

WATER MANAGEMENT AND TECHNO-SCIENTIFIC KNOWLEDGE: A COMPARATIVE STUDY OF THE USE OF CLIMATE FORECASTING INFORMATION IN DECISIONMAKING IN BRAZIL AND UNITED STATES¹

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Abstract

This study seeks to understand a few of the factors affecting the use of climate forecasting in policymaking from a comparative perspective. It finds that among the many variables shaping the potential for the use of climate forecasting by water managers in Brazil and the United States, institutional environment is critical. While water managers in the U.S. operate in a mostly fragmented and risk-averse system which constrains the adoption of innovation, decisionmakers in Brazil can afford significant more flexibility to introduce new policy tools as a result of widespread management reforms initiated in the 1990s.

1 CLIMATE FORECASTING AND WATER MANAGEMENT

Recent progress on the science of climate forecasting has stimulated the idea of decisionmaking tools based on the ability of models to predict—in some cases with a lead time of up to a year—seasonal climate variations in different parts of the world. Such models have been particularly salient concerning the effects of the El Niño Southern Oscillation (ENSO), especially flooding and drought, in regions historically plagued by these phenomena such as Northern Peru (flooding) and Northeast Brazil (drought). In principle, the ability to forecast climate has the potential of critically affecting decisionmaking in some crucial policy areas such as disaster prevention and relief, agriculture and food security, and most importantly for this study, water use and management.

Despite early optimism (Glantz 1996, Golnaraghi and Kaul 1995), recent empirical studies suggest that the capacity of different policy systems to use seasonal climate information in decisionmaking can be constrained by a number of factors such as access to information, communication and comprehension of probabilistic information, availability of alternative technologies, and in particular, the institutional environment that shapes decisionmaking (Lemos et al. 2002, Lemos 2003, Rayner et al. 2002). Whereas great effort has been put into understanding users' needs and into addressing communication issues, there has been less attention paid to the role played by the institutional environments within which water resources

¹ This on-going research is funded by grants from the National Science Foundation (NSF) and the National Oceanographic and Atmospheric Administration (NOAA). It is part of broader efforts to study water management in Brazil (Projeto Marca D'água) and United States (CLIMAS—Climate Assessment of the Southwest). Preliminary, ethnographic field research has been carried in Ceará, NE Brazil and Arizona, SW United States. In Ceará, we interviewed a comprehensive sample of water managers (35) at the state level, including utility companies. In previous field campaigns carried from 1997-2000, policymakers from several levels of government, including the state governor, officials within the agricultural and drought relief policymaking apparatus (meteorology, rural extension, water resources, public works, seed distribution, civil defense), state assembly representatives, local mayors, agricultural and drought-relief policymakers, rural extension agents, and others were also queried on their use or potential use of climate forecasting in drought planning. In Arizona, 15 managers were interviewed in Yuma, Tucson, Phoenix and Safford. I want to thank Marcelo Flores and Alison Schneider for the assistance in collecting data and helping with the research.

managers make decisions in either constraining or providing opportunity for the use of climate forecasts.

In this study, I draw a few preliminary comparisons between the use of climate forecasting information in Brazil and the United States, using data collected in the context of ongoing field research in Ceará, Northeast Brazil, and Arizona, Southwest United States. I also rely on the excellent case studies carried out by Steve Rayner, Denise Lach, Helen Ingram and Mark Houck in Southern California, the Washington, District of Columbia area and the Pacific Northwest (Rayner et al. 2002). Empirical research in both countries paints a dramatically different picture of the use of climate forecasting in water management. While water managers in Ceará seem to be actively seeking to incorporate climate forecasting information—especially in reservoir management—managers in the U.S. cases reported here show considerable resistance to ‘mess’ with a model of decisionmaking they perceive as having worked for them over the years (Rayner et al. 2002). What factors account for these two different approaches? I contend that the flexibility of decisionmakers to adopt innovative decisionmaking tools depends on a myriad of factors ranging from perceptions of the relevance of the information, to organizational opportunities and constraints to incorporate innovation in decisionmaking, to the formal and informal institutional arrangements shaping the policy arena. For this study, I will focus on one of these factors, specifically, the ‘character’ of the broader institutional environment where decisions are being made. In turn, the character of the institutional environment depends on the formal institutional arrangements (legislation, nested rules, rates of institutional change) regulating water management and on informal norms, practices and belief systems at the decisionmaking level (political culture, professional practices, managers’ discretion, accountability, water user’s input and the role of ideas) shaping water related decisionmaking at different scales of management and use.

