NOAA Report

The social and policy implications of seasonal forecasting: a case study of Ceará, Northeast Brazil

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Acronyms

BNB	Banco do Nordeste do Brasil (Northeast Development Bank of Brazil)
CEDEC	State Civil Defense Agency
CHESF	Companhia Hidroelétrica do São Francisco (São Francisco Hydroelectric Company)
CODEVASF	Companhia de Desenvolvimento do Vale do São Francisco (São Francisco Valley Development Company)
COGERH	Compania de Geraciamento de Recursos Hídricos (Water Resources Management Company, State of Ceará)
COMDEC	Comite de Defesa Civil
CPTEC	Centro de Previsão de Tempo e Clima (Weather and Climate Forecast Center)
DNOCS	Departamento Nacional de Obras Contra as Sêcas (National Department for Works Against Drought)
ENSO	El Niño Southern Oscillation
EMATERCE	Empresa de Assistência Técnica e Extensão Rural do Ceará (Rural Extension Office, State of Ceará)
FAO	Food and Agriculture Organization
FUNCEME	Fundação Cearense de Meteorologia e Recursos Hídricos (Ceará Foundation for Meteorology and Water Resources)
GAC	Grupo de Ação Comunitária (Community Action Group)
IBGE	(Instituto Brazileiro de Geografia e Estatística) Brazilian Institute for Geography and Statistics
IFOCS	Inspectoria Federal de Obras Contra as Sêcas (Federal Inspectorate for Works Against Drought)
INPE	Instituto National de Pesquisas Espaciais (National Institute for Space Research)
IPLANCE	Fundação Instituto de Pesquisa e Informação do Ceará Research and Information Foundation Institute of Ceará
IRI	International Research Institute for Climate Prediction
ITCZ	Intertropical Convergence Zone

MJO	Madden Julian Oscillation
MUSAG	Modelo de Umidade do Solo para Atividades Agrícolas
NOAA	National Oceanic and Atmospheric Administration
PFPT	Programa Frentes Produtivas de Trabalho (Productive Work Fronts Program)
SAS	Secretaria de 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)
SST	Sea Surface Temperature
SUDENE	Superintendência do Desenvolvimento do Nordeste (Northeast Development Agency)
UA	University of Arizona
UFC	Universidade Federal do Ceará (Federal University of Ceará)

Executive Summary

This project was designed to assess the socioeconomic and policy impacts of a well-developed climate forecast system in the Northeast Brazilian state of Ceará, a semi-arid area particularly vulnerable to severe drought. Ceará has a well-defined winter rainy season that is influenced by a strong ENSO (El Niño Southern Oscillation) signal, and therefore constitutes an important case study of the application effects of improved seasonal forecasting based on El Niño phenomena. The state agency responsible for the seasonal forecasting (and watershed research) is the Ceará Foundation for Meteorology and Water Resources (FUNCEME), and it has been in existence for over two decades. This study focused on: (a) expanding and enhancing the understanding of decision making processes of farmers within different vulnerability groups and who have differing types of land tenure and size, and who utilize different levels of technology in agriculture and (b) understanding how actors such as small farmers, extension agents, local and state policymakers and politicians use seasonal climate forecast and what they expect from data producers.

The objectives of this study can be summarized as follows:

- To describe the policymaking process that incorporates climate information into government programs aimed at mitigating and preventing the impacts of drought or at fully taking advantage of favorable rainy seasons;
- To assess the articulation between state and local levels of power in the use of climate forecast data;
- To document the use of climate forecast information disseminated from FUNCEME at the level of rural stakeholders who face differential vulnerability situations;
- To identify the strategies that rural families employ to mitigate the impacts of drought.

The methodology used in the study included two formal surveys. The first survey of 484 families in six different climate regimes, occurred in 1998. The second survey, in 2000, included 120 families, 54 of which participated in the 1998 survey. Key informant and focus group interviews at all levels of policy and *Decision-making* related to the mitigation and prevention of drought impacts were carried out during both field work seasons. The research was carried out primarily during two forecasting seasons, one with the strongest El Niño signal of recent memory (1997-99). The research period also encompassed one the most severe droughts on record. The interviews queried the role of individuals in the policymaking process; the strength of the political commitment to drought and agricultural policy, current policies for drought preparation and agricultural policymaking; the recounting of the use of forecast information during the famed 1992 drought; the overall willingness to use climate forecasts; perceived constraints and limitations to information use; perception of the accuracy and timing of the forecasts; and the costs associated with error and perception of error in the forecast.

Summary of Findings

Based on asset endowment (land, animals, etc) and income flow (from agricultural and non-agricultural sources), the analysis of the 484 families generated a vulnerability classification with 60 percent of the households falling into the most vulnerable category. Consistent with what is known generally about Ceará and the Northeast, this sample accurately reflected the deep pockets of poverty that exist throughout the region. On the other hand, over the last three decades there have been vast improvements in statewide infrastructure, including the expansion of television and other means of communications into formerly isolated zones. Within this context, our findings are summarized as follows:

- The climate science product itself is not yet sufficient to meet the needs of stakeholders, particularly farmers. The Ceará case confirms what researchers have suggested elsewhere—namely, that the forecast of average annual precipitation forecast over a wide area of the state is less important information than the spatial and temporal distributional patterns. Climate information is a new technology and subject to the "new technology blues", that is, stakeholders must go through a period of learning how to incorporate the new technology (forecasts provided in probabilistic terms) into eminently risk-based decisions. Ceará has only recently demonstrated in its public sector an increasing sophistication in the use of climate information.

- Virtually all the households know of the existence of FUNCEME and follow its forecasts from either television or from radio as the "science" perspective on the climate.

- Climate forecasts, when perceived as inaccurate, can seriously damage the public credibility of the agency responsible for product dissemination. For example, the "scientific" forecast of below normal rainfall, disseminated as a state-endorsed reality, was perceived in 1997-98 as being wrong, and FUNCEME suffered a widespread loss of credibility among rural stakeholders and some sectors of the state policymaking apparatus.

- The perceived relation between FUNCEME forecasts and the mobilization of seed distribution and rural credit program further damaged its reputation as a provider of climate information. In effect, many farmers thought that there was no access to seed or to credit because of the FUNCEME forecast. The problem is one of the probabilistic nature of the forecast, timing of release of the information, problems with data communication, lack of local level precision, and the fact that it is the distribution as much as the quantity of rainfall that determines the harvest outcome. In other words, the information in its present form is of limited use and, in fact, easy to misinterpret.

- Even with accurate forecasts—either from FUNCEME or from the rain prophets that abound throughout the state—most farmers do not have a range of options in order to respond to the information. There is no "drought technology" available to them. Large landholders and ranchers can perhaps move their cattle to less drought prone states (further north) and irrigated farmers can in fact change cropping decisions to take advantage of expected scarcities, but the more vulnerable families do not have an alternative, even with prior knowledge. Thus, forecasts must be seen as part of a wider development effort. Ultimately the use of forecasts by private decision makers is directly tied to their level of vulnerability.

- State and local policy makers are in a position to respond to climate forecasts, and some agencies, such as the Civil Defense and Water Management, use the forecasts to prepare for the eventuality of drought. Local authorities are not proactive in their response to drought forecasts and still react to the disaster once it is manifest. In fact, local leaders in this patronage-based society often prosper politically during a crisis.

- There is a clear disconnection between state agency representatives and farmers with regard to perceptions of the effectiveness of state assistance and support. In the minds of many rural stakeholders, to forecast the climate is to influence the climate and many early pronouncements of policy makers did not dissuade such a perception.

- The Ceará case demonstrated that in politically charged policymaking environments, the use of climate forecasting information may go beyond its problem solving function to influence broader issues of accountability and democratization, especially in less developed countries. Indeed, Ceará provided an example of policy makers attempting to use climate forecast products to legitimate their power positions, that is, to suggest in public discourse that Science could be made the handmaiden of policy making. In this politically charged environment, technocrats rely on scientific information about climate to insulate policymaking from both political "meddling" and public accountability. Policymakers, in other words, look for a technocratic policymaking model—defined as the pursuit of a policymaking process grounded on technical and scientific knowledge, rationality, efficiency, and autonomy—that isolate *Decision-making* from outside interference. However, insulation afforded by the use of climate information has played different roles in the policy areas examined in this study. While in drought-emergency policymaking the use of climate information critically contributed to the democratization of policy implementation, in agricultural policymaking, it worked towards further insulating decision making from public accountability and client participation. Climate information can be used in ways–positive and negative–that significantly differ from the use information producers intended.

- The Ceará case further suggests that the value of the information is only partially dependent on its quality since, even at very low skill, climate information can be used to further policy agendas not necessarily associated with information producers' original goals. These findings question the assumption that better data use will undoubtedly follow improved skill.

Project Impacts

This project has already reaped a number of positive impacts in both an intellectual and application sense. First, it identified a clear case of the politicizing of a scientific process that ultimately, and unnecessarily, discredited the science product. Second, this study has reaffirmed that drought is a social-economic phenomenon more than a climatic one. Average rainfall does not determine a crisis as much as the distribution of rainfall does. Also, the most vulnerable farmers face seasonal crisis situations even in a normal rainy season. Farmers do have a vast trove of indigenous knowledge, but it does not seem to change their planting decisions any more than scientific information does.

Another major insight is that the true potential for seasonal forecasting lies with state and local agencies responsible for the welfare of rural families. Here the potential of forecasting is vastly under-utilized because drought is still seen as an uncertain event rather than a part of life in the semi-arid. None of the six local authorities in the study area took proactive steps to prepare for the 1998 El Niño drought despite a strong forecast of sub-normal rains.

As far as local coping strategies are concerned, improved infrastructure means that families are no longer forced to flee the drought as in the past, with remittances from their migrated children and the retirement pension program providing the two most prevalent protections against the impact of drought.

