THE USE OF SEASONAL CLIMATE FORECASTING IN POLICYMAKING: LESSONS FROM NORTHEAST BRAZIL

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Abstract. This article examines the use of seasonal climate forecasting in public and private efforts to mitigate the impacts of drought in Ceará, Northeast Brazil. Here, forecasts have been directed towards small scale, rainfed agriculturalists as well as state and local level policymakers in the areas of agriculture, water management, and emergency drought relief. In assessing possibilities and constraints of forecast application in Ceará, the present analysis takes into account three types of variables: (a) characteristics of the forecasts; (b) policymaking systems; and (c) institutional environments. We conclude that, on the one hand, several factors in the Ceará case have limited the effectiveness of seasonal climate forecast use. First, the current level of skill of the forecasts is inadequate for the needs of policy development and farmer decisionmaking. Second, forecast information application has been subject to distortion, misinterpretation and political manipulation. Third, focus on the forecast as a product until recently neglected to take into account end users' needs and decisionmaking behavior. On the other hand, climate forecasting has the potential to offer a dramatic opportunity for state and local level bureaucracies to embark on a path of proactive drought planning.

1. Introduction

In the semi-arid Northeast Brazil, drought is part of everyday life, shaping culture, environment, politics, and society. In this region ravaged by poverty, *nordestinos* – as people from Northeast Brazil are known – anxiously await the annual arrival of the rainy season and its promise of an adequate harvest for that year. In the event of drought, which occurs regularly, agricultural production is compromised and immense human suffering prevails.* For over a hundred years, local

* Many studies have documented the aggregate economic hardship and social disruption related to agriculture and cattle ranching, including production losses, lack of water for consumption, unemployment, displacement, famine, and poverty. See for example, Johnson (1971), Aguiar (1983), Alencar Araujo Filho (1987), and Coelho (1985).

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and national governments have attempted to respond to the challenge of drought with limited success. More recently, the government of the state of Ceará, one of Northeast Brazil's poorest areas, has sought to escape this pattern of frustration and ineffectiveness by initiating a series of drought mitigating policies, including the systematic use of seasonal climate forecasting in agricultural and emergency drought relief policymaking.

In recent years, advances in climate science, particularly with regard to the El Niño Southern Oscillation (ENSO), have allowed the prediction of drought six months in advance in regions such as Northeast Brazil and Southern Africa. On the one hand, past predictive success (for example, in 1986 and 1991) encouraged the research community to improve forecast accuracy and reliability (Glantz, 1994); on the other hand, the advances in seasonal predictability prompted many ENSO-vulnerable countries to incorporate climate forecast information into the formulation of drought mitigation policies (Roncoli et al., 2000; Eakin, 2000; Mangaña, 1999; Phillips et al., 1998).

This study examines the use of early climate forecasting by policymakers and end-users to reduce the negative impacts of drought. At the level of policymaking, we assess the use of climate information to formulate public policy in agricultural production, water management, and emergency drought-relief provisioning. At the level of end-users, such as farmers and ranchers, we seek to identify both the opportunities and the constraints that define the success of seasonal forecast applications, given the nature of socio-economic vulnerability to climate variability in the region.

In contrast to an earlier wave of optimism regarding the value of climate forecasting in reducing the ravages of drought in Northeast Brazil (see Glantz, 1996), this paper argues that socio-economic, political, and cultural conditions can compromise the use of seasonal forecasts by both farmers and policymakers. We contend that seasonal forecasting faces a 'new technology adoption' problem in the sense that the potential uses and limitations of the technology are not fully understood and a process of learning must ensue in order to determine appropriate use. At the same time, the presentation of the forecast and its mode of communication to policymakers and farmers are critical to application success. While much attention has been paid to the science of climate forecasting and its application for drought mitigation, there is limited understanding of the socio-political environment through which climate forecasts are channeled and interpreted. Once in the hands of policymakers, the science product loses – in a very critical sense – its desired objectivity and becomes woven into a complex mesh of social, economic, and cultural realities that influence how information is in fact used. It is this interaction of policymaker, end-user, and scientist that is addressed here. We analyze the policy process that underlies the application of seasonal climate forecasting in the state of Ceará in Northeast Brazil specifically examining three groups of variables: (1) the characteristics of the forecasts in terms of accuracy, timing of release, data format, and mode of communication; (2) the policymaking system at all relevant administrative levels; (3) and the relative social and economic vulnerability of the population toward which the forecasts are directed. In addition, this study explores still untapped opportunities for data use especially in long-term drought-relief planning.

2. Science, Policy, and Politics

The climate literature suggests that scientists perceive the effective utility of scientific knowledge as an automatic outcome of providing information. This 'utility' assumption emerges from traditions of opportunity-driven or 'pure' science in which scientists remain unfettered and untouched by the surrounding political context while producing objective 'out-the-door' knowledge, which in turn can be adopted for use by society, including policymaking institutions. Policymakers, for their part, are driven by the demands of constituents and the practicality of the knowledge. Accordingly, they seek scientific and technical information that is timely and readily applicable to their most pressing problems *and* which can be used as an authoritative and legitimizing policy tool. As a result, scientists and policymakers are two very different social actors bound by distinct sets of goals and rules. While scientists are mostly concerned with the state of their science, policymakers are often constrained by such time-sensitive considerations as stakeholder demands, political agendas, and the need to demonstrate practical results. Starting from these distinct 'cultures', Weiss (1978) proposes two basic models of how policymakers recruit scientific information. The first is a problem-driven model where policymakers when faced with a specific problem seek solutions in the pool of pre-existing research solutions or commission new research to meet their needs. In either case, science is more directly recruited and expected to have clear and practical utility for policymakers. The second model is a knowledge-driven model where science – independent of a specific problem – has discovered new knowledge that displays a potential application. As Weiss puts it, this model assumes that the 'sheer existence of knowledge presses it toward development and use' (1978, p. 30). Thus, the solution, rather than the policy problem, provides the main recruitment avenue (Kingdon, 1985; Stone, 1988).

This latter model best describes the Ceará case where the availability of ENSO climate information triggered the reorganization of the policymaking apparatus so that forecasts could become part of the drought relief and agricultural policymaking system. At the same time, however, this case study will reveal that knowledge-driven recruitment poses comparatively greater challenges. First, the science product – being off-the-shelf rather than commissioned technology – has to be adapted to the encompassing and complex policy system. Perhaps more demanding, however, is what might be called the 'new tool blues'. In a region where climate extremes inflict such a drastic toll, it is understandable that expectations for a new technology run high both among policymakers and end-users. Nonetheless, new technologies require time to discover effective and appropriate uses of that innovation, particularly one developed outside the local context. While the climate applications literature has not focused widely on this adaptation process, the Ceará case study suggests that much trial and error is needed to move up the learning curve.

A second theoretical issue this paper examines is the 'trueness of fit' between scientific knowledge and the cultural context in which policies are made and implemented. That is, science production is supposed to meet three certain standards of appropriateness in order for climate-based policymaking to be successful. To begin, the quality of scientific information must meet the perceived needs of the user population; equally important, the information must be communicated in comprehensible manner; and, finally, it must be consistent with existing value and meaning systems of potential users (Thompson and Rayner, 1998; Gerlach, 1993).