In the following sections, I will briefly examine these variables in light of both the emergence of seasonal climate forecasting as a research tool and the recent reformulation of water management in Brazil as a consequence of extensive reforms implemented within the last ten years. Section two will briefly describe the water management institutional environments in Brazil and the United States, highlighting the similarities and differences between the two systems.² Section three compares decisionmaking strategies and the willingness to incorporate seasonal climate forecasting in the two policy systems. Finally, I conclude with a few preliminary findings and suggest new areas for further research.

2 WATER MANAGEMENT IN BRAZIL AND THE UNITED STATES.

Water systems in both countries pose very similar challenges to water managers: (a) they are subject to multiple, sometimes contradictory uses such as hydropower, fisheries, water supply, recreation, irrigation, wastewater treatment and reclamation, (b) a wide variety of users depend on water resources at diverse levels of need, (c) management systems span through different scales and many times at overlapping jurisdictions, and (d) resources themselves are subject to different levels of stress, scarcity, and depletion. Yet, whereas in Brazil the water management has recently undergone a complete overhaul, in the United States reform has been hard to come by. Indeed despite an impending sense of crisis, most change in the U.S. has been implemented in piecemeal incremental fashion (Stakhiv 2003).

² For simplicity, the comparison between the cases carried out in Ceará, Brazil and Arizona, California, District of Columbia and the Pacific Northwest, United States will be referred hereafter as Brazil and the United States. Yet, I am aware of the limitations of such characterizations in the context of these two very vast and federalized countries, where regional and state variation of policymaking process can be substantial.

In the 1990s water management in Brazil has gone through an extensive reform which replaced the previous centralized, top down and sectoral system by a decentralized, participatory and integrated model which adopts the watershed as the main unit of management. While a few states started the reform as early as 1992, it was not until 1997 that the federal government followed suit and enacted Law 9,433 also known as “Water Law” (Lei da Águas). The new legislation at the same time instituted the National Policy for Water Resources and created the National System for the Management of Water Resources. It also created a National Water Agency (Agência Nacional de Água—ANA) that both oversees the application of the law and has jurisdiction over the management of interstate rivers' watersheds.

The new legislation introduced mechanisms for the management of water resources more in tune with the democratization of state-society relations following the demise of the Brazilian military dictatorship in the mid-1980s. These included (with variations across different state regulations) the organization of management at the watershed level, overhauling a previous system that favored municipal, state and federal jurisdictions; the creation of specific regulation to protect water resources at the watershed level; the decentralization of decisionmaking and resources; the design of a new system for the concession of water use permits; the creation of different instances of public participation, especially the organization of watershed committees and State and National Water Councils; the insertion of water resources management within a larger realm of environmental concerns which challenged the traditional supremacy of economic criteria in the management of water resources; and, the implementation of a users' fee system at the watershed level- the most controversial of the new policies.

After the enactment of the national law, most Brazilian states introduced their own legislation which, although preserving the spirit of the federal regulation (to which they are supposed to abide), hold different, and sometimes contradictory, characteristics concerning the organization of users and the organization of institutions and mechanisms to manage water resources. This has been especially true regarding the implementation of state-level water resources management systems. In Northeast Brazil, for example, only two states (Ceará and Minas Gerais) created operational agencies to implement the new legislation. Such agencies have the mandate to provide technical and legal support to the participatory management system, to implement water management actions, and to facilitate and mediate over conflict among users, the government, and society in general.