At a more general level, project results have demonstrated that climate information is a new technology, and neither local farmers nor statewide policymakers have fully learned how best to exploit this information as a tool. This research reveals the nature of the incorporation of new scientific products into a policy and socio-economic context that has little experience in, for example, probabilistic risk assessment and risk-taking. On the other hand, the project has the time depth to demonstrate that such learning does occur and that slowly the potential for climate forecasting is being incorporated into both private and public decision making.

The project has stimulated several state-wide changes in policy:

- The government, primarily the Secretary of Rural Development, has severed the tie between the FUNCEME forecast and the availability of seed and credit programs, allowing farmers to make their own planting decisions based on their assessment of the seasonal forecast;

- The government has now begun to think more in terms of a policy of drought, treating the phenomenon as a part of the Northeast reality, thus allowing a more realistic role for FUNCEME in proactive drought planning;
- FUNCEME has taken the initiative to work with the state extension service to orient extension agents in the use of the forecasts. This ensures that the locally based agents can play a more substantive role in orienting farmers as to the meaning and the implications of a forecast product. FUNCEME has also tried to narrow the gap between its personnel and targeted beneficiaries by encouraging its scientists and technicians to travel throughout the rural areas and to get acquainted with the socioeconomic impact of seasonal climate forecast dissemination.

I. Introduction

Droughts have often caused serious agricultural losses and human suffering in arid and semi-arid regions of the world. The images of famine in Africa and human displacement in Northeast Brazil illustrate just a few of the hardships that are part of a much larger problem. One important aspect of mitigating these hardships is understanding the process through which policymakers and the people affected by climate variability make decisions to adapt and respond to such events. Only then will it be possible to implement policies that not only effectively mitigate negative consequences of climate-related phenomena but also promote democratic values such as fairness, transparency, accountability, and legitimacy in policymaking. A study of the use of seasonal forecasts of climate in policymaking is important not only because of the potential for lessening economic hardship and human suffering, but also as a primer for understanding policymaking in the context of global climate change. Because of the high degree of interconnection between environmental problems and solutions at a global level, understanding how different cultures and policy systems perceive and respond to climate forecast information is critical for the implementation of policies to mitigate anthropogenic causes of global climate change.

Despite advances in food production technology and signs of a slowdown in population growth, many regions of the world remain extremely vulnerable to disruptive and damaging climate-related events such as drought and flooding. Departures from the seasonal rhythms of climate often provide the difference between wealth and poverty, feast and famine, health and disease, and even life and death (Stern and Easterling 1999). Because hydrologic systems are generally sensitive to climatic changes, the amount of groundwater and surface water available is directly related to temperature and precipitation. Both short-term and long-term changes, as well as extreme climate events such as severe droughts and floods, are expected to have significant influence on water supply. In arid and semi-arid regions, known for their limited water resources and fierce competition among users, it can be expected that the impact of any changes in the hydrologic system would be magnified. One such region, Northeast Brazil, is presently the object of concerted efforts to assess the vulnerability of human and natural ecosystems to climate variability. In this region, water scarcity and vulnerability to drought have historically been given high priority on policy and *Decision-making* agendas.

Brazil's Northeast is comprised of nine states and encompasses eighteen percent of the national territory as well as one third of the country's population. It constitutes the vast majority of the infamous "drought polygon", the particularly vulnerable region which has recorded five centuries of periodic crisis. In a "normal" rainfall year (about 750 mm for the Northeast), the winter rains arrive in December or January and diminish into May, with the heaviest precipitation occurring from February to April. In a drought year, the rains are not abundant enough to support an agricultural harvest, or the uneven distribution of rains does not meet timing requirements for crop moisture. Thus, even an annual average level of precipitation can incur a drought situation (referred to locally as a "green drought").

Such climate variability has always been considered the major constraint to the economic development, as well as the principal cause of the numbing rural poverty, that besieges Northeast households. As in colonial times, the rural economy remains based on rainfed agriculture and livestock, both of which are highly vulnerable to climate. Furthermore, an exceedingly unequal pattern of land and resource distribution, another colonial legacy, has resulted in a large resource-limited population scarcely able to eke out a minimal subsistence. These landless and smallholder farmers comprise the critically vulnerable groups from which much of the rural-urban exodus has drawn. Even under a normal scenario, the rural poor experience difficulty in procuring basic necessities during part of the year. In a drought year, these households face critical survival challenges, which traditionally have been answered by out-migration or major government relief. At the same time, the livestock sector, controlled primarily by large *fazendeiros*, suffers for lack of pasture and water, and the value of the herd can become significantly reduced during a drought crisis. Finally, the water supplies of rural towns and cities are also threatened during periods of prolonged drought, and local commerce virtually grinds to halt. The severity of the human and economic impacts of drought thus reverberates through all sectors of rural society. Drought, therefore, pervades the everyday life of the *nordestino*, defining the region's rich culture, highly contentious politics, and economic hardship.

For over a century, local and federal governments have attempted to alleviate the negative effects of drought in the region. 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 (Johnson 1971; Aguiar 1983; Alencar Araujo Filho 1987; and Coelho 1985).

Among the nine states that comprise the semi-arid region of the Brazilian Northeast, Ceará is one of the most vulnerable to recurrent drought. The 1997-1998 El Niño-related drought resulted in crop losses of up to 80% in some regions. It also triggered several episodes of social unrest, such as land invasions by landless peasants, riots, and the migration to cities of families affected by drought (The Economist 1998).

The vulnerability of rural populations to climate variability is not surprising considering the significant role of agriculture in the region. Although in normal years, the agricultural product comprises only around six percent of the total state GDP, approximately 40% of the economically active population rely on agriculture for employment (SEPLAN 2000). Thus while agriculture has progressively lost its economic importance, it still has tremendous social impact, especially among the poorest segments of the state population.

Through history, scientists and laymen have sought effective tools and procedures to predict the onset, duration, and intensity of droughts. States highly dependent on agriculture were particularly concerned with the destabilizing and economically crippling effects of droughts. In such cases, climatic factors clearly comprised an important part of central planning. Now, with major scientific advances in forecasting capability, governments are acquiring the ability to base their decisions on greater predictability of climate. In recent years, climate modelers have been able to use the onset of the El Niño phenomenon to forecast drought in regions such as Northeast Brazil and Southern Africa up to six months in advance. Repeated success in these predictions (1986 and 1991) has encouraged the research community to expect that the forecast accuracy and reliability would significantly improve in the following few years (Glantz 1994). However, if we expect information such as seasonal climate forecasting to realize its full potential as a policy tool, we need to better understand how this information is being used in diverse policy environments, which in turn is critical to the promotion of capacity building, both for science and policymaking.

This study sought to understand how seasonal forecasting—particularly the El Niño/La Niña forecasting—can be used by policymakers and end users to mitigate the negative impacts of climate-related hazards. To accomplish this task, this research adopted a multidisciplinary approach to investigate:

(a) the applicability of current seasonal climate forecasting to different users in Ceará—its limitations, constraints, advantages, and possibilities—and the potential for improving its use in the near future;

(b) the socioeconomic profiles of potential users of this information through a careful assessment of different levels of vulnerability, adaptability, and the relative ability of households differentiated by size, tenure, technology, and crop mix to respond to seasonal climate variability in six different microclimatic zones;

(c) the process through which seasonal climate forecasts are communicated from scientists to policymakers to end users, the potential for negative outcomes of climate forecast releases, and the ability of different users to use seasonal climate forecasting data as a response to climate variability; and

(d) the process through which policymaking systems adapt to the emergence of new scientific information as research and *Decision-making* tools.

We chose the state of Ceará for several reasons: (1) of all the states in Northeast Brazil, Ceará is the one with the largest part of its territory located within the semi-arid geoclimatic zone, being, therefore, the most physically vulnerable to drought episodes; (2) it was also the first Northeastern state to build up regional climate expertise by expanding the mandate of FUNCEME to include climate forecasting in 1988; (3) the last four state governments have actively pursued reforms to modernize public policymaking–especially with regard to drought response–so as to avoid historic patterns of inefficiency, *clientelism*, and corruption. The government has recently implemented a series of more socially and politically progressive policies which encourage community participation in policymaking (Magalhães and Neto 1991, Tendler 1997); and (4) the use of an ENSO forecast in Ceará during the 1992/93 drought is widely publicized as a successful example of how early climate predictions mitigate the negative impacts of ENSO-related drought episodes (Moura et al. 1992; IAI 1994; Golnaraghi and Kaul 1995; Glantz 1996).

Besides its dedication to this overarching goal, this study contributes to science and policymaking in several other ways. First, by empirically assessing current applications of seasonal climate forecasting, it has the potential to inform policymakers and users of the possibilities and constraints for application of climate forecasting, as well as to provide data producers with information on the users' needs. The responses from applications and social science to the modeling community are essential to a fully integrated and policy-relevant effort in climate prediction and global change research (end-to-end). In this sense, this study may have a direct effect on social and economic planning for the mitigation of negative global climate phenomena, with real benefit to vulnerable groups and societies all over the world. Second, by examining political and cultural aspects of seasonal climate forecast applications in distinct policy environments, this study aims at contributing to analytical frameworks within the policy sciences, such as social constructivism, policy analysis, and the sociology of science. Third, there is a need to document and disseminate case studies—and the lessons therein—of successful and unsuccessful connections between atmospheric science research and societal needs, as well as to understand why research programs sometimes fall short of their societal benefit goals (Pielke 1997).