With regard to the quality of the science product, climate forecasts are particularly vulnerable in semi-arid environments where climate variability – both spatial and temporal – is such a critical factor. Farmers and policymakers demand highly specific information on the timing and the location of rainfall in order to make their respective decisions, while the current state of climate prediction produces a much coarser spatial product with virtually no information on the intra-seasonal timing of rainfall. Looking for a common trend across different examples of policy failure, Cash and Moser (1998) discerned that existing information and decision-making systems were inadequate to deal with this cross-scale problem. In the case of seasonal climate forecasting, while climate forecasters use large scale models to make low-spatial resolution long-term predictions, policymakers wish for high spatial resolution information relevant at the local level, especially for agricultural decisions and drought-relief purposes. Although 'downscaling', that is, empirically linking large-scale, low-resolution data to specific small-scale geographic regions, has become a common aspiration of scientists (and policymakers) everywhere, climate forecasting science is still far from the level of temporal and spatial accuracy expected by users on the ground (Cane, 2000). Thus, the use of climate information in policymaking is first limited by this fundamental gap between the science product that is offered and the one that is demanded by policymakers and users.

The communication of uncertainty constitutes a related problem of quality. Forecasts are presented in the language of probabilities, but are often not perceived as such. Probabilistic information is difficult to assimilate because people do not think probabilistically nor do they interpret probabilities easily (Gigerenzer and Hoffrage, 1995, cited by Stern and Easterling, 1999, p. 75; Nicholls, 1999). From a purely technical or statistical perspective, an unlikely event, one with a low probability of occurrence, can in fact occur. But for farmers and policymakers to use forecast information as a risk-reducing tool, they must have an appropriate understanding of the meaning of a probabilistic forecast. Where local levels of illiteracy are very high, as in Ceará, and the semi-arid climate is highly variable in spatial and temporal terms, the interpretation of the forecast is yet more complex. To these stakeholders, when drought occurs in the face of a forecast of probable rainfall, their perception is that the forecast was, simply, wrong. Even when statewide levels of annual precipitation are consistent with the forecast for that season, those end-users negatively affected by inadequate spatial or temporal distributions of rainfall, judge the forecast failed.

Communication difficulties between scientists and policymakers (Offut, 1993; Barnabo et al., 1993; Weiss, 1978) and in turn between policymakers and end-users can severely compromise the value of forecast applications, particularly when the media interposes itself as a primary interpreter of the climate message. Different technical jargons and communication styles can play a critical role in the ability of policymakers to release information that is perceived as 'usable' by farmers. Here, there is an intrinsic contradiction between the probabilistic nature of the forecast and the media's pursuit of powerful headlines. In the best-case scenario, the media disseminates a 'colloquial' interpretation that seldom addresses the nature of probabilities. At its worst, the media distorts the forecast and misleads the public. Strategies such as creating or engaging third-party organizations as intermediaries across scales and users – e.g., advisory scientists (Shackley and Wynne, 1996) and extension agents – or encouraging stakeholder participation to enhance information delivery can potentially reduce these communication problems (Stern and Easterling, 1999).

In their ranging survey of El Niño applications, Orlove and Tosteson (1999) argue that the challenge of utilizing El Niño-based seasonal forecasts lies precisely in framing the biophysical phenomenon itself so as to find an adequate informational format culturally consistent with the meaning systems of both local populations and the organizations that deal with the impacts of climate variability. If scientific information does not fit end-user values and belief systems, it will likely be ignored (Westley, 1995). Indeed neo-institutionalists argue that individual decision-making processes are influenced not only by rule-driven routines, procedures, conventions, roles, etc., but also by 'the beliefs, paradigms, codes, cultures, and knowledge that surround, support, elaborate and contradict those roles and routines' (March and Olsen, 1989, p. 23, cited by Thompson and Rayner, 1998). Thus, 'to influence actor's behavior, it is important to see the decision situation from that actor's perspective' (Stern and Easterling, 1999, p. 81). Here, behavior is supported by the logic of appropriateness rather than the logic of consequences. Therefore, 'a calculus of political costs and benefits is less important, and a calculus of identity and appropriateness is more important' (March and Olsen, 1989, p. 38, cited by Thompson and Rayner, 1998). Our fieldwork in Ceará documented a highly public debate that contrasted the value of climate forecast produced by the state's Foundation for Meteorology and Water Resources – FUNCEME with that offered by local 'rain prophets', who base their predictions on Nature's signs and empirical experiments (Finan, 1998). This debate highlighted a major credibility crisis for scientific forecasting throughout all levels of end-users, which cannot be explained only as an accuracy problem, but also as a clash with the local meaning systems of local populations.

3. Methodology of the Study

This paper is the fruit of a multidisciplinary research project carried out over the last five years in the state of Ceará, a region that represents a unique opportunity to address issues of forecast application. Within Northeast Brazil, Ceará has the largest proportion of its territory characterized as *semi-arid*, and is thus highly vulnerable to drought episodes. It is also the first Northeastern state to acquire technical expertise on regional climate science and to attribute climate forecasting to the mandate of a public institution – FUNCEME. In addition, the last four state governments have actively reformed and modernized the public structures responsible for drought mitigation in an effort to correct historical patterns of inefficiency, clientelism, and corruption. As part of this trend, the current government has especially embraced community participation as a critical element in drought reduction interventions (Magalhães and Neto, 1991; Tendler, 1997).

In this research, we employed a methodology based on the integration of qualitative and quantitative fieldwork tools. To examine the use of climate forecast data in policymaking related to agricultural production, water management, and drought relief, qualitative in-depth interviews were conducted with decisionmakers at all relevant levels of the state policymaking apparatus, including the state governor and his secretaries responsible for rural development, water resources management, emergency relief, state assembly representatives, FUNCEME, local political leaders (*prefeito*), local bank managers, rural extension agents, and rural labor union representatives. The research team also met with farmer associations, non-governmental organizations, church leaders, and the local media.

At the state level, these key informant interviews focused mainly on the timing and use of forecasts, the role of climate information in supporting different governmental programs, and the potential for the future expansion of such applications. At the local level, we sought to assess the need for climate forecasts, access to the information, and local perceptions of the accuracy and value of forecasts. The information from state and local levels was used to construct an analysis of the entire policy system responsible for drought mitigation and the role of forecast information in that effort. We meticulously sought to describe the sequence of intervention decisions that accompany the issuing of a forecast, the arrival of a drought, and the mobilization of resources to address an ensuing crisis. We also examined agricultural development and drought relief programs that used forecast information in the implementation process. In so doing, we were able to identify both the constraints to the effective use of climate information and the political fallout caused by an erroneous forecast.