In the beginning of the 1990s, as part of Ceará's modernizing government administration, and in response to a long period of drought which threatened water supply to the capitol city of Fortaleza, a concerted effort was put together to design a new set of institutions to manage the state's water resources. This included the hiring of expert consultants as well as the study of state-of-the-art management options being implemented in other parts of the world. At about the same time, the government of Ceará approached the World Bank with a proposal for the Bank to finance new water infrastructure, including the construction of new reservoirs in areas not covered by the existing network (Kemper and Olson 2001). The Bank agreed but insisted on a few conditions: first, that the state implemented and used the instruments outlined in the new law, including the creation of water committees and the introduction of tariffs for all water users (including irrigation); second, that the state created a water resources management company. Thus, “(B)ank officials reasoned that without an implementing agency, the state would be hard pressed to carry out reforms that required improved monitoring, forecasting, and reservoir operations, as well as linkages between the operation of the system and water user market in the project design.” (Kemper and Olson 2001:342). As a result, COGERH (Companhia de Gestão de Recursos Hídricos—Water Resources Management Company) was created in 1993 with financing from the World Bank as an attempt to avoid the commonplace of paper laws, that is reformist legislation doomed to failure because of lackluster or inadequate implementation.

COGERH followed Brazil's traditional model of insulated technocracy in which agencies, created under the guise of technical expertise, meritocratic hiring and plenty of resources, are shielded from the maladies of the inefficient public sector associated with third world bureaucracies. Yet, in one aspect COGERH was critically different from other 'technical' agencies: at the insistence of outside consultants, the agency included social scientists in addition to the usual makeup of engineers and hydrologists associated with water management agencies. The combination of social and physical scientists within the agency allowed for the amalgamation of ideas and technologies that critically affected the way the network of technocrats and their supporters went about implementing water reform in the state. One consequence of the actions of these networks is the emergence of new approaches to policy implementation, including a concerted effort on the part of technical agencies to involve users and clients in the decisionmaking processes which may strengthen the position of both groups—technocrats (or *técnicos* as they are known in Brazil) and users—in relation to policy opponents inside and outside the state (Lemos 1998). In this context, new ideas and technologies may work as a critically enabling tool. Indeed, in the case of COGERH, climate information was instrumental not only in informing the creation of many of the organizational schemes pursued by COGERH *técnicos* but also in inviting mobilization from users who perceived their participation as meaningful and effective.

One particularly innovative aspect of COGERH's organization of management at the watershed level was the creation of Users' Commissions which—in addition to the more institutionalized watershed committee envisaged in the legislation—participate directly in water allocation decisionmaking. These groups meet periodically to evaluate and plan for water use at the watershed level and function in parallel to the watershed committee. It is also within the context of these Commissions that most of the techno-scientific information supporting decisionmaking is used. Hence, in the case of the Baixo Jaguaribe River Watershed, Ceará's most important watershed, climate information, including forecasting, is routinely used to support Users' Commissions decisions to distribute water resources among different users, especially, irrigated farmers, large agribusinesses, and water utilities. In this case, *técnicos* from COGERH put together a series of data charts displaying historical data on rainfall, prognosis for the following season, reservoir capacity, recharge, and runoff. They also build simple hydrological models where different case scenarios are displayed to help users to make decisions about discharge and use. This information is presented in large users' meetings (over 200 participants) held twice a year in three of the largest watersheds in the state. In these meetings, water users engage in quite sophisticated debates in which they seek to reconcile their water needs with water availability according to different case scenarios provided by COGERH. For example, in a meeting I attended in June 2001, a year of drought, irrigated rice farmers (who use large amounts of water) agreed to reduce their consumption of water by 50% by cutting down their planting in half (one crop instead of two a year).

This example of use of climate forecasting in Ceará is in stark opposition to most of the tales of water management in the United States reported by Rayner et al. (2002). While it seems that water managers in Brazil showed much less resistance to the incorporation of climate information in water decisions, research focusing on the United States suggests that widespread insertion of climate forecasting in decisionmaking might be a long ways to come (Rayner et al. 2002). Other authors (Callahan et al. 1999, Lund 2000, Pulwarty and Jacobs 2003) agree that the U.S. system has been traditionally risk-averse and constrained by a series of factors cutting across most water systems: (a) water managers are heavily constrained by institutional arrangements such as water laws, related regulations, institutional linkages, local politics, inter-agency competition, etc. which lend water management systems highly inflexible and resistant to the introduction of new decisionmaking technology; (b) water decisionmaking systems are greatly fragmented and complex, spanning from multiple scales and many times conflicting jurisdictions, (c) change is hard to implement because of inertia built in the system by large and expensive infrastructure, private interests, and regulatory agencies; (c) current state-of-the-art climate forecast information is perceived as too uncertain, lacking in geographical and temporal

specificity, lacking in interpretation and demonstrated utility, and too unreliable (low skill) to water managers' decision making needs; and (d) there is still a significant disconnect between information producers and users.