II. Research Methods and Background

II.1 Methods

The study utilized a mixed methodological approach that included both qualitative and quantitative data collection and analysis. King, Keohane, and Verba (1994:5) emphasize the importance of breaking down the barriers between qualitative and quantitative research on the grounds that "[m]ost research does not fit clearly into one category and the other. The best often combines features of each." Quantitative analysis alone often yields ambiguous causal inferences. This ambiguity can be fleshed out and contextualized when combined with detailed qualitative analysis. Quantifiable data can be examined, compared, confirmed, or infirmed through the data provided by ethnographic studies and detailed personal interviews with stakeholders, end users, and policymakers.

In 1997, the first team of researchers went to Ceará to map the policymaking environment and define further field research. Extensive in-depth interviews were conducted with decisionmakers at several levels of government, including the state governor, officials within the agricultural and drought relief policymaking apparatus (FUNCEME, rural extension, water resources, public works, seed distribution, civil defense), state assembly representatives, local mayors, agricultural and drought-relief policymakers, rural extensionists, and others. These interviews examined both the dissemination of climate forecast data and the policymaking processes related to agriculture, water management, and drought relief. Also interviewed were representatives from rural labor unions, farmers, farmer associations, non-governmental organizations, politicians, journalists, radio personalities, and clergy.

At the state level, the interviews focused mainly on how and when the forecasts are applied, the adequacy of the information for different governmental programs, and policymakers' expectations regarding future applications. At the local, or *município*, level, research focused on forecast communication, local perceptions, and expectations of the information and asked specific questions about agricultural and drought relief programs. The interviews queried the role of individuals in the policymaking process; the strength of the political commitment to drought and agricultural policy, current policies for drought preparation and agricultural policymaking; the role of forecast information during the famed 1992 drought; the overall willingness to use climate forecasts; the perceived constraints and limitations to information use; the perception of the accuracy and timing of the forecasts; and the costs associated with error and perception of error in the forecast.

To represent the use of forecast information by farmers, in 1998 the team interviewed 484 households in six different *municípios* (Limoeiro do Norte, Barbalha, Boa Viagem, Parambu, Guaraciaba do Norte, Itarema) located in six different microclimatic zones (see details below). The interviews were conducted by a team comprised of individuals, both faculty and student, from the University of Arizona (UA), the Federal University of Ceará (UFC), and FUNCEME. Besides collecting background information on different levels of vulnerability and coping strategies among farmers, the interviews focused on individual perceptions of climate forecast information including levels of uncertainty and risk, perceptions of FUNCEME as a forecast provider, the value of "scientific" forecasts vis-à-vis traditional methods of drought forecasting, and local participation in public drought relief and agricultural support programs. The research team also sought to assess the local level of trust in the government in general and in specific agencies such as FUNCEME and the Ceará State Extension Agency (EMATERCE). Finally, the team carried out documentary and newspaper archives research (especially for general perception of FUNCEME's forecast), including institutional materials, FUNCEME's publications, and forecast releases.

In each *município* approximately 80 families were interviewed. The vast majority of these families resided on farms. In some cases, the team interviewed families residing in towns, but which either owned or leased the farmland they cultivated. During the rapid appraisal in 1997, lists of farmer associations were collected containing names and sub-regions of the farmers in the *municípios.* Almost all of the farmers belong to an association or collective, through which they have potential access to governmental programs, such as credit and development assistance. When it is time to enroll for pension benefits membership also serves as a form of proof that a person has been involved in farming. Thus, it was felt that use of these lists would provide a nearly comprehensive pool from which to draw the sample randomly. Local health workers or other local representatives familiar with the families were used as guides.

These household interviews were followed up in August of 1998 and again in the early part of 1999. The summer of 1998 was the middle of one of the worst droughts in decades and brought about a large influx of national and state level resources to combat the severe impacts that the lack of a harvest, and continued lack of water were having on the population. Informal interviews were carried out with some of the families from the original sample to develop an increased understanding of both drought impacts at the household level, as well as the coping strategies employed. Interviews were also conducted with some of the region's large *fazendeiros* to gain insight into how producers with access to greater levels of resources utilized forecast information in making strategic decisions.

The return in 1999 was similar in intent, though the situation was different. The first rains were falling, farmers had begun to plant, and the government relief programs were winding down. In the spring of 2000, additional 120 formal interviews were conducted in the *municípios* of Boa Viagem and Limoeiro do Norte, *municípios* that were felt to represent best the range of agricultural, climatic, and socio-economic indicators. Of these households 54 were previously interviewed in 1998. The purpose of these interviews was two-fold. First, systematically capturing the unfolding of strategies and responses over 3 years gave insight into the dynamic nature of vulnerability. Second, while the 1999 agricultural season started out strongly, for many it ended up as a continuation of the 1997 and 1998 drought and allowed for study of the impacts of a multi-year drought.

A principal component of this study is based upon human perception and cognition. This required the incorporation of both quantitative and qualitative data in questionnaire design. The first was used for compilation and analysis of the quantitative data. This data set has several applications including an overall description of the sample population. Demographics, income, assets, and land holding data were used to provide baseline descriptions and help to provide a backdrop to the policymaking settings. In addition, this data allowed for the discrimination of vulnerability levels within the sample.

The qualitative data was introduced into a database specifically designed for manipulation and analysis of this data type. The database includes transcriptions of the interviews with the policymakers and government officials as well as questionnaire responses from small farmers and ranchers relating to the areas of climate information access and use, credit histories, coping strategies, and impacts of drought.

Through the development of a qualitative database, two types of analyses were possible. First, comparisons of policy makers' viewpoints in the differing policy sectors were made. For example, questions such as how do policymakers in the regions respond to different stakeholders such as politicians, business, and agriculturists, how do policymakers perceive seasonal climate forecasting as policy tool, and how does policy implementation integrate feedback from data users. In addition, vulnerability groups were compared in relation to perceptions and actions, to give critical insight into how mitigation strategies can be made more effective for the target populations. Second, the qualitative and quantitative databases were integrated. The combination of these data allowed for detailed descriptions of the different sections of the population in terms of access and response to forecast information and the overall impact of government intervention through the fleshing out of the discrete, descriptive variables. This made possible a more comprehensive understanding of the interactions and relationships between scientists, public policymakers, and farmers.

II.2 The Study Site and population

The state of Ceará is highly diverse in terms of agro-ecological climate. Physical characteristics range from humid coastal and mountainous regions to semi-arid *carrasco* lands and the *sertão central*. From each of the climatic regions of the state, a representative *município* was selected. *Municípios* were selected not only based on variations in rainfall but also to address issues of how responses are affected given different crop and livestock selection, as well as access to irrigation. Figure 1 locates the state of Ceará within Brazil; Table 1 provides basic characteristics of the six microclimatic zones sampled in 1997.

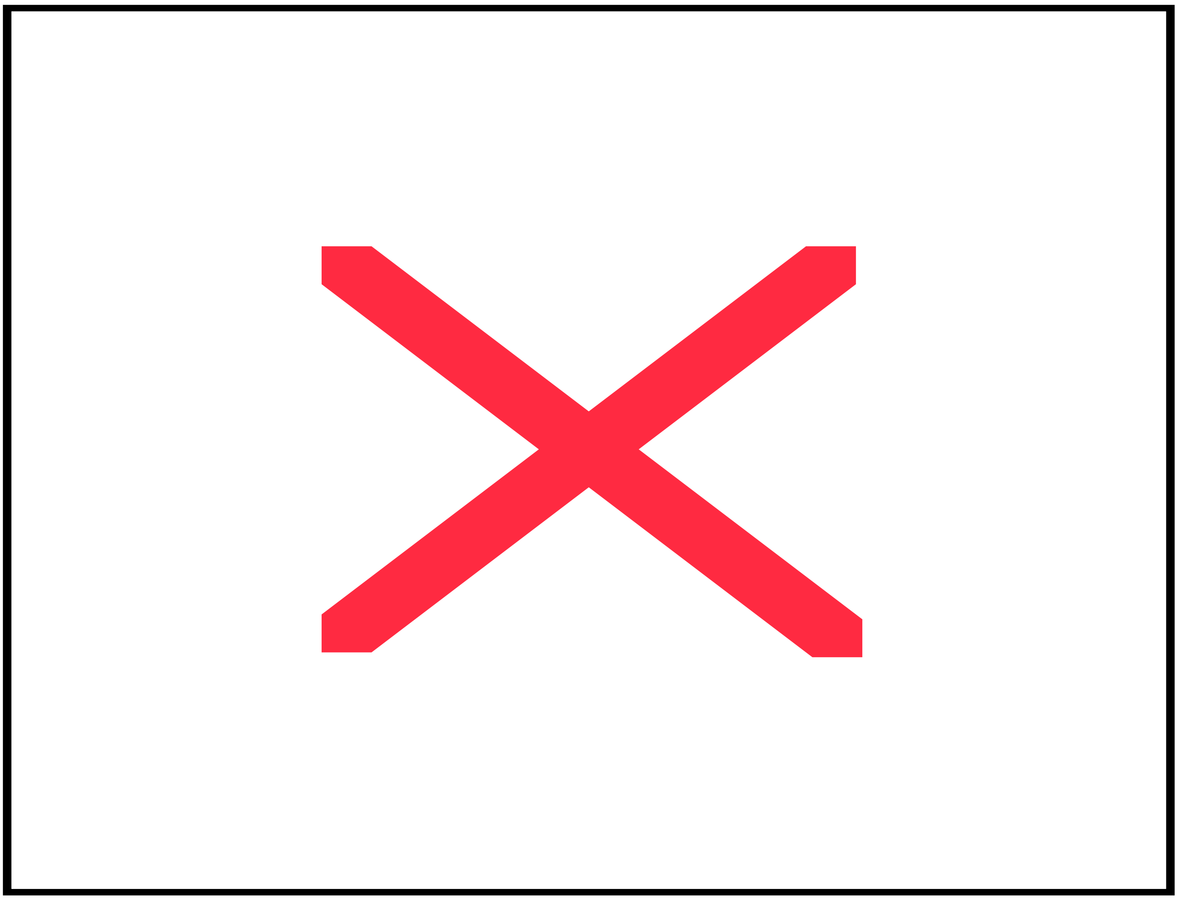


Table 1: Basic Characteristics of Selected *Municípios*

Município	Population *	N Rural Households*	N Sampled Households	Area (Km_)*	Microclimatic Region
Limoeiro do Norte	45,088	4265	81	771	Vale do Jaguaribe
Barbalha	43,296	3138	82	452	Cariri
Parambu	30,948	4298	80	2440	Inhamuns
Boa Viagem	47,751	6848	80	2738	Central *Sertão*
Itarema	25,793	3078	80	738	Litoral Norte
Guaraciaba do Norte	31,982	4245	81	537	Serra da Ibiapaba
Total	**224,858**	**25,872**	**484**	**7676**	**n.a.**