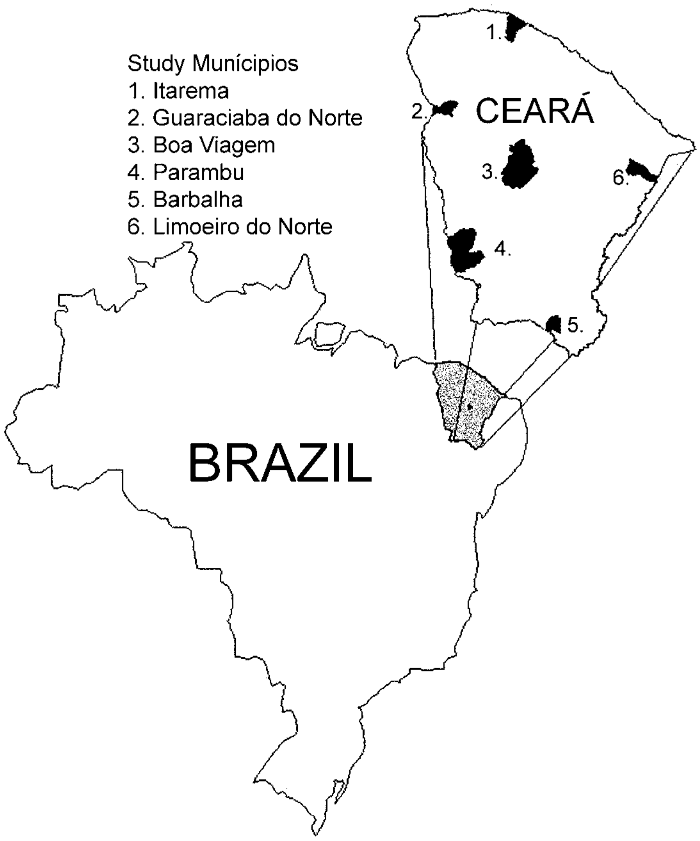

Figure 1. Map of the study area.

For the quantitative analysis of climate forecast applications, the research team conducted formal interviews with a random sample of 484 farm households in six different *municípios* (Limoeiro do Norte, Barbalha, Boa Viagem, Parambu, Guaraciaba do Norte, Itarema), each of which represents a distinct micro-climatic zone.* Figure 1 shows the map of Ceará and the six *municípios* studied.

This component of the methodology designed a questionnaire meant to characterize the vulnerability level of each family to extreme climate events. The team collected information on farm assets (land and livestock), income flows, technology, access to off-farm employment, and the coping strategies used by families to respond to a crisis (Finan and Nelson, 2001). These data generated a typology

* A *município* is the most local political and administrative unit, consisting in most cases of an urban center and the surrounding rural area that is divided into *distritos* (which do not have an administrative function). The size of a município varies, but is roughly similar to a county in the U.S. The chief elected administrative official in a município is the *prefeito* (roughly, mayor) and his/her office is the *prefeitura*. Prefeitos both make critical policies regarding the local resource allocation and implement state and federal programs.

comprised of three vulnerability categories into which the 484 households were placed. Analysis of the use of climate information and the impacts of climate policy interventions were thus differentiated by the household vulnerability classification. At the same time, these formal interviews traced actual household responses to specific drought years, their knowledge and use of climate forecast information, local perceptions of FUNCEME as a provider of information, the value of 'scientific' forecasts vis-à-vis indigenous methods of drought forecasting, and the level of local participation in public drought relief and agricultural support programs. In effect, the interview data allowed not only a vulnerability assessment of rural households, but also an evaluation of trust in government drought policy and the specific agents of that policy such as FUNCEME and the state's extension agency, EMATERCE. Finally, we reviewed all relevant documents available at the state level and performed a content analysis of newspaper archival materials (to identify public perceptions of the FUNCEME forecast).

4. Drought and the Use of Seasonal Forecasting in Ceará

Devastating droughts have been recorded in Northeast Brazil since the settlement of the country in the early 1500s (Villa, 2000). Early patterns of climate vulnerability were established not only by climatic extremes, but also by the highly inequitable socio-economic structure of regional society and the physical isolation of the rural population. The Great Drought of 1877–79 incurred a famine in which about 500,000 *nordestinos* perished in Ceará alone, and many others fled the region (Furtado, 1962; Davis, 2001, p. 114). This tragedy was the first to focus national attention on the problem of drought and established the responsibility of the state for drought mitigation. Since then, public policy has assumed a major role in both emergency relief activities and permanent interventions aimed at reducing the inherent vulnerability of local populations.

The vulnerability of rural populations to climate variability is not surprising considering the significant role of rainfed agriculture in the region. In the state of Ceará, as in most of the Northeast, the economic contribution of agriculture to the overall economy is low (6.6% of state GDP), but the percentage of the economically-active population in agriculture is high (40%), this ratio providing a particularly strong indicator of the level of rural poverty (SEPLAN, 2000). Rural livelihoods are based on the small-scale subsistence farming of staple food crops (corn, beans, manioc), supplemented in some regions by such cash crops as cotton or cashew and by the sale of livestock and livestock products. Despite significant amounts of water storage in reservoirs throughout the state, 92% of farm families do not have access to irrigated land and thus depend entirely on annual rainfall (IBGE, 1996). Rural non-farm income-generating activities are limited and tend to be low paying and seasonal or highly irregular. These paltry and unreliable income opportunities become even scarcer in drought years, when economic activity grinds to a halt.

Since the great drought of the nineteenth century, the Brazilian government has invested an enormous amount of federal resources in both long-term drought prevention and in crisis-based emergency relief. Drought has traditionally been perceived as a shortage of water for agriculture, livestock, and human consumption, without reference to underlying vulnerabilities of the rural population. Consequently, most policy interventions have been directed towards large-scale water management projects, including the construction of reservoirs and dams to capture surface water, the installation of wells to capture groundwater, and the creation of ambitious irrigation systems (Carvalho et al., 1993). More recently, policies have emphasized the need for long-term programs to mitigate drought-related poverty (Pessoa, 1987), the root cause of livelihood vulnerability. Starting in the 1970s, the federal and state governments began to invest in major programs to permanently reduce rural vulnerability, such as Polonordeste, Projeto Sertanejo, and Projeto São José.* More recently, with the advance of Brazilian democratization process in full swing, the government of Ceará established investment priorities for community-based long-term projects with comprehensive development strategies that include agrarian reform, the creation of small-scale irrigated zones within hydrographic micro-basins, the promotion of micro and small businesses as well as agro-industry, and programs for the improvement of education and basic rural health and sanitation (Magalhães and Neto, 1991, p. 33). This development strategy seeks to strengthen the resilience of the rural population to drought by buffering resource-poor rural families from the vagaries of a semi-arid climate.

Because of the acute human suffering incurred by drought, emergency relief has historically been the most politically charged public policy in Northeast Brazil. The traditional public response to a crisis has always involved two strategies – food distribution as monthly food baskets (*cestas básicas*) and temporary public employment on 'work fronts' (*frentes de trabalho*). The effort to provide emergency relief carries a very heavy economic burden for the public sector. For example, during the crises of 1979–83, which directly affected eighteen million people throughout the Northeast, the government spent U.S.$1.8 billion in emergency programs established to assist approximately 2.5 million workers (Magalhães et al., 1988, p. 293). During the recent 1997–98 El Niño drought, around $400 million in emergency relief was spent in the state of Ceará alone to provide public employment and food baskets to about 250,000 families (SEPLAN, 2000).

Beyond the high financial cost, emergency programs also engendered the infamous 'drought industry', as they were cynically labeled. The monies directed toward relief provided widespread opportunities for corruption, graft, and clientilism that produced personal fortunes in the wake of social catastrophe (Coelho, 1985). Phantom workers were registered and paid for work front activities; fat

* For a detailed description of these projects, see Magalhães et al. (1988).

contracts were issued for services never provided; and political cronies were favored in the distribution of relief work and food. Over the last two decades, the state government has made a concerted effort to correct the abuse associated with drought relief. During the 1979–83 drought, the government cancelled large-scale public works projects in order to reduce the widespread displacement of workers and family separation during a crisis. Publicwork projects on individual properties, once a means of increasing the infrastructure of private large holdings, were limited only to water storage projects where property owners agreed to community access to the water (Magalhães and Neto, 1991). The 1993 drought precipitated a new direction in use of the public work front programs as a tool of emergency relief. Its new philosophy attempted to localize the use of emergency relief labor in the construction of community public use structures, such as dams or schools, and it encouraged the creation of local municipal councils responsible for selecting emergency program beneficiaries and the specific local public works projects to be executed (Carvalho et al., 1993, p. 114; Tendler, 1997). These councils reduced the influence of traditional patterns of clientilism and corruption common in the implementation of past emergency programs.