Such conservatism has its roots on three sources: water managers attempts at routinization of the irregular; their dependency on craft skills and local knowledge; and their hierarchy of values designed to ensure political invisibility. Routinization of the irregular refers to the water management's goal to attenuate the impact of weather or other factors which may threaten water quantity and quality. Accordingly, the system strives to control as much of the process as possible, and avoiding irregularity becomes part of the routine of management. Second, water systems are widely diverse and perceived to be sensitive to local conditions. In this scenario, managers perceive local experience and knowledge as a highly desirable function. Finally, because of the high expectations of the public regarding water supply and quality, managers perceive themselves as greatly accountable and strive to achieve public invisibility. Indeed, Rayner et al. report that "these performance expectations give rise to a particular configuration of values. Water managers at all levels and all organizations we interviewed consistently described a common hierarchy of values for managing water resources: reliability, quality, and cost. (Rayner et al. 2002: 22). Although expectations will vary across management systems, in many cases, reliability is expected to be 100 percent.

Yet conservatism does not equate to the absence of change. Water agencies, such as other public agencies, mostly change slowly through incrementalism or adaptive management rather than radical change (Stakhiv 2003). At the same time, reluctance to use probabilistic data or any other kind of innovative tool may just mean that water managers tested them and either found them wanting or not worth the time and resources required to use them (Pulwarty and Jacobs 2003).

In this context, it is not surprisingly that water managers express great reluctance in introducing new tools they perceive as unproved by their day to day experience. Moreover, negative experiences from other systems which dare to try can potentially exacerbate managers' resistance to climate forecasting (Changnon and Vonnahme 2003, Pielke Jr. 1997). Empirical evidence show that a very small number of water managers report that they actually use climate forecasting although a larger number express interest in using it in the future.

3 FLEXIBILITY, ACCOUNTABILITY, INSTITUTIONAL CHANGE, AND WATER MANAGEMENT.

A first approach comparison, based on preliminary field research, suggests that although the institutions of water management in Brazil and United States seem quite distinct, at the decisionmaker level, there are consistent similarities. Thus, water managers in both countries share many of the perceptions of their job description and goals and are driven by comparable motivations. Similarly to the U.S., the majority of managers interviewed in Brazil also considered that client satisfaction was their main motivation and that a functioning, reliable system was the main goal of their job. They perceive their work as eminently technical and non-political and took pride in their invisibility.³

In addition, despite of little empirical evidence, they described their organizations as open to innovation and up to date with the cutting edge technology in the field. However, when probed about the use of climate forecasting in decisionmaking, responses were mixed. The majority would like to have a better idea of the reliability of the forecasts in order to be able to make

³ This is particularly important in the case of Ceará where, traditionally, water management has been closely associated with clientelism because of the state's recurrent drought episodes and political conservatism. For more details, see Lemos (2003).

better informed decisions. While some técnicos interviewed (especially from utility companies) were intrigued by the idea of climate forecasting but did not identify a specific use for this kind of information in their decisionmaking processes, others (particularly in areas related to drought planning such as water management, agriculture and civil defense), when asked whether they used climate forecast information in their decisionmaking process were quick to say "yes." Moreover, when asked about the value and importance of this kind of information to their decisionmaking, the answer was often an enthusiastic "very important," in particular among higher ranked decisionmakers. There was also frequent mention of the great potential of the information to improve decisionmaking as its "quality" improves.⁴ This perception was shared by climate forecasters at the state meteorology agency who believed the use of climate forecast was critically contributing to improve proactive planning for drought. However, many of the policymakers, when probed about the role of seasonal climate forecasting in their decisionmaking, described it as either decision "background," that is, a piece of information resting in the "back of [their] mind" or having little to do with planning for drought. This behavior can be partly explained by two factors. First, there is some confusion between what is climate information in general, weather forecasting, and seasonal climate forecasting. Thus, in a few occasions, although policymakers stated they were using seasonal climate forecasts, a closer analysis of their decisionmaking process revealed they were actually using other types of climate information such as historical rainfall series. Second, as I have argued elsewhere, many policymakers genuinely believe in the power of seasonal climate information to improve their ability to plan and respond to drought. Here, the *idea* of predictive science is almost more important than the results it is supposed to yield. In this case, policymakers' faith in prediction science is influenced by what I call a 'fascination effect' which combines the allure of state of art technology and the expectation of solving a problem perceived as intractable by currently available policy tools.

