of institutions and policy interventions. In order to further the ability of the reform to promote adaptive capacity, I present the following recommendations: greater consideration of the role of water management in the context of floods by recognizing the befitting structure of the basin-level committees; further articulation of the committee with civil defense agencies, which have largely remained at the sidelines; and, greater integration of issues

within the committee, especially the relationship of land use planning and disorganized settlement in water and disaster management.

This study contributes to a deeper understanding of the role of governance in adaptive capacity and water management and builds on theory to validate these relationships in practice. I have identified some areas of future research, namely further study that characterizes theories in actual cases to identify the limitations of prescriptions and possible tensions. In addition, more investigation of the variable role of governance in slow-onset and sudden impact events could identify measures to promote a deeper synergy in adaptive capacity to multiple stressors. A greater emphasis on qualitative studies in the climate change adaptation literature would give insight into the institutional and governance components that enable adaptive capacity. This research agenda is critical given the growing prevalence and intensity of natural disasters around the world.

## APPENDIX

**Interview Questions from 2010 Questionnaire (translated from Portuguese)**

**I. Survey of Extreme Events**

1. Please indicate the three climate events (floods, droughts, storms, landslides, etc.) that had the largest impact in the basin in the last 5-10 years that you have professionally been involved with or have knowledge about.
2. For each event, please answer the following
    a. Date and type of event?
    b. Location of event?
    c. Principal actions in response?
    d. Which institutions acted locally in response to the event?
    e. Which institution coordinated these actions?
    f. Were the institutions adequately coordinated? Give examples.
    g. What were the damages caused by the event (economic losses, death, injury, displaced population, etc.)?
    h. Where was the impact most intense?
    i. Which sector or social group was most impacted?
    j. Was the basin committee involved in the response? How?

**II. Identification of Institutional Roles in Basin Management**

1.
    a. What is the jurisdiction of your institution?
    b. Within this area, where do you act most frequently?
    c. Has your institution even been involved in decisions outside of this jurisdiction? Give examples.
2. What are the main problems related to water resources that your institution works with?
3. Are these problems being adequately addressed?
4. Please indicate in order of importance the 5 options that you view as most important for water management today in the basin:
    i. Water allocation
    ii. Operation and management of reservoirs
    iii. Flood control and prevention
    iv. Living with and preventing drought
    v. Preventing environmental disasters
    vi. Planning and construction of hydraulic infrastructure
    vii. Monitoring and information systems
    viii. Planning and response to the future impacts of climate changes
    ix. Other (indicate)

5. What are the primary institutions involved in water management in the basin? Which are most important?

*What is the level of cooperation or participation between your institution and the following types of institutions: (on a scale from 0 to 10, with 0 being none, 10 being very high)*

6. Federal institutions?
7. State institutions?
8. Municipal institutions?
9. Civil society or non-governmental organizations?
10. Basin committee?
11. Agriculture?
12. Industry?
13. Other water users (please indicate)?

14. Indicate the name of some institutions with which your agency most frequently works or cooperates.
15. Has your institution ever experienced some type of conflict or disagreement with the decisions or activities of other institutions in the basin? Give examples. How were these conflicts resolved?
16. Thinking about the future, what will be the most important issues for integrated water management in 10 years? And in 25 years?
17. Are these long-term issues being considered or foreseen in the planning of your institution? Do you know of another institution that deals with these issues?

**III. General Actions in Planning and Management Related to Extreme Climate Events**

18. Does your institution have any formal jurisdiction in the planning or management of extreme events?
19. What type of information is used in the planning or management related to extreme events? Who produces or provides this information?
20. Is this information shared with other institutions or the population at large? Indicate.
21. How do you deal with the level of uncertainty that characterizes climate information?
22. In your opinion, how prepared is your institution and other institutions in responding to extreme events?
23. What factors do you believe determine a successful response to extreme events?
24. On the contrary, what are the principal factors that hinder a better response to extreme events? Has there been any change in the past few years? Why?
25. Is there any type of flexibility in the management of extreme events? Please indicate.
26. Are the impacts of extreme events evaluated? How?
27. Has your institution promoted or participated in events related to climate change? Please explain.
28. Who are the individuals in your institution that have the greatest influence in determining policies related to response to extreme events? Describe the process and who participates in this process.
29. Are there individuals or institutions that influence the direction of policy related to extreme events? Please indicate.

**IV. Evaluation of the Committee**

30. Is there any committee member in your institution?
31. How often does the committee solicit information, action or response from your institution?
32. Normally what do they request?
33. How often does your institution solicit information, action or response from the committee?

34. Normally what do you request?
35. Does your institution consider the opinions or interventions of the committees? Please explain.
36. What is the most important role of the committees? Please explain.

*On a scale from 0-10, with 0 being completely irrelevant and 10 being extremely important, how do you assess the role of the committee:*

37. In general?
38. With respect to managing water?
39. With respect to promoting cooperation?
40. With respect to rational water use?
41. With respect to innovation or improving management?
42. With respect to promoting greater communication and information diffusion?
43. With respect to planning or communication about climate change?

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