At the same time, Ceará invested significantly in science-based tools to combat drought. Since the early 1920s, scientists and engineers had attempted to develop forecasting methods for Northeast Brazil. Magalhães et al. (1988, p. 315) identify two main classes of forecasting methods. The first seeks to predict the character of the rainy season a few months in advance by applying knowledge of physical processes, i.e., the large-scale parameters that indicate rainfall regimes in Northeast Brazil, both in the atmosphere and in the oceans. The second method predicts drought by extrapolation employing statistical models based on the apparent existence of periodicity in the historical rainfall series observed in the region.

The origins of Ceará's forecasting agency – FUNCEME – go back to the creation of the Bureau of Drought linked to the Federal University of Ceará during the 1950s. Although the Bureau started as a physics research group, it soon moved to applied activities such as cloud seeding experiments. This experimental phase extended until the early 1970s when FUNCEME was formally created with the goal of providing operational support to cloud seeding. The state acquired three planes to carry out regular experiments (F. Viana, personal communication, 1997); however, there was little scientific research supporting these experiments and very little documented success (R. S. Farias, personal communication, 1997). Cloud seeding was the first serious attempt to use science to mitigate drought by 'making' rain, and it became a powerful political tool with politicians regularly requesting that missions be carried out over their regional strongholds. When FUNCEME phased out the program in the 1990s, the agency's new president was harshly criticized for selling two of the planes (Pessoa, 1997).

In the early 1980s, FUNCEME's mission was expanded to develop theoretical research seeking a scientific basis for drought-related policymaking in the state. By the late 1980s, the new state government had decided to change its approach to drought mitigation and launched a comprehensive effort to increase the state capacity to implement effective policy. As part of this endeavor, FUNCEME was provided with state-of-the-art equipment and was allowed to recruit highly-qualified personnel. FUNCEME also embarked on a period of strengthening its cooperation with other national and international climate research institutes and attracting funds from federal sources.

Meanwhile, scientists in the United States involved in ENSO research were excited by the potential of forecast information as a policy tool to mitigate the negative effects of El Niño teleconnections (Glantz, 1996). Early work on the connection between El Niño and drought in Northeast Brazil raised expectations that forecasts could be used in drought planning (Magalhães et al., 1988). Consequently, FUNCEME found the political and financial support to expand research activities into climate modeling, monitoring, and forecast, weather forecast, remote sensing, and water resources management. Thus cloaked in scientific legitimacy, FUNCEME came to play a much more prominent role within the state policymaking machinery.

In the early 1990s, FUNCEME began to disseminate seasonal climate forecasts on a regular basis to sectors of the state government involved in drought relief and agricultural policymaking. For example, the *Hora de Plantar* Program ('Time to Plant') was created to distribute high quality seeds to farmers in Ceará, but only when certain planting conditions are met. This program, started by Governor Tasso Jereissati in the late 1980s, is widely cited in the literature as a successful example of an ENSO application in policymaking. Golnaraghi and Kaul (1995) report that during the 1991–92 El Niño event, the Ceará state government initiated agricultural support and water management strategies based on an ENSO-related forecast of impending drought. According to this account, the FUNCEME forecast convinced the then-governor, Ciro Gomes, to design a drought mitigation plan that included technical information on the appropriate timing of planting, the construction of a new aqueduct to supply the capital city of Fortaleza, and an urban water conservation program. As part of a grassroots campaign, the governor himself traveled throughout the rural areas of the state confirming the reliability of FUNCEME's forecast and promoting cooperation with the mitigation plan. In 1992, although rainfall was 23% below normal, agricultural output in Ceará dropped only to 80% of the average grain production while during the previous 1986–87 El Niño episode, without the benefit of a forecast, 30% less rainfall produced an agricultural output of only 15% of the state average (Golnaraghi and Kaul, 1995).

Based on recent interviews with the principal actors, these percentages and indeed the entire sequence of events appear questionable (Nelson and Finan, 2000), and our efforts to recreate the comparable production figures for the two agricultural campaigns have shown significant discrepancies from the published evidence.⋆ It is even more telling that average precipitation is an imperfect es-

⋆ For example, according to official government data, production in 1987 was more than double what was initially reported. According to our figures, while production in 1992 was still higher than timator of production in any semi-arid environment where spatial and temporal distributions are so critical. Nonetheless, this event was widely cited as a bellwether of application success. In reality, the political benefits likely outstripped the actual economic gains from the forecast. In 1993, however, the agency's release of an inaccurate forecast demonstrated the political dangers involved in forecast information.* The subsequent crisis in credibility forced FUNCEME to re-think the role of seasonal forecasts as a tool for policymakers.

5. The FUNCEME Forecast Product

The meteorological department of FUNCEME formulates a forecast based on an array of primary data received from climate institutes in the U.S., Europe, and Brazil. This information includes the analysis of output from dynamic rainfall models from the Scripps Institution of Oceanography, International Research Institute of Climate Prediction – IRI, and Weather and Climate Forecast Center from the Brazilian National Institute for Space Research – CPTEC/INPE. In addition, statistical models from the University of Wisconsin, the Hadley Center Meteorological Office (U.K.), FUNCEME/CPTEC, and others are also utilized. Several Northeast Brazil states have created climate study nuclei that meet once a year before the rainy season to analyze the climatic phenomena and physical data known to affect rainfall in the region. These climate scientists assess the various datasets separately and in relation to each other, then formulate a 'conceptual model' that calculates the probability of how each of the different phenomena will affect the upcoming rainy season (January–May). Each factor (ENSO, etc.) is then classified as 'favorable', 'neutral', or 'unfavorable', a decision which requires substantial levels of interpretative intuition. Thus, the nature of the climate data and methodology chosen to build the model incur highly variable model outputs, and the degree of forecast uncertainty can be higher in some years and lower in others. Figure 2 shows an example of FUNCEME's conceptual model.

Each year in December, FUNCEME begins to issue three-month (February–April) forecasts and adjusts them periodically as the rainy season approaches. The forecasts are expressed in probabilistic terms, that is, a likelihood that the outcome of the rainy season (in total amounts of annual precipitation) will fit into one of five descriptive categories: two above normal, normal, and two below normal. These categories are then translated, using historical data, into maximum and minimum

in 1987, 61% and 36% of the mean respectively (IPLANCE 1989, 1993), it was not nearly as high as portrayed in the literature. For more details, see Nelson and Finan (2000).

* FUNCEME predicted the ongoing drought of 91–92 would end in 1993 but the state experienced one of its driest seasons in history. Right after this mishap, FUNCEME's president was replaced. Although many will argue that there is no such a thing as an 'inaccurate' forecast, rather than focusing on the information per se, this article is concerned with people's perception of this information. The user public does not easily understand a probabilistic statement and will interpret it in more accessible language, i.e., 'wrong'.