One area of significant difference between water managers in Brazil and the U.S. however, is the willingness of the former to assume much higher risks than the latter. This was particularly true in the case of reservoirs managers who, during in-depth interviews, when asked to describe their decisionmaking processes, demonstrated much less risk-averseness and more discretion than U.S. decisionmakers. For example, one reservoir manager reported that many times he will authorize discharge of water from some reservoirs until they empty to what he described the "mud" state. When asked if he did not fear a negative reaction from clients, he responded "well, people here understand. If there is no water, there is nothing I can do. At least now, with all other resources, people don't die as much as they did in the past." (personal communication 2002, my translation). On the one hand, although this statement may seem callous, it actually reflects the reality of recurrent events and the sense of impotence many decisionmakers and clients in NE Brazil feel when faced with drought. There is a widespread acceptance that there is so much one can do against drought. Resignation is informed both by the recurrent character of drought as well as by a few extreme events when famine, displacement and lack of water have been branded in people's memory as inevitable or "God's will". On the other hand, his position can also be partly explained by the general low level of accountability pervading public policymaking in Ceará and in Brazil. Although political reform and democratization has had profound effects on the accountability of the state to society, many pockets of bureaucratic insulation persist, especially among technical agencies that are able to shield themselves behind the cloak of science to avoid answering to clients (Lemos 2003).

Still, more important for this comparison, is the significant difference between the formal institutional arrangements shaping water management in Brazil and the United States. As mentioned before, whereas Brazil has undergone through encompassing reforms that have created a national water policy, the U.S. continues to struggle over a fragmented and many

⁴ In this case, quality is mostly related to better temporal and geographic skill, that is, how good the information is for predicting rainfall distribution through time and space.

times contradictory water management system (Stahkiv 2003). The Brazilian system, however, although based on national regulation, has followed a highly federalized model that has afforded much flexibility to states to design and implement institutions that better ‘fit’ the characteristics of their water resources and socio-political systems. Thus, different states have pursued different strategies and created different structures to manage their water resources. The state of Ceará, for example, was the only one to create a separate Users Commission that works in parallel with the more ‘official’ Watershed Committee. This has not only increased the space for users’ participation but has been also considered a model of successful watershed-level management (ANA 2001). Within this rather loose institutional framework, managers may afford greater degrees of freedom not only to create new institutions but also to change the existing ones. Hence, “within the constraints imposed by particular technological or economic configurations, actors can modify institutions to solve new problems, to facilitate network-based collective learning, or achieve increasing efficiency (Clemens and Cox 1999: 451). This seems to be precisely what COGERH técnicos tried to do by opening the decisionmaking process at the watershed level.

Ideas and technologies were each found to play a pivotal role in this process of institutional building. First, ideas—here defined as a cluster of beliefs affecting the design of strategies of action geared towards policy outcome—shaped the creation of the new water management structure in Ceará by supporting the initiative of policymakers to push for decentralization and participation. In the Brazilian case, these ideas are part of a global trend towards decentralized and participatory water management approaches which adopt the watershed as the main unit of decision and action. Another important aspect of this approach is the establishment of water permits and market systems. This new paradigm for water management has been intensely promoted in less developed countries by organizations such as the World Bank and USAID. Notwithstanding their pervasiveness, many times, in the context of policy design and implementation, these paradigms become influenced by policymakers’ belief systems and world views which essentially transform them into somewhat modified experiments which resemble the original model but with critical differences. Thus in the case of Ceará, under the influence of social scientists with a strong reform-oriented agenda, the implementation of decentralization and participation at the watershed level went beyond the suggested framework to include Users Commissions. In this sense, institutional change provided opportunities to the design of an innovative model of watershed management. However, ideas can also act as constraints by limiting what is normatively ‘appropriate’ within policy systems (Campbell 1998, 2002). Indeed, after the election of a more politically conservative governor in Ceará in 2002, COGERH’s model has been openly under attack (COGERH técnico, personal communication 2003).