Source: IBGE 1996

In Table 1, Limoeiro do Norte represents the region of the Jaguaribe Valley, an area conducive to development of an intensive agriculture due to the existence of the perennial Jaguaribe river. The *município* is comprised of three distinct sub-regions, the *chapada do Apodí,* irrigated highlands, the *várzea* or lowland*,* and the *caatinga* one of the driest areas of the entire sample. Barbalha represents the Carirí region where the rains of Ceará generally initiate and are more abundant than in most of the state. It also contains three sub-regions, the *chapada do Araripe* a humid highland area, the *chapada "arisco",* highlands that have sandy, poor soils, and the *brejo,* which is a low-lying humid valley. Parambu is located on the western side of the state and represents the *Inhamuns* region, the driest area of the state. It is characterized by two sub-regions; the *sertão,* the drier, more populated region, and the *serra* mountain region, which receives higher rainfall, but has a lower population and limited sources of ground water. Boa Viagem represents the *sertão-central*, a hilly, dry region that occupies the largest part of Ceará. Guaraciaba do Norte, is located in the highest part of the *Serra da Ibiapaba*, in western Ceará. It is comprised of two sub-regions, the humid plateau, and the semi-arid *carrasco*. The humid region is one of the wettest of the sample and is distinguished by a high level of irrigated horticulture. Itarema is located on the northern coast of Ceará and is characterized by two sub-regions, the coastal area and the interior *sertão*. Fishing frequently complements coastal crop production, and the area receives higher levels of precipitation than the neighboring *sertão*.

III. Ceará, Northeast Brazil

III.1 Physical and Socioeconomic Characteristics and Indicators

The state of Ceará lies on the northern coast of the Brazil and covers 146,817 square kilometers. The majority of the state falls within the semi-arid region of the Northeast known as the *sertão*. The average temperature for the state is 26 degrees Celsius with an annual rainfall between 400-800 mm concentrated within a three to four month period between December and March (Sustainable Development Plan of Ceará, Brazil 1995-1998, p. 22). This period corresponds roughly to the state's planting season and is popularly referred to in the region as "the winter" despite corresponding to Brazil's summer months. While virtually all of Ceará is characterized as semi-arid, there is in fact substantial variability from one region to another, as annual average rainfall data from the *municípios* sampled for this study—Limoeiro, Barbalha, Parambu, Boa Viagem, Itarema, and

Guaraciaba do Norte— demonstrates in Table 2. Although most soils are fertile, effective agricultural use is limited because the soils are also shallow, impermeable, non-porous and lacking in water resources. The state's geography is quite diverse with large areas of coastal low-lands and intermediate zones of the *sertão* and highlands mostly covered by desert-like vegetation (*caatinga*). The main rivers are Jaguaribe, Acaraú, Curu, Poti, Coreaú, Pirangi, Chorό, and Pacoti which divide the state into 11 hydrological regions (Coreaú, Acaraú, Aracatiaçu, Curu, Metropolitana, Poti, Banabuiú, Baixo Jaguaribe, Médio Jaguaribe, Alto Jaguaribe e Salgado) from which most of the water for agriculture and consumption originate since the state has scarce ground water resources.

III.2 The Nature of Rainfall in Ceará

The climate of Ceará is characterized by highly variable rainfall, both spatially and temporally. Because little of the region's agriculture, 15% of the sample, is irrigated, a vast majority of the producers are entirely dependent on rainfall for production of subsistence crops. Most years, excepting a few highly productive seasons, are marked by a period of hunger. It is rare that the amount of food produced by a family is enough to get them through to the next harvest. In years where there is little to no harvest, this period of suffering is extended and remedied only through government intervention.

The spatial variation of rainfall is demonstrated in Table 2, which shows the inter-annual variation in rainfall by sample *municípios*. Average precipitation ranges from 532mm in Parambu to more than twice that in Guaraciaba do Norte. The highly divergent precipitation levels are significant factors in determining crop and livestock production strategies between the various *municípios*. Those *municípios* such as Parambu and Boa Viagem with low levels of rainfall tend to focus more heavily on cattle production, while Guaraciaba do Norte and Barbalha produce a greater level of water intensive, cash crops.

The table also demonstrates the impressive temporal variation, evident through the wide range of precipitation totals from year to year. In most of the sample *municípios* maximum rainfall is more than twice the average, and the minimum is less than half the average. Most of the *municípios* have lower than average rainfall between 60% and 70% of the time. The fact that a significant majority of the years are below average is an indication not only of the wide range of rainfall but the fact that what are considered normal years are consistently difficult. One factor not apparent from the table is the level of variability within each of the *municípios*. Ecological and climatic features tend to vary widely within a limited geographical area. Precipitation totals are collected from a restricted number of rain gauges, that are not systematically dispersed, and averaged over the entire *município*. In fact, Limoeiro do Norte, with two collection stations, is the only sample *município* with more than one. The *município* however, is comprised of three distinct agro-climatic regions, which results in a large amount of intra-*município* variation being ignored because the daily and monthly precipitation data neglects to distinguish between these diverse areas. As a result, it is possible that the drier, more arid part of the *município* can suffer from lack of rainfall, but can go unnoted at the state level due to good, consistent rains throughout the rest of the *município*.

While the inter-annual variation is significant and is used on a statewide level to officially declare a drought, the timing of the rain also has a very telling impact on rainfed agriculture. Ceará generally receives 4-5 months of rain per year. (See Figure 2). Depending on the location, the rains begin in January and continue throughout April or May. Planting begins in January and if no rains have fallen by March 19, the day of Saint Joseph, farmers consider the year a drought year. Even years with ample rain, however, can negatively impact harvest production. Table 3 demonstrates the average temporal rainfall distribution on a monthly basis for a full year. It is evident that the bulk of rain normally falls in March and April, and yet due to the nature of rainfed agriculture if no rain falls for a period of time (*veranico)* during a critical phase of the development of a crop, the impact is the same as if there had been no rain at all. Figure 3 reveals the variation in March rainfall for the state, which ranges from 104 mm to 372 mm. Due to the capricious nature of the rains farmers are accustomed to having to replant some or all of their crops almost every year

Table 2: Annual Rainfall Totals (mm) by Selected *Municípios*, 1974-1998

	Município						
	Limoeiro do Norte	**Barbalha**	**Parambu**	**Boa Viagem**	**Itarema**	**Guaraciaba do Norte**	**Ceará**
1974	679	1461	n.a.	1068	2362	1598	1579
1975	871	1235	n.a.	992	1051	1605	1141
1976	532	681	n.a.	411	938	973	793
1977	1060	930	n.a.	833	1112	1373	1107
1978	914	1168	266	548	1196	933	854
1979	702	1390	475	460	441	1050	680
1980	824	920	555	350	347	785	785
1981	693	571	554	693	631	978	662
1982	602	564	487	593	969	867	707
1983	321	753	328	262	464	416	433
1984	1289	1092	923	911	1296	1536	1119
1985	1624	2148	2237	1371	2887	2602	1891
1986	1310	1139	1114	973	1861	1961	1317
1987	735	876	514	454	1041	1156	739
1988	849	1321	814	869	1700	1428	1161
1989	990	1567	1379	1122	968	1627	1266
1990	425	791	494	550	689	1000	627
1991	430	926	584	499	1281	1301	776
1992	592	973	428	679	693	1008	694
1993	286	744	490	184	616	484	420
1994	684	1063	1016	761	1714	1780	1167
1995	933	1059	767	751	1548	1462	1083
1996	760	1529	624	668	1491	1422	1067
1997	410	856	644	537	689	1259	709
1998	313	759	344	395	923	714	493
Mean	721	1153	532	704	1140	1273	946
Min.	286	564	266	184	347	416	420
Max.	1624	2148	2237	1371	2887	2602	1891

Source: FUNCEME 1999
n.a. indicates no data available

Table 3: Historical Monthly Rainfall Averages (mm) 1974-1998

Month	*Município*					
	Limoeiro do Norte	Barbalha	Parambu	Boa Viagem	Itarema	Guaraciaba do Norte
January	73	177	71	57	28	133
February	130	198	79	99	58	193
March	207	244	166	159	139	330
April	158	209	153	164	114	250
May	92	52	38	85	52	151
June	46	15	17	52	16	75
July	18	9	5	25	10	33
August	2	2	2	5	2	8
September	2	9	5	5	0	3
October	1	23	5	0	0	6
November	3	46	17	2	0	17
December	22	78	43	25	3	54
Yearly Mean	721	1153	532	704	1140	1273

Source: FUNCEME 1999

Figure 2: Average Monthly Rainfall for Ceará (mm)