Variables	NOV 96		DEC 96		JAN 97		FEB 97	
Pacific Ocean Basin								
SST	+		+		+ N		N	
d SST/dt			N		- -		-	
Thermocline	+	+	+	+	-	-	-	
Zonal Winds	+		+		- -		N	
Equatorial PNM	+		+		-		N	
PNM			-		-		-	
SOI	N		+		+		+	
OLR	+		+		+ -			
Northern Atlantic Basin								
SST	+		-		- -		-	
d SST/dt		+	-	-	- -	-	-	-
Trade winds	+		(')		-		-	
PNM	+		-		-		-	
OLR	+		-		+			
Teleconnections	-		-		-			
Southern Atlantic Basin								
SST	N		N -		- -		-	
d SST/dt		N	N	N	- N	-	-	-
Trade winds	N		N		+		-	
PNM	N		-		-		-	
OLR	-		N		+			
Equatorial Atlantic								
Southern Winds	+		+		-		N -	
Zonal Winds	-	+	N	+	+	N	+	N -
ITCZ								
Pre-season Rainfall								
Northern NEB	+		-		+	+	+	+
Southern NEB	-	+	+	-	+	+	+	
SST Forecast – Pacific Ocean								
NCEP	-		-		-		-	
CCA	-	-	-	N	-	N	-	
CA	-		-		-		-	
CZ	+		+		+		N	
COLA	-		+		+			
SST Forecast – Atlantic (SIMOC)								
Northern Atlantic	-	-	-	-	-	-	-	-
Southern Atlantic	-		N -		-		-	
Rainfall Forecast – NEB								
CPTEC	-		N		N		-	
IRI	-	-	-	-	-	N -	-	-
CCA	-		-		N		-	
HASTENRATH			-		+		+	
HADLEY							-	

(N) – neutral
(+) – favorable
(-) – unfavorable

Department of Meteorology – FUNCEME

Figure 2. Prognosis table: Rainfall season for the Northern sector (semi-arid) of Northeastern Brazil (NEB) February–May 1997 (source: FUNCEME).

ranges of expected precipitation for each micro-climatic zone of the state. The degree of certainty of the forecasts varies, sometimes widely, from year to year and is stated in terms of probabilities. Moreover, the forecasts themselves are based on climate phenomena that are not site-specific, although the spatial variability in any semi-arid region is great. Hence, the scale specificity of the forecast is highly limited. Finally, the forecast says very little about the temporal distribution of precipitation over a given rainy season.

We have already suggested that policymakers do not always appreciate the probabilistic character of the FUNCEME forecasts, since they seek to achieve political advantage through the expropriation of scientific knowledge. It is equally true that other sectors of society, including both media and end-users, impose their own interpretative frameworks upon the forecast, often with undesirable consequences for FUNCEME. The format of the forecast – and its release to stakeholders and the public – poses substantial problems for application. In the past, FUNCEME has tried several methods of forecast dissemination including press releases, press conferences, and one-on-one interviews, all with mixed results. As Nicholls (1999) effectively shows, the public tends to restate information dealing with risk and uncertainty in terms consistent with their cognitive experience. Thus, the end-user prefers a cognitive touchstone that facilitates decisionmaking rather than an explanation of probabilities. FUNCEME scientists complain that their efforts to 'translate' the technical jargon and convey the idea of probability has yielded little results. Rather, they contend that the media has performed 'cognitive' translations and reduced the probabilistic forecast to headlines such as 'the miracle of rain is coming' or 'drought in Ceará!'* Consequently, even when releasing 'accurate' forecasts, FUNCEME is often *perceived* as being wrong.

In addition, FUNCEME is constantly challenged by – and judged against – other forecast producers and traditional methods of drought forecast such as local 'rain prophets' (*profetas de chuva*), amateur meteorologists, and popular beliefs. Interviews with policymakers, local authorities, and farmers showed that while the general public expects FUNCEME, as a scientific agency, to be right all the time, it is usually more forgiving towards these 'ethnometeorologists' who are held to a lower standard of expected accuracy. The debate between science and local empiricism is partially of FUNCEME's own making, since during its period of expansion, FUNCEME boosted expectations that improved forecasting would provide farmers the information tools to decrease their vulnerability to drought. FUNCEME scientists publicly challenged traditional methods of drought forecasting emphasizing

* Information about the difficult relationship between FUNCEME and the media was obtained from interviews with both FUNCEME's technicians and journalists. At least two journalists interviewed for this research had been FUNCEME employees themselves (in the media relations office) and could appreciate the intricacies of working on both sides. They both confirmed that there is a basic conflict between publishing scientific information and selling newspapers. Moreover, they pointed out that because of the high turnover in newspapers, FUNCEME's efforts to form an educated cadre of journalists were mostly ineffective.

the superiority of science to both rain prophets and local lay forecasters (Diário do Nordeste, 1997).*

6. Farmers as Forecast End-users

As our previous discussion has emphasized, the primary target of climate forecasts is the subsistence farmer for whom the annual rains have such critical importance. In this study, the vulnerability of these farmers was analyzed using their asset base and income streams as the classifying criteria.** Table I characterizes the three vulnerability classes that emerged from the analysis of the 484 households. Those households that evince the highest degree of vulnerability (43% of the sample) tend to be sharecroppers or renters who cultivate relatively small areas each year. Their agricultural cash income is very low and total income is only 472 reais per capita (about U.S. $340). Only 5% of this category of households had access to any irrigated land. The least vulnerable families own their own land, cultivate greater areas, and have a significant annual income from the sale of crops or animal products. Over 40% of this category have access to irrigated land and their total per capita income is 3.6 times that of the most vulnerable families. Table I shows the livelihood characteristics of the 484 households interviewed for this study by vulnerability category.

The majority of these households rely on rainfall for their livelihood, and the advent of the rainy season is a period of collective anxiety. In most of the state, the rains are expected in January or February, but if it does not rain up until St. Joseph's Day (March 19th), the agricultural campaign is considered lost. Farmers prepare their lands in December, mostly using manual labor or animal traction, then plant when the rains moisten the soil to a depth of about 25 cm. If, as frequently occurs, the rains are poorly spaced,*** a replanting will be necessary. The basic subsistence cropping mix is corn and beans, usually grown on separate but contiguous plots. At the same time, most households have some livestock. Cattle are most highly

* In addition, rural labor leaders interviewed for this study suggested that another reason to explain farmers' lack of trust in FUNCEME's information was that most of the agency's technical personnel were 'imported' from Brazil's southern states and therefore were 'ignorant' of the problems of Northeast Brazil and *nordestinos*.

** The vulnerability categories were established by summing all subsistence production for the year 1997, then separating the sample in quartiles. Similarly, all sales of agricultural and animal productions were assembled and divided into quartile crops. The production quartiles formed the vertical axis and the agricultural income quartiles formed the horizontal axis of a 'vulnerability matrix'. Each of the sixteen cells were assigned, using ethnographic information, to one of three vulnerability categories. Off-farm income, while important for vulnerability analysis, was treated exogenously as a coping strategy. In general, however, the most vulnerable categories obtain less off-farm income.

*** It is common to have an abundant rain that moistens enough to allow germination. A *veranico* is an extended period following these rains during which there is no precipitation. This dry period causes great stress to the young plants and can compromise their development.