Second—technologies such as reservoir models and climate forecasts—not only provided for better informed decisions within the Users’ Commission but also for more active participation by users. On the one hand, the advantages in this case seem to be many. First, users might be more likely to abide by the decisions at the watershed level (at this point there is not an established enforcement system, so basically, social pressure is the only weapon the técnicos and other users have to enforce how much water is being used) if they are directly involved in the decisionmaking process. Second, by making simplified reservoir models available to users, COGERH is enhancing not only knowledge about the watershed but also crystallizing the idea of collective risk. While individual users may be willing to “free-ride”, collective decisionmaking processes may be much more effective in curbing overuse. Third, information can play a critical role in the democratization of decisionmaking at the watershed level, training users to make decisions and dispelling widespread distrust informed by traditional patterns of bureaucratic insulation. On the other hand, there is an intrinsic risk that users’ lower risk-averseness when compared to managers may bring the system to a collapse. In addition, many feel that intergenerational environmental issues and the sustainability of the watershed may be put at risk if the state does not step in to protect the stake of society and ecosystems. Water managers have attempted to include some safeguards—for example, users are allowed to decide

reservoir discharge up to a level and, during meetings and técnicos use their influence to advise more conservative decisions—however, this approach is quite a departure from the highly redundant U.S. system.

4 CONCLUDING REMARKS AND MORE RESEARCH.

The emergence of climate forecasts as a policy tool has encouraged the production of a steady-stream of scholarship speculating and evaluating potential roles of such information in decisionmaking. This study seeks to understand a few of the factors affecting the use of climate forecasting in policymaking from a comparative perspective. It finds that among the many variables shaping the potential for the use of climate forecasting by water managers in Brazil and the United States, institutional environment is critical. While water managers in the U.S. and Brazil share many similar characteristics and perceptions, the institutional arrangements shaping their decisionmaking environment vary considerably. In the U.S., water management is mostly characterized by a fragmented and risk-averse system where the most sought after outcome is reliability and stability. Whereas in Brazil, water managers also worry about reliability, they seem to have considerable more discretion and be willing to take more risks than the U.S. water managers described in this study. Although there are many other variables affecting water resources management in the two countries, this article contends that one critical reason for such disparity is the higher level of institutional change in Brazil where a widespread reform of the water management system has been initiated in the 1990s. In this case, the change of the basic water management paradigm in Brazil provided actors and organizations with greater degrees of freedom both to create new institutions that better ‘fit’ their water resources and their users management needs as well as to incorporate new technologies in the decisionmaking process. Hence the new system in Ceará adopted a jurisdiction for decisionmaking—the watershed—and created a number of organizations such as the Users Commissions which significantly decentralized decisionmaking and stimulated user participation. In the context of these new institutions climate information may have played a critical role in producing better informed decisions as well as users’ heightened perception of efficacy.

Still, this preliminary comparison is just the first step of a much broader research effort required to understand the use of technoscientific information in policymaking across systems. More research is needed focusing both on organizational, informational and institutional variables (e.g. the role of the quality and relevance of forecasting information, the “character” of the organizations producing and using forecasting, broader socio-economic and political variables shaping the decisionmaking arena, etc). Systematic data collection through in-depth interviews and surveys of managers and users need to be carried in different watersheds.⁵ Only by understanding the motivations, opportunities and constraints for the use of climate forecasting in decisionmaking in different policy systems in different countries can we hope to achieve its potential as a policy tool.

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⁵In order to continue this research, in the summer of 2003, in-depth interviews with water managers and policymakers in two other watersheds in Brazil (Paraíba do Sul and Itajaí) will be carried out. In addition, in collaboration with researchers from Projeto Marca D’água, a survey of approximately 2,000 watershed committee members from 60 different watersheds will be carried out, including queries on scientific information use and public participation

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