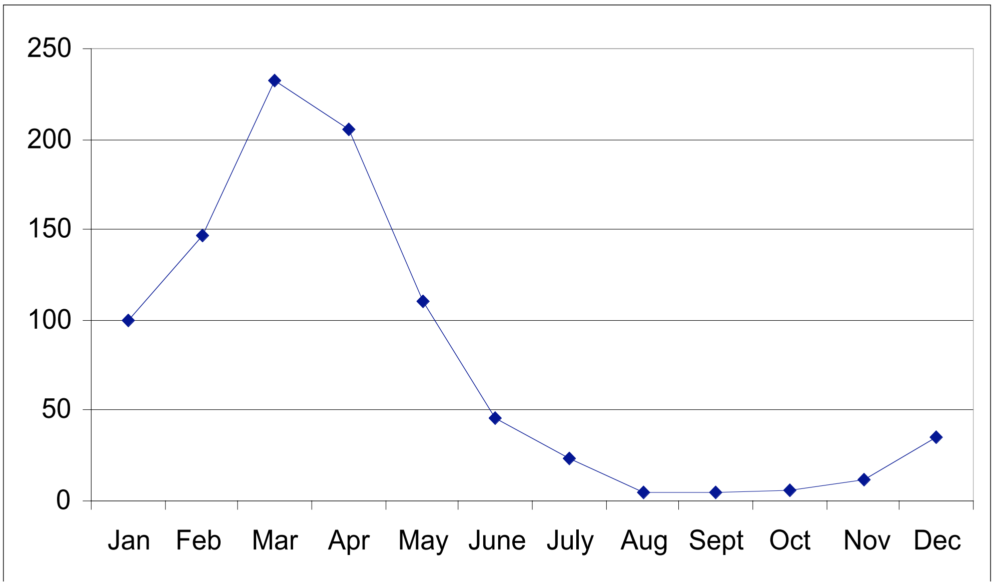
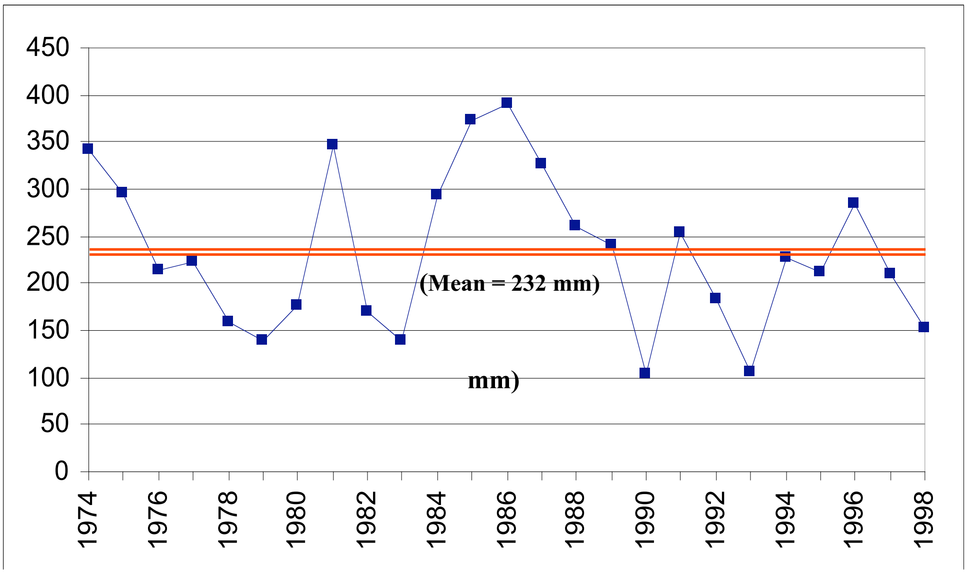


Figure 3: Average March Rainfall for Ceará (mm)



III.3 State Economic Activity

As mentioned above, in the state of Ceará, as in most of the Northeast, the economic contribution of agriculture to the overall economy is low, but the percentage of the economically-active population in agriculture is high, a particularly strong indicator of the levels of rural poverty. Almost 80 percent of the approximately three million rural inhabitants in the state are employed in agriculture and livestock activities (SEPLAN 2000).

Tables 4 and 5 show the structure of economic sectors and the variation in the distribution of employment based on activity sectors in Ceará. Local rural livelihoods are based on the small-scale subsistence farming of staple 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 percent 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.

Table 4: Structure of the Economy by Sector

Sector	1985	1990	1998
Agriculture and Livestock	15.32	12.13	5.32
Industry	34.01	33.75	37.44
Services	50.67	54.12	57.24
Total (In Millions R$ 1998)	11,737	14,167	18,525

source: IPLANCE 1998

Table 5: Changes in Employment by Activity Sector

Sectors	1985/1990		1990/1995		1995/1998		1998/1985	
		%		%		%		%
Agriculture	-114.485	-12.14	341.993	41.26	9.072	-7.61	138.436	14.68
Industry	5.384	1.13	1.396	.029	51.518	10.65	58.298	12.22
Commerce	79.228	36.25	77.469	26.02	10.124	2.7	166.821	76.33
Services	221.974	35.53	130.311	15.39	35.091	3.59	387.376	62.00
Others	-5.764	-15.64	1.998	6.43	396	1.2	-3.3370	-9.14

source: IPLANCE 1998

In 1999, the state's population surpassed 7 million people of which approximately 67% live in urban areas (IPLANCE 2000). Although Ceará's economy is ranked 11th in Brazil, the state has the highest relative poverty rate in the country (Carvalho et al. 1993: 13) with a per capita GDP of approximately US$ 1,250. This value corresponds to 50% of the national and 101% of Northeast Brazil levels (IPLANCE 2000). Despite high levels of poverty, for the past ten years, Ceará has been undergoing a remarkable political and socio-economic change that has critically affected its social indicators and policymaking process. In 1997, for example, while Brazil's growth rate was 3.2%, Ceará's growth rate was 4.5%. Other indicators show the general improvement of living conditions in the region. In 1997, the state's GDP was US$ 9 billion (2.02% of Brazil's GDP) of which 6.3% originated in the agricultural sector, 38.1% in the industrial sector, and 55.6% in the service sector.

This positive change can be partly explained by broader processes of democratization in Brazil and concerted efforts from progressive politicians in Ceará—especially at the higher echelons—to improve public policymaking implementation. Recent research on policymaking in Brazil has identified Ceará as a case where policymakers have achieved a significant level of success while carrying out public policies (Tendler 1997, Carvalho et al. 1993). These studies have pointed out several conditions found in successful policy implementation that challenge frequent assumptions about traditional policymaking processes in Northeast Brazil. For example, Tendler (1997) found that in Ceará dedicated civil servants, who become increasingly empowered by their ability to affect policy implementation, can bypass local patronage practices with the support of a progressive state

Table 6: Selected social indicators

Indicators	1985	1998
Infant Mortality Rate	106.0	38.9
Illiteracy Rate	40.4	29.5
Rate of Primary School Completion	56.4	98.6
% of Rural Households	12.1	7.4
% Houses with Running Water	31.6	56.8
% Houses with Garbage Collection	26.7	57.7
% Houses with Electricity	53.0	80.3
% of People over 10 that receive at least _ the minimum salary	20.2	6.7

source: IPLANCE 1998

government. Moreover, demand from "intermediate users" such as governors and other public officials can also play a pivotal role for policy implementation success (Tendler 1993). In a study focusing on agricultural policymaking in Northeast Brazil, Tendler (1993) found that pressure from higher-ranked officials drove agricultural research and extension personnel to concentrate on problems relevant to the region's more immediate needs. Finally, policies are also more likely to succeed with support from higher ranked state officials (Tendler 1993, 1994). This seems to be the case behind Ceará's impressive improvement of social indicators in the last 15 year as shown in Table 6.

III.4 ENSO and Drought in Ceará

The impact of ENSO on precipitation in Northeast Brazil, including Ceará, is two-fold: while rainfall is dramatically reduced during the warm phase of an ENSO episode (El Niño), abundant rainfall occurs over the region during the cold phase (La Niña). These droughts and floods can cause large disruptions in the region's economy. Although droughts in Ceará and Northeast Brazil also occur when there is no ENSO episode underway, the severest drought episodes occur when there is an El Niño event. This makes ENSO prediction a potentially important tool in the forecast of extreme drought events (Kousky et al. 1984).

Precipitation over Northeast Brazil is also modulated by the movement of the intertropical convergence zone (ITCZ) (Lough, 1986) and by the variability of the Atlantic SST (Moura and Shukla 1981). The main physical process responsible for the modulation of precipitation in the northern region of Northeast Brazil is the movement of the ITCZ. In normal years, the ITCZ migrates from its northernmost position (around 10 N) in August, to its southernmost position (over the northern region of Northeast Brazil) in March. During anomalously dry years, the ITCZ does not reach Northeast Brazil in its southward migration. Since the ITCZ is part of the atmospheric global circulation, the extent of its annual migration and its strength are modulated by global-scale weather phenomena such as ENSO and Atlantic Ocean SST anomalies (Hastenrath and Heller 1977, Nobre et al. 1984). Anomalously high rainfall rates, in turn, seem to occur when the sea surface temperature (SST) is high south of the equator but is colder further north. The variability of the Atlantic Ocean SST is not related to ENSO, but it resembles the ENSO variability in many respects (Katz et al., 1986).

Concerning the southern region of Northeast Brazil, the northward penetration of cold fronts is the main physical process responsible for the modulation of precipitation (Kousky 1979, Nobre and Molion 1988). These events are also influenced by global scale phenomena, such as ENSO, and therefore, are subject to large interannual variability. Additionally, the main physical process responsible for the coastal precipitation maximum in Northeast Brazil is sea breeze fronts (Kousky 1979, Cavalcanti 1982). Local topographic features also play an important role in determining the precipitation field in the coastal region (Ramos 1974). Finally, the Madden Julian Oscillation (MJO) weakly modulates precipitation over Northeast Brazil (personal communication by Silva Dias, 1996). Therefore, an operational forecast of precipitation anomalies over Northeast Brazil must take into consideration the effects of ENSO, Atlantic SST patterns, ITCZ movement, and MJO.