Table I
Livelihood characteristics 484 households by vulnerability category

Vulnerability category	Sample (N)	Family size	Cultivated land		Farm income		Non-farm income		Total income	
			Landless (% HH)	Area (ha)	HH %	Avg. amt. R$	HH %	Avg. amt. R$	Avg. amt. R$	Per capita R$
Highest	210	5.9	72	1.6	60	270	96	2423	2481	472
Intermediate	166	4.9	49	2.7	92	474	85	2265	2470	610
Lowest	108	4.4	23	5.8	100	4128	87	2915	6475	1690
Total sample	484	5.2	47	2.5	80	1427	90	2467	3369	791

Table II
Sources of climate information by selected municípios

Vulnerability category	% HH that receive climate information	% HH with knowledge of *profetas* or traditional experiencies	% HH with knowledge of FUNCEME activities	% HH that believe in FUNCEME forecasts
Limoeiro do Norte	86	79	99	9
Barbalha	85	85	67	6
Parambu	84	80	95	6
Boa Viagem	86	86	90	4
Itarema	74	79	51	3
Guaraciaba do Norte	75	72	44	4
Average	82	80	75	5

valued and can be pastured on crop residues. Only 30% of the most vulnerable households have any cattle, while almost 65% of the least vulnerable households are cattle owners.

The level of dependence on highly variable rainfall speaks to the potential importance of climate information for agricultural decision-making, but the survey data have identified binding constraints on such information use. Tables II and III show forecast access and use among rainfed farmers in Ceará by *município* and vulnerability category respectively. The dissemination of climate information in general is widespread, although there are significant differences among vulnerability groups. Around 60% of the most vulnerable families and 90% of the least vulnerable declared that they were aware of FUNCEME forecasts, mostly through television and radio. The most vulnerable farmers tend to have less education and to reside in more remote districts of their *municípios*, and their access to information in general is more limited. At the same time, however, the tables demonstrate that access and awareness do not translate directly into trust and – even less – into use. Overall, only 5% placed credence in the forecasts, and the qualitative data suggest that very few farmers actually changed their planting or cropping behavior based on this information. Also, the level of household vulnerability had no significant relationship with levels of confidence in FUNCEME's forecasts.

This exceedingly low utility value of the forecasts is related, on the one hand, to the socio-cultural and political context that influences the dissemination and interpretation of climate information and, on the other, to the structural constraints upon its use. In the first case, farmers have developed a very negative perception

Table III
Sources of climate information by vulnerability category

Vulnerability category	% HH that receive climate information	% HH with knowledge of *profetas* or traditional experiencies	% HH with knowledge of FUNCEME activities	% HH that believe in FUNCEME forecasts
Highest	80	78	63	5
Intermediate	83	86	81	4
Lowest	84	76	90	8
Average	82	80	75	5

of the FUNCEME forecast product for reasons of 'inaccuracy', to the point of widespread dismissal of its validity. As we have seen, the forecast is disseminated as maximum and minimum precipitation levels that correspond to the forecast category (e.g., 'normal'), for each climate micro-region of the state. For example, in the drier parts of the state, the forecast may announce that the upcoming rainy season is expected to be 'normal', which means a maximum of 600 mm and a minimum of 400 mm of rainfall during the season. In such a semi-arid environment, however, actual rainfall may be highly localized within the region, and the forecast does not provide information on what this spatial or temporal distribution of rainfall will be. Farmers are concerned naturally with their individual fields and not entire regions, and they are painfully well aware that their own fields can remain dry and barren even when the region as whole has received 'normal' precipitation levels.

The meaning of a probabilistic forecast is also poorly comprehended. While there is a non-zero probability that actual precipitation totals will not fall within the predicted ranges, the media and some policymakers attribute an unfounded sense of certainty to the forecasts. As mentioned before, as probabilistic statements, forecasts are doomed to be labeled 'wrong' in some years if the reality of uncertainty and risk is not understood by information users. Moreover, in Ceará there has traditionally been tension and distrust between farmers and government. In their own eyes, the poor farmers are rarely the beneficiaries of significant government assistance; and, in fact, some feel that government actually works against the population. This environment of suspicion does not facilitate the transfer of ideas and information from the government to the farmers and affects the perceptions of FUNCEME. Not only do most people believe that FUNCEME is usually incorrect, but some are convinced that the forecasts are fabrications developed in the interest of the state government.

In addition to issues of mistrust, cultural factors affect user perceptions of the forecasts. The rural population has depended upon high-risk, rainfed agriculture for centuries, and local stocks of indigenous knowledge are plentiful. Farmers commonly produce their own individual forecasts through reading and interpreting localized natural signs, and over 90% of the survey sample described indicators that they or their neighbors use to determine whether the upcoming year will be wet or dry. Most farmers also have access to local rain prophets, and this knowledge is well disseminated and respected. While farmers, in general, have much more faith in Nature, being under God's control, than they do in science, they realize that man cannot know this Nature. Thus, even traditional indicators of the upcoming rainy season do not significantly alter actual cropping practices. Farmers continue to rely on age-old growing technologies designed to spread risk and maximize production during any type of year. For example, farmers plant a variety of seed types in every year, some of which are more drought tolerant and quick maturing but with low productivity, while other varieties require more moisture, take longer to mature, but are higher in productivity. In sum, farmers do not fully understand the meaning of forecasts nor do they trust them. Even the available ethno-meteorological information does not translate into specific alterations in plantings strategies.

The second reason for low application of forecast information is related to the underlying vulnerability of the rural population. Even if producers believed and trusted FUNCEME and even if the agency could deliver forecasts with perfect accuracy, agricultural strategies would change little. The population in general simply does not have the assets, resources, or ability to choose among alternate climate-sensitive technologies. They do not have access to stores of water for irrigation, they do not have consistent access to off-farm sources of income, and they do not have the ability to switch to other types of crops. In order to support their families, farmers are forced to plant every year, and so they do as soon as the ground has enough moisture. Even when the harvest is minimal, it is still a contribution to the survival of the family. Therefore, until farmers can reduce this structural vulnerability and define technological options that correspond to different kinds of forecasts, the utility of the information will remain compromised.

7. Policymakers as Forecast End-users

In principle, since climate science can predict the onset of ENSO and forecast drought in regions such as Northeast Brazil up to six months in advance, policymakers have a unique opportunity to anticipate climate variations and manage regional resources to reduce the negative effects of climate extremes (Moura et al., 1992; Carvalho et al., 1993; Glantz, 1994; Golnaraghi and Kaul, 1995). Here we analyze three state-level public drought mitigation policies that systematically integrated the FUNCEME forecasts. The first is the seed distribution program, *Hora de Plantar*, administered by Ceará's Secretariat of Rural Development (SDR); the second is the emergency drought relief program administered by the Secretariat of

Labor and Social Action (SAS) through its Civil Defense Agency (CEDEC); and the third is the water management system at the state level, in particular reservoir management, administered by the Secretariat of Water Resources (SRH) and its operational agency the Water Resources Management Company (COGERH).

As mentioned above, the *Hora de Plantar* program was hailed as a successful use of seasonal climate forecasting in policymaking in the early 1990s. The philosophy of the program was to provide farmers with high quality seeds (corn, beans, rice, and cotton), but to distribute them only when planting conditions were appropriate, or, as the public discourse went, when 'winter had established itself'. The goal of this program was to use scientific information to orient farmers with regard to the true onset of the rainy season, remembering that farmers tend to plant with the first rains (sometimes called the 'pre-season'), which often requires a later replanting.

Relevant information was provided by FUNCEME in two forms. First, through the conceptual model described above FUNCEME issued a seasonal climate forecast in December of each year; second, a soil humidity model developed by FUNCEME using daily precipitation, evaporation, soil type, and topographic features generates estimates of soil humidity using information from the 184 rain gauges distributed across all the *municípios* of Ceará. The output of this model in effect assesses the capacity of the soil to sustain plant growth given the amount of rainfall already recorded (Andrade, 1995). When soil moisture is sufficient to support growth for eleven days without rain, the *município* is deemed ready for seed distribution. At this point, SDR authorizes seed distribution through its network of rural extension agents (Andrade, 1995).* Furthermore, the Bank of Brazil, the major channel of subsidized agricultural credit, also used FUNCEME's forecast to make decisions on annual production loans in rural areas. A forecast of a poor rainy season served to reduce credit available to subsistence farmers.

Media coverage of the impending rainy season associated the releasing of seeds with the scientific information of FUNCEME. In the public perception, FUNCEME 'announced' the winter, and then SDR released the seeds. Often, in specific regions where rainfall was sufficient for farmers to plant following their traditional practices, government seeds were not yet released. For farmers, this unavailability of government seed was perceived as due to the fact that FUNCEME had not yet sanctioned their distribution. These situations created a dynamic tension not only between farmers and policymakers, but also between FUNCEME and SDR with the former frequently playing a scapegoat role (Diário do Nordeste, 1996; O Povo, 1997). For example, in 1997, climate signals were particularly difficult to interpret, and FUNCEME released a cautious forecast of 'below average rainfall, irregularly distributed spatially and temporally'. In fact, rain fell in many *municípios* in January, but FUNCEME considered this a 'pre-season anomaly'.

* These criteria may change based on the seasonal climate forecast. In years of below average forecast, the number of days can be reduced so that farmers can take advantage of any opportunity to plant (Andrade, 1995).

SDR postponed seed distribution until later in the season despite the early rainfall, and consequently seed arrived too late for many to plant. FUNCEME was harshly criticized for releasing a 'wrong' forecast (Ripardo, 1997; Tribuna do Ceará, 1997). By mid-season, the rains had stopped, and the forecast was proven right. Nonetheless, the public perception of a failed forecast prevailed. From this point on, FUNCEME limited direct contact with the media, opting for the press release as its primary method of forecast delivery. The agency also began to train rural extension agents in interpreting the forecasts in an effort to improve communication to the end-users.

Moreover, despite the attention *Hora de Plantar* got in the literature, evidence from the 484 households surveyed suggest that the program did not have the level of support as the intensity of public discourse would indicate. In fact, only 54% of the sample had ever used government seeds and only 40% was registered during 1997. With regard to rural production credit, only 30% of the sample (15% of the most vulnerable group) had ever taken out a production loan. Thus, the reach of these policies was not great. With regard to seed distribution, this research revealed important flaws in the program design. Local livelihoods have been built upon the accumulation of generations of indigenous knowledge with regard to the timing of planting and the selection of quality seeds. Ignorance of when to plant is not the major constraint to successful production. Also, farmers are themselves plant breeders and risk managers in the sense that they collect seed from their most robust plants and save them for following planting seasons. They also exchange varieties with other farmers, always seeking the most drought and insect tolerant characteristics (as well as taste, yield, etc.). The attraction of the *Hora de Plantar* program was not the provisioning of drought-resistant seed, but rather the accessibility to seed when it was otherwise scarce or needed for replanting. Farmers also complained of program problems such as the timing in the arrival of the seeds and the logistics of distribution. Nonetheless, the criticism heaped upon FUNCEME for not releasing seed in a timely fashion suggests a broader distrust of government policies and the role of government in their lives.

Although until recently SDR policymakers continued to rely on the soil moisture and forecast information to initiate seed distribution, the management of FUNCEME has attempted to disengage itself from this decisionmaking process. It was particularly convenient for SDR to forestall the program because FUNCEME 'had not declared winter yet', thus shifting the focus of public ire toward the messenger rather than the message.* In addition, by relying on 'scientific' tools to make planting decisions, SDR could insulate the process from its constituency (Lemos, n.d.). Finally, policymaker 'fascination' with scientific tools and the guise of legitimacy and rationality they bring to the policymaking process diverted attention

* For example, as a reaction to what was perceived as the agency's gross mistake, one local state representative submitted a motion to forbid FUNCEME from releasing its forecast publicly (Costa, 1997). The public and institutional reaction to FUNCEME indicates the agency's inability to disentangle itself from the 'politics' of policymaking.

from other more effective policy alternatives (Lemos and Tucker, 1998). In this sense, *Hora de Plantar* and the use of seasonal climate forecasting was one more example of the dominance of technology-based policymaking as the strategy for drought mitigation in Ceará.

Another main user of climate information is CEDEC, the state civil defense agency responsible for emergency drought response. During periods of drought, CEDEC uses several FUNCEME data products to assess the level of need in each *município* in Ceará. At the onset of a drought, it employs a local level monitoring system based on the quantity and temporal distribution of rainfall, vegetation indexes, yield losses, and social tension episodes to establish a triage ranking for government response (Governo do Estado do Ceará, 1997). By basing the ranking of *munícipios* on 'objective' techno-scientific information, CEDEC seeks to eliminate the corruption excesses associated with the 'drought industry'. However, because these actions are mostly geared towards response instead of prevention, the usefulness of climate information has been associated primarily with the agency's ability to 'insulate' its decisionmaking from political favoritism and clientilism rather than to use it in the implementation of preventive policies (Lemos, n.d.). Thus, despite the state government's increasing emphasis on proactive planning, to date, civil defense officials mostly report an interest in seasonal climate predictions as 'background information'. Nonetheless, CEDEC's management recognizes the use potential of the seasonal climate forecast for drought relief.

Finally, COGERH uses seasonal climate forecasting information to plan and manage water resources all over the state. Water is available in Ceará at three main levels. At the most vulnerable level are localities, or *municípios*, that are located far from the state's water resource infrastructure and depend almost exclusively on wells and small reservoirs (*açudes*) for water supply. Many wells and *açudes* can barely sustain water supply during periods of mild water deficit – which in Northeast Brazil occur 80% of the time – but offer no resistance to multi-year drought events (Viana and Gondim Filho, 1999). Next, there is a network of mid-size reservoirs that are regulated to sustain water supply for over a year with natural recharge. These are fundamental to respond to drought at the local level but their efficiency is also critically challenged by multi-year events. The bulk of the state water supply infrastructure is located around the capital city of Fortaleza and connected to the region's only perennial river and its large reservoirs.⋆ Since during multi-year drought events (e.g., for the last hundred years there were six multi-year events recorded), these large reservoirs become the only reliable source of water, they are managed with extreme caution and conservatism. Thus in 'normal' years COGERH usually releases only 20–30% of their capacity to consumption.⋆⋆

⋆ In reality, Ceará has no naturally permanent rivers, but a system of large storage reservoirs that have made the Jaguaribe River permanent below the spillways.

⋆⋆ In addition, reservoirs lose approximately 3,000 mm/yr of water to evaporation, making the need to conserve water even higher.