ENSO is a reasonably well understood global phenomenon which strongly modulates precipitation in Northeast Brazil. Out of seventeen El Niño episodes between 1906 and 1985, sixteen coincided with anomalous dry years in Northeast Brazil (Ropelewski and Halpert, 1987). The connection between ENSO and local weather anomalies was identified almost seventy years ago (Walker 1928), but only recently have efforts to forecast El Niño onset shown some success. Twenty years ago it was not possible to make accurate ENSO predictions. Indeed, it was not even possible to know, with reasonable certainty, when an El Niño episode was underway (Moura et al. 1992). Since then, theoretical and modeling studies have led to substantial improvement in ENSO forecasting. El Niño onset predictions, for example, are made based on the initial state of the ocean. In order to improve the knowledge of the initial state of the ocean, an array of meteorological and oceanographic instruments has been deployed throughout the Pacific (The Tropical Atmosphere Ocean moored array). Moreover, a new generation of atmosphere-ocean interaction models, which can take advantage of the extensive observational data network, has been developed. These models have the potential to substantially improve ENSO forecasting.

The temporal variability of precipitation over Northeast Brazil is very high. Positive precipitation anomalies of about 200 percent of the long-term mean value and negative anomalies of nearly 100 percent are not unusual (Kousky et al. 1984). The causes for this great interannual variability are still not well understood, but there is evidence that ENSO plays an important role. Moreover, the spatial variability of precipitation in Northeast Brazil is also very high. Many times one region experiences drought while another experiences a rainy season wetter than the normal. The cause for this spatial variability is the fact that regional precipitation in Northeast Brazil is modulated by different physical processes.

Kousky (1979) showed the existence of different rainfall regimes for various regions of Northeast Brazil. In the northern portion of the region, which includes the state of Ceará, March is the month of maximum precipitation. In the southern and southwestern portions of the region, December is the month of maximum rainfall. The coastal region south of 5 S receives maximum precipitation during the month of May. Regions of overlap, such as the central and coastal regions of the state of Bahia, present a double maxima in the temporal distribution of precipitation.

Although the ability to forecast ENSO episodes has been steadily improving, the potential for inaccuracy is still quite high (Glantz 1994) and the relationship between the ENSO forecast and local climate is not yet fully understood. In order for an early ENSO forecast to be useful to policymakers, it has to be not only accurate and reliable but also applicable to specific regions.

III.5 Ceará and Drought Policymaking: Historical Response to Drought

In Northeast Brazil, reports about devastating drought episodes trace back to the first Jesuit missionaries who arrived in the region in the late 1500s. From 1877-79, a severe drought resulted in widespread famine in which 500,000 people (4% of the Brazilian population at the time) might have died and 3 million migrated from the region (Villa 2000:83). More recently, the drought of 1979-83 affected eighteen million *nordestinos* (as people from Northeast Brazil are known) and the government (local, state, and federal) spent approximately US$1.8 billion in emergency programs (Magalhães, et al. 1988: 293).[1]

For over a century, local and federal governments have attempted to alleviate the negative effects of drought in the region.[2] Historically, the literature describes five main governmental approaches to drought: the naturalistic approach, the engineering approach, the ecological approach, the development approach, and the social differentiation approach (Magalhães et al. 1988, Pessoa 1987). The basic difference between each of these approaches lies in the way their proponents define the root of the drought problem in Northeast Brazil.

The naturalistic approach, following the great drought of 1877-79, marks the beginning of government support for studies, discussions, and publications related to droughts in the Northeast Brazil (Pessoa 1987). In 1856, Emperor Pedro II of Brazil created the first governmental commission to study the drought problem in the Northeast and make policy suggestions (Ministério do Interior 1981). Because drought at the time was perceived mostly as a consequence of water shortage, the solution focused on the construction of massive waterworks–especially reservoirs–which at the same time would alleviate water scarcity and employ large numbers of local residents whose main economic activity, agriculture, had been negatively affected. Additionally, the Commission recommended the construction of railways, the construction of an extensive canal that would redirect water from the São Francisco River to the Jaguaribe River region in Ceará (Carvalho, et al. 1993), and the creation of the first meteorological observatories in the region. By 1910, Northeast Brazil had 124 rain gauges and 4 hydrometer stations installed. Here, the first of many technology-based tools made its way through the region's drought-relief policymaking process.

[1] The most recent drought even from 97-99 caused an almost 80 percent loss of crop yields in some parts of the Brazilian Northeast and resulted in considerable social unrest. For example, in the town of Baturité about 500 rural workers occupied the municipal capital building to demand water trucks in their communities and employment in work fronts in early 1997. In José Milton Rocha, "Prefeitura de Baturité é ocupada por agricultores," O Povo (Fortaleza, Ceará), 8 March 1997.

[2] These policies ranged from the sublime–such as the distribution of food baskets among poor families affected by drought– to the bizarre as exemplified by the importation of 14 camels from Northern Africa to work as farm animals in Ceará in the late XVIII century. For an interesting description of the history of drought and government response, see Villa 2000.

Such as the naturalistic approach, the engineering approach (1877 to ca. 1950) focused on water supply as the solution to drought-related problems (Magalhães et. al 1988). During this phase, the government saw drought as a shortage of water for consumption (human and animal) and cultivation. Policymakers identified storing water during years of normal rainfall for later use as the solution and emphasized the building of dams to solve the problem of drought. The first large public dam (Cedro Dam) was constructed in Quixadá, Ceará between 1881 and 1906. Then, in 1909, a drought-fighting bureaucracy was created: the Federal Inspectorate for Works Against Drought (IFOCS), which later became the National Department of Public Works and Drought Relief (DNOCS) (Frota, 1985:183). The major intent of DNOCS was to build the water supply infrastructure consistent with this technological approach (Magalhães, 1993: 193). However, in Ceará, these reservoirs did not engender a major expansion in irrigated agriculture, and where large projects were introduced, they were beset by organizational and technical problems.

The ecological approach, adopted in the post-war era marked a significant change in the perception of drought. In this approach, instead of fighting drought, policymakers sought to adapt to it. Policies were created which emphasized the need to adjust agricultural practices to the semi-arid environment (Pessoa 1987). New crops were introduced that were more resistant to drought and farmers were advised to adapt to the ecological conditions of the semi-arid region by planting hardier varieties of crops (Magalhães and Glantz 1992: 61) and increasing their cattle ranching activities.

The next phase, the development approach (mid-1950s to 1975) – also known as the industrial phase – proposed that the roots of drought-related problems in the Northeast Brazil originated in the region's economic underdevelopment and dependence on the central-southern part of Brazil. To solve the drought problem, policymakers implemented industrial policies such as the creation of the São Francisco Hydroelectric Company (CHESF) to provide the energy for industrial development in the Northeast. Between 1950-1970 three major organizations were established to initiate and manage the regional modernization effort: the São Francisco Valley Development Company (CODEVASF) installed a major irrigation program along the São Francisco River; the Northeast Development Bank of Brasil (BNB) was created to provide the financing, much of it under subsidized credit programs; and the Northeast Development Agency (SUDENE) provided the overall management apparatus and oversaw the different development initiatives. As Frota (1985: 265-84) points out, the modernization push did little to reduce the consequences of drought, primarily because the majority of the rural population did not have access to the programs. Still within the aegis of Brazil's military government's developmentalist mentality, in 1970, another major drought compelled the government to reduce the population of the region through out-migration to the sparsely-settled Amazon. The Transamazonian highway system was constructed to channel the movement of people and goods, and in fact some families migrated out of the Northeast.

After 1975, adopting what has been called the social differentiation approach, policymakers sought to increase the resource base of small farmers by creating programs to fight rural poverty, such as POLONORDESTE, Projeto NORDESTE, and Projeto ARIDAS (Pessoa 1987).[3] Various agrarian reform programs were designed to reduce the concentration of land resources and the overwhelming numbers of landless farmers. During the 1980s, investment in the rural economy was expanded with major World Bank financing of a series of integrated rural development projects. These intensive efforts specifically targeted smallholder agriculture and involved the institutional collaboration of SUDENE (as manager), BNB (as financing agent), and the DNOCS (for technical support). The projects centered around sustainable socio-economic development as a method of reducing vulnerability to drought throughout the Northeast through access to water resources, credit, promotion of non-agricultural income sources, education, and health care (Magalhães, 1991:32-33). In the state of Ceará, several irrigation projects in the Jaguaribe Valley were developed under DNOCS during this period.

Notwithstanding the efforts of different governments to implement the wide range of drought-related policy described above, the expansion of the water supply system remained a focal point of drought-relief policymaking in the Northeast. Indeed, between 1884 and 1983, DNOCS built 1,121 dams, exceeding 15 billion cubic meters of water capacity (IBGE, 1984 cited in Pessoa, 1987).

[3] For a detailed description of these projects, see Magalhães et al. 1988.

While technology has provided the long term strategy for eliminating the impacts of drought, emergency relief has typically relied upon a class-based power structure, weaving drought assistance into a patronage system that has plagued this society since its inception. Through the years, "the drought industry"—as the drought-relief public policymaking apparatus is known in Brazil—has been continually plagued by charges of political manipulation, *clientelism*, and corruption (Tendler 1997, Villa 2000).[4] Early on, powerful local groups "captured" the drought-relief policy apparatus, which mostly benefited large landowners and local political bosses. Thus, "the infamous drought industry of the Northeast effectively concentrated federal subsidies. Workers on the public payroll built dams, irrigation channels, or roads and other facilities for big landlords, either on private land, or on public land but to benefit giant private livestock holdings" (Goldsmith and Wilson 1991: 446). Additionally, by helping to curb out-migration, emergency work fronts were often used as a tool to guarantee the region's availability of cheap labor.

The principal strategy of emergency drought relief since the beginning of the century has been that of public work fronts (*frentes de trabalho*), which continue to be a national symbol of suffering. Traditionally, the organization of these emergency relief programs was decidedly vertical and linear. Local officials informed the state government of critical levels of deprivation, which then was relayed through political channels to the federal government. Once crisis was declared, resources were then released at the federal level to move back down the structure to the state, to the *município*, to the *flagelados* (drought victims). In recent years, the National Civil Defense Agency has managed disaster control through regional coordination by SUDENE and state coordination by the State Civil Defense Agency (CEDEC). Federally allocated funds employ rural individuals on projects of public interest, predominantly the construction of roads, dams, schools, and so forth. Beneficiaries of the program receive a minimal salary, calculated as enough to guarantee the food security of rural households, albeit at basic survival levels.

In part, the top-down and weighted bureaucracy responsible for drought relief created organizational constraints that slowed the flow of resources and information to drought victims. More seriously, however, the large influx of money into drought-affected regions engendered widespread corruption and political manipulation of the suffering populace. Evidence abounds of work fronts clearing land or building dams on private *fazendas* (large landholdings), of phantom workers registered on the fronts, of non-existent tanker trucks contracted to deliver drinking water, of families not included in the program because of their local political affiliations. In effect, as these funds filtered into the local power hierarchy, they reinforced the clientelistic essence of rural society. Under these programs, the anguish of the masses fueled the profits of the more powerful, and at the end of a crisis, the relative positions of the advantaged had been strengthened.

Over the past fifteen years, however, the approach to emergency drought relief changed substantially. During the 1987 drought, with the Brazilian democratization process in full swing, Ceará's first openly reformist government dramatically changed drought-relief policymaking.[5] Rather than short-term actions, the state government decided to focus on long-term projects associated with communities. As mentioned above, new programs such as POLONORDESTE and Project NORDESTE emphasized rural development and alleviation of poverty through agrarian reform, creation of irrigated zones, development of hydrographic microbasins, rational water management, development of micro and small businesses in the interior, education, basic rural health and sanitation, agro-industry, rural extension, creation of food security programs, community development, etc. (Magalhães 1991: 33).

These programs intended to strengthen the resistance of the rural population to drought by stabilizing production for the small farmer. Along with a focus on long-term solutions to drought,

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[4] Although the expression "drought industry" had been in use since the XIX century, it became a symbol of everything that was wrong with drought policymaking after Brazilian journalist Antonio Callado used it in a series of influential articles published in 1958 to describe the misappropriation by elites of public funds earmarked for drought-relief. In Villa 2000.

[5] For the past fifteen years, the state government in Ceará has gone from an entrenched oligarchy of a few traditional political families to the most progressive state government in the Northeast. The shift started in 1987 with the election of Tasso Jereissati as governor, his succession by Ciro Gomes in 1991, Jereissati return to power in 1994, and reelection in 1998.

government programs also encouraged more community involvement in the *Decision-making* process. However, many of these initiatives never left the planning stage while others either only partially achieved their goals or failed altogether. Consequently, large segments of Ceará's poor remain significantly vulnerable to climate variability (Lemos et al. 2001).

One exception was the implementation of emergency drought-relief policies. For the first time, Ceará's government created a centralized structure for drought response that coordinated the efforts from all areas of the state government (Carvalho 1993). This structure, organized under the state department for Social Action (SAS), was a departure from the *clientelism*-infested policy structure of the past.

From the early 1990s on, adhering to a new philosophy of drought policy, the Productive Work Fronts Program (PFPT) embodied two major changes over past efforts. First, it sought to identify and pursue permanent public works directed to community use. Second, the PFPT 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: 114). These councils reduced the influence of traditional patterns of *clientelism* and corruption common in the implementation of emergency policies. Work for PFPT concentrated on the restoration and construction of hydrological infrastructure, mainly dams, wells, and water harvesting structures. Table 7 shows the impact of emergency programs from 1987 to 1993.

Table 7: Drought-relief Emergency Programs in Northeast Brazil from 1987-1993

Years of Drought	Number of *Municípios* Reached	% of Total Number of *Municípios*	Rural Population Reached	% of Total Rural Population
1987-88	1,287	79.9	15,632,173	91.8
1990	780	48.4	9,075,113	53.3
1991	775	48.1	8,849,577	52.0
1993	1,151	96.5	11,636,020	68.3

SUDENE. Coordenação de Defesa Civil. (Carvalho, et al. 1993)

The most innovative aspect of the new policy approach was the creation of local, community-based emergency committees and the design of new criteria for the kind of works and workers that would qualify for funding (Tendler 1997). The new Community Action Groups (GACs) became the focal point for *Decision-making* regarding emergency relief. In contrast to previous programs where local politicians used relief funds and jobs as political currency, the GACs (under the coordination of local extension agents) included representatives of several sectors of society such as the Church, rural labor unions, city council representatives, landowners associations, state officials, and professional associations. Tendler (1997:50) describes the workings of the new GACs:

> In a process that was quite unusual for rural Brazil, the GACs would deliberate in weekly meetings over a set of two lists submitted by each village or community in the *município*, the villages ranging in size from five to 200 families. One list ranked a set of projects desired by that particular community; the other ranked those families hardest hit by the drought and most in need of employment and relief supplies.

In addition, government emergency programs cancelled large-scale public works projects in an effort to reduce the widespread displacement of workers and family separation. Work projects shifted from individual, private properties to public services, except for hydrological projects where property owners agreed to allow the entire community access to the water (Magalhães 1991).

Despite these improvements, what these different drought-related policies in Ceará share is the strong emphasis on solutions that fail to address the structural economic and social inequalities that critically shape the way different groups are vulnerable to climate-related phenomena. Hence, in Northeast Brazil where, on average, at least four in every ten years are affected by drought, policymakers have favored the adoption of "technical fixes" rather than implementing re-distributive policies that would reduce the population's vulnerability to drought. Because long-term adaptive policies might be met with strong political opposition, the use of sophisticated science-based research might provide policymakers with a politically "palatable" alternative.

Therefore, in Ceará, policy choice is critically informed by a consensus among decision makers and politicians to avoid the design of policies that challenge the power structure in the region. It should be emphasized that even Ceará's recent generation of more progressive leaders still rely heavily on the electoral vote under the control of traditional political strongholds in the state's interior to win elections.[6] In this context, policymakers in Ceará search for tools, that will at the same time allow for the insulation of the policymaking process from "irrational" elements–such as politics, support the status quo, and hold the promise of a solution. In this context, the use of seasonal climate forecasts to design proactive drought relief policies has bee perceived as an attractive possibility to local policymakers.

IV. Seasonal Climate Forecast and Policymaking in Ceará

IV.1 Historical Background

Since the early 1920s, scientists and engineers have attempted to develop forecasting methods for the Northeast Brazil. Magalhães, et al. (1988: 315) identify two main classes of forecasting methods. The first method attempts to predict the character of the rainy season a few months in advance based on knowledge of physical processes. It tries to identify large-scale parameters that indicate rainfall regimes in Northeast Brazil, both in the atmosphere and in the oceans. The second method uses statistical models based on the existence of apparent periodicities in the historical rainfall series observed in the region and attempts to predict drought many years in advance by extrapolation. In addition, throughout time, farmers themselves have learned to read signs from nature and some community members proclaim themselves prophets who can predict drought. These informal methods with a large following among subsistence farmers, are part of a rich local culture, which mixes popular practices, religious beliefs, and folklore.

As described in section IV, in Northeast Brazil, the first attempts to create an institutional apparatus specifically dedicated to understand drought-related problems and solutions dates back to the Brazilian Empire with the creation of the Drought Commission in the XIX century. Ceará was chosen as a research site because the state is the geometric center of the semi-arid region. In 1906, the federal government created the agency IFOCS and located its headquarters in Fortaleza, the capital city of Ceará.

FUNCEME's origins can be traced back to the 1950s with the creation of the Bureau of Drought linked to the Federal University of Ceará. 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 created with the goal of providing operational support to cloud seeding. The state bought three planes and carried out cloud seeding experiments regularly.[7] Although there was scarcely any documented success, cloud seeding became a powerful political tool since it conveyed the idea of government "action." Indeed, it was common for politicians to request that "seeding campaigns" be carried out in their regional strongholds, especially around election time. According to a local policymaker, "the sound of the airplane flying

[6] In the past three gubernatorial elections (with an exception of 1990), votes from the interior have been critical since the winning candidates systematically lost in the capital city of Fortaleza (Moraes, 2000).

[7] Interview with Francisco Viana, former president of FUNCEME, August 1997.

over their cities became more important than the rains they were supposed to bring."[8] Cloud seeding was the first serious attempt to use science to mitigate drought by "making" rain. 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).

At the same time, the agency started to create a small database on rainfall in the state. By the late 1980s, the new state government had decided to change its approach to drought mitigation and launched a concerted effort to increase state capacity to implement policy. As part of this effort, FUNCEME was provided with both state-of-the-art meteorological 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 applications potential of the forecast 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 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. The international scientific community has monitored the evolution of FUNCEME closely, since it is a major case study of the application of scientific climate information in the benefit of society. Thus FUNCEME, cloaked in scientific legitimacy, came to play a much more prominent role within the state policymaking machinery. FUNCEME's mission expanded to develop theoretical research seeking to provide a scientific basis for the government to address drought issues in the state.

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. Early in its role as climate forecaster, FUNCEME gained an unusually high level of prestige, reinforcing the expectation that "science" could thwart drought and reverse the negative consequences of climate variability. Part of this reputation was due to a famous and somewhat apocryphal account of the 1992 drought that has been reiterated in both academic and government circles (Glantz 1996:80-1, Golnaraghi and Kaul 1995). As an official representative of science, FUNCEME was integrated into a wider government effort to mitigate drought especially regarding two programs, one for seed distribution and the other for production credit which as a result became tied to the forecast. The seed distribution program, called *Hora de Plantar* (Time for Planting) created in 1989, was managed by the Secretary of Agriculture, which acquired quality seed for the upcoming campaign, but would only release the seed after FUNCEME had documented enough soil moisture and had issued a favorable forecast to guarantee seed survival.[9] The credit program was administered by the Bank of Brazil through local agencies that would release funds only after the winter had been "secured" (*assegurado*) by FUNCEME. In such a system, the pronouncements of FUNCEME assumed an urgent public posture with daily media coverage throughout the months preceding the onset of the rainy season.

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 ENSO-related forecast of impending drought. According to this account, the FUNCEME forecast stimulated the populist governor, Ciro Gomes, to mobilize several sectors of government to design a drought mitigation plan that included technical information on the appropriate timing of planting, and 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 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

[8] Personal communication, August 1997.

[9] See details in section VI.

only 15% of the state average (Golnaraghi and Kaul 1995). These figures and indeed the entire sequence of events appear questionable. Our efforts to recreate the comparable production figures for the two agricultural campaigns have shown significant discrepancies from the published evidence. 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 in 1987, 61% and 36% of the mean respectively (IPLANCE 1989 and 1993), it was not nearly as high as portrayed in the literature. It is even more telling that average precipitation data are imperfect estimators of production in any semi-arid environment where the spatial and temporal distributions are so critical.

In 1992 FUNCEME reached the zenith of its popularity; however, in 1993, the agency's release of an "inaccurate" forecast provided the first indication of the difficulties of applying climate forecast data. FUNCEME predicted the ongoing drought of 1991-92 would end in 1993 but the state experienced one of its driest seasons in history. Right after this mishap, FUNCEME's then president left. Although many will argue that there is no such a thing as an "inaccurate" forecast, rather than focusing on the information per se this study 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, e.g., "wrong." As we argue in the following sections, a widespread crisis in credibility experienced by FUNCEME in subsequent years has cast doubts on the ability of policymakers to use early seasonal climate forecast to mitigate drought-related effects on rainfed agriculture.

IV.2 Seasonal Climate Forecasting

In Ceará, seasonal climate forecast data release and use starts with FUNCEME's receiving primary data from producers in the U.S., Europe and other research institutes in Brazil. These include the analysis of the results of dynamic models for rainfall forecast from the Scripps Institution of Oceanography (University of California – San Diego), the International Research Institute for Climate Prediction – IRI (Columbia University), and the Center for Weather and Climate Forecast - CPTEC (Centro de Previsão de Tempo e Clima – INPE). In addition, statistical models from the University of Wisconsin, the Hadley Center Meteorological Office (UK), and from FUNCEME/CPTEC are also analyzed.

In order to organize and study the data, several of the Northeast Brazil states created climate study nuclei that meet once a year before the rainy season to analyze the climate and physical data that affect rainfall in the region. The result of this meeting is a "conceptual model" that summarizes and evaluates the different sets of data affecting the region's quantity and distribution of rainfall. Among the phenomena affecting rainfall in the Northeast Brazil are ENSO, La Niña, ITCZ, Sea Surface Temperature (SST), wind conditions, and teleconnections. In order to build the conceptual model technicians from FUNCEME, CPTEC, and the climate study nuclei analyze these sets of data separately and in relation to each other. These analyses aim at calculating the probability of how each of the phenomena will affect rainfall for the rainy season (February-May). Each phenomenon is then classified as "neutral," "favorable," and "unfavorable." Figure 4 shows an example of the conceptual model for the year 1997. Critics of this model contend that rather than based on scientific data, the model relies on individuals' personal judgment to weight the role of each phenomenon.

Because of the characteristics of the data and methodology chosen to build the model, there can be a high degree of variation regarding the model's final result. The nature of the climate data and methodology chosen to build the model imply a significant degree of variation in the model output. That is, in certain years the degree of forecast uncertainty can be higher than in others. In any year, however, the output of the model is 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. These categories are then translated, using historical data, into maximum and minimum ranges of expected precipitation for each micro-climatic zone of the state. In sum, 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 regions 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. In 1996, because the primary forecast data was more reliable, FUNCEME was able to release a more detailed and accurate rainfall forecast. For this rainy season, instead of a statewide prediction, FUNCEME produced regional precipitation forecasts. Figure 5 shows an example of FUNCEME's seasonal forecast maps for 2001.

As it will be discussed in more detail in the following sections, the conceptual model poses serious limitations to public decision and policymaking. Because policymakers usually need a high degree of certainty to make policy decisions, forecast uncertainty and scale limit its applicability. For example, in order to make decisions regarding seed distribution, policymakers need to know when and where it is going to rain while the models can only offer probabilities at broader spatial and temporal scales. Since in Ceará, low rainfall is the rule rather than the exception, forecasts that indicate "below average" do not affect decisions that users make in the absence of the forecast. Moreover, an incorrect forecast can have devastating consequences for policymaking in Ceará given the lack of resources and time to rectify an incorrect policy decision. Finally, forecast time of release can also hamper its use. This is the case of policies for which decisions have to be taken before FUNCEME releases the forecast such as water management.

Until recently, FUNCEME technicians perceived these limitations as extraneous to their work. The prevailing attitude was that as long as these researchers worked to improve the quality of the forecast there was little they could do to improve its applicability in the public policymaking process. This gap between data producers and their clientele both among policymakers and end users in the field seriously hampered forecast data use.

Figure 4: Prognosis Table
Rainfall Season for the Northern sector (semi-arid) of Northeastern Brazil (NEB)
February-May 1997

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		-	
Trade winds	N		N		+		-	
PNM	N		-		-		-	
OLR	-		N		+			
Equatorial Atlantic								
Southern Winds	+		+		-		N -	
Zonal Winds	-		N		+		+	-
ITCZ								
Pre-season Rainfall								
Northern NEB	+		-		+		+	
Southern NEB	-		+		+		+	
SST Forecast – Pacific Ocean								
NCEP	-		-		-		-	
CCA	-		-		-		-	
CA	-		-		-		-	
CZ	+		+		+		N	
COLA	-		+		+			
SST Forecast – Atlantic (SIMOC)								
Northern Atlantic	-		-		-		-	
Southern Atlantic	-		N -		-		-	
Rainfall Forecast – NEB								
CPTEC	-		N		N		-	
IRI	-		-		-		-	
CCA	-		-		N	-	-	
HASTENRATH			-		+		+	
HADLEY							-	

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

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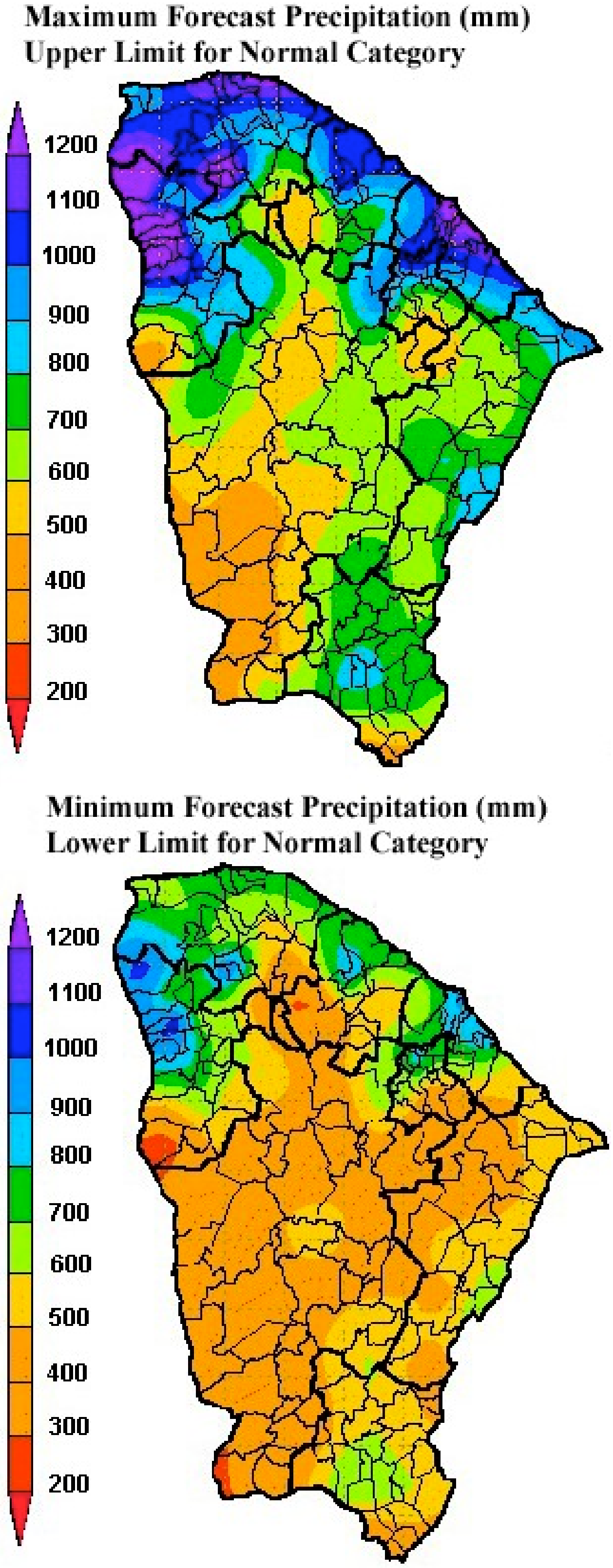
Figure 5: FUNCEME's Precipitation Forecast for 2001



source: FUNCEME, 2001

IV.3 Information Release and Communication

After scientists and technicians from the Northeast Brazil climate study nuclei and INPE meet