Indeed the potential use of the climate forecast at GOGERH is high, and the agency has consistently sought to incorporate this information into its decisionmaking, especially year-to-year reservoir management (F. Viana, personal communication, 2001). Yet, the seasonal climate forecasting lead-time, that is, how soon FUNCEME is able to release its regional assessment, constrains the decisions of water managers. As it stands, COGERH is able to use some information, especially El Niño forecasting as an indication of a 'weak winter' to plan for reservoir management. However, as we described above, El Niño forecasting is one of the many phenomena analyzed for FUNCEME's seasonal forecasts. While policymakers have to make water management decisions by August, early seasonal climate forecast will not be ready for release until December. By then, most of the more critical decisions have been made.

Forecast information is more relevant to infrastructure planning and maintenance where the risk of a 'wrong' forecast is attenuated by little immediate impact on livelihoods and the potential for long-term positive effects. For example, after a mildly dry season in 1997 – when rainfall failed to restore reservoir capacity – and a forecasting of a great El Niño event for 1998/99, COGERH initiated a series of actions to 'buffer' the water resources system from a probable multi-year drought event, in particular by speeding up maintenance and upgrading construction of key infrastructure for the Fortaleza water supply system to avoid a crisis such as the one in 1992/93 (Viana and Gondim Filho, 1999). Here the likelihood of a multi-year drought event helped COGERH move much-needed infrastructure maintenance and construction up on the government agenda.

8. Application Lessons from the Ceará Case Study

This analysis of a decade of forecast applications in the state of Ceará demonstrates both the challenges and the opportunities. The Ceará case is one where an existent technology – an emergent one in fact – was appropriated and pressed into service of a policymaking apparatus designed to reduce the impacts of severe droughts. In the early years of forecast, policymakers exaggerated the potential usefulness of this science product therefore creating a situation of cultural dissonance between science and local knowledge and belief systems that quickly eroded the value of the information. Simply stated, the end-users, primarily highly vulnerable farm families, began to perceive FUNCEME and its forecast in an adversarial light. The initial problem was not necessarily one of the interpretation of the probabilistic forecast, but one of unrealistic expectations and broken promises. Our interviews with farmers strongly suggest that some individuals even consider FUNCEME to be the *cause* of drought rather than a science messenger. This crisis in cultural perception was engendered by the untempered use of the forecasts in the early part of the decade as much as by the inherent 'shortcomings' of the product.

A second lesson to be learned from this case study was the effort of government to use the forecast as a tool to manage agriculture. The *Hora de Plantar* program in effect expropriated from farmers a critical decision-making process, presumably based on the assumption that farmers do not know when to plant. This created great resentment among rural populations, which was mostly directed toward FUNCEME (and occasionally reinforced by SDR). Over the last two years, both state agencies have adjusted their policies to reduce this interference with local decision-making, and the forecasts have been disassociated with the timing of the distribution of seeds. The information on appropriate conditions for planting is made available, but not used as a condition for obtaining seeds. The planting decision is now the purview of the farmer.*

The third lesson is that the forecast is limited by the socio-economic conditions of the beneficiary population. Most farmers in Ceará are so vulnerable to climate variability that they are unable to respond to climate predictions irrespective of the quality and precision of the forecast. The lack of resources among rainfed farmers critically limits their range of choice in terms of alternative crops, technologies, or cash generating activities. Thus, in most cases, the only alternative available to poor farmers is to work in emergency work fronts or to migrate to urban areas where they face a different kind of poverty. In this sense, the impact of forecasts is insignificant among most farm households in Ceará, and will continue to be so until relative levels of vulnerability are reduced in a more permanent fashion.

From a more technical perspective, two lessons are obtained. First, policymaking in drought mitigation and vulnerability reduction has to learn how to adapt forecasts to a semi-arid environment. The wide variability in spatial and temporal distribution of rainfall makes the 'packaging' and dissemination of the forecast a tremendous challenge for both scientists and policymakers. There is now a call within FUNCEME to direct research toward the frequency of *veranicos*, or prolonged cuts in the rainy season, and toward 'pre-season' climatic patterns. Second, we have learned that the timing of forecast delivery affects the ability to use it in some policy areas such as water management. Although there is a recognized potential for the use of climate data in areas such as the regulation of dams and reservoirs, current timing of data release precludes policymakers from taking advantage of early forecasts. Here again, as forecast release timing improves, that is, as forecasters are able to predict climate more in advance, there will be a better opportunity to use early climate forecast in water management. For now, ENSO forecasting can be available up to six months in advance, thus providing a general indication of how conservative or not policymakers can be in their water management decisions.

In conclusion, this case study of Ceará contributes to an understanding of how improved climate information systems are embedded in socio-economic and po-

* It is accurate to say that the results of this research duly reported to state officials have been instrumental in this policy change.

litical contexts. It demonstrates that scientific knowledge can only be objective in the hands of the scientist, if then. Once such knowledge is applied in a real-world policymaking context, it suffers the risk of distortion, misinterpretation, even manipulation. It is accurate to assert that in Ceará, the limits of the use of climate information in policymaking derive in part from the level of skill of the science product itself and in part from the necessity for a policymaking apparatus to learn how to apply it usefully toward drought mitigation. Here, the availability of ENSO climate information triggered the creation of a dedicated policy apparatus to use the forecasts in drought relief, water management, and agricultural policymaking. In this process, the state government seized upon the opportunity of new knowledge to create drought-related policies in which scientists and policymakers attempted to preserve the distinctness between science production and policymaking while ignoring basic institutional constraints to policy choice and application in the region. As experience so effectively instructs, FUNCEME and the rest of the policymaking apparatus now display increasing signs of sophistication in expanding the applicability of forecast information.

The historical mishandling of the forecast by policymakers does not diminish its potential benefit to this drought-plagued society. Although in Ceará, FUNCEME's scientific information has been used both as a source of authority and mechanism of accountability (civil defense) and as an originator of policy (agriculture), there are many instances where social organization and management lag behind the science and technology. This study argues that most farmers in Ceará will find that the value of forecasts increases as greater progress toward overall economic development is made and technological alternatives reduce their climate vulnerability. On the other hand, the forecasts offer a dramatic opportunity for state and local level bureaucracies responsible for drought mitigation to embark on a path of proactive drought planning. Nevertheless, to achieve this potential, policymakers have to learn how to use the information. This is the challenge that will determine the ultimate success of this advance in climate knowledge.

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Appendix 1: List of Acronyms

CEDEC	Comissão Estadual de Defesa Civil do Ceará Ceará State Civil Defense Commission
COGERH	Compania de Gerenciamento de Recursos Hídricos (Water Resources Management Company, State of Ceará)
CPTEC	Centro de Previsão de Tempo e Clima (Weather and Climate Forecast Center)
ENSO	El Niño/Southern Oscillation
EMATERCE	Empresa de Assistência Técnica e Extensão Rural do Ceará (Rural Extension Office, State of Ceará)
FUNCEME	Fundação Cearense de Meteorologia e Recursos Hídricos (Ceará Foundation for Meteorology and Water Resources)
INPE	Instituto Nacional de Pesquisas Espaciais (National Institute for Space Research)
IRI	International Research Institute for Climate Prediction
SAS	Secretaria do Trabalho e Ação Social (Secretary of Labor and Social Action, State of Ceará)
SEPLAN	Secretaria de Planejamento e Coordenação (Secretary of Planning, State of Ceará)
SDR	Secretaria de Desenvolvimento Rural (Secretary of Rural Development, State of Ceará)
SRH	Secretaria de Recursos Hídricos (Secretary of Water Resources, State of Ceará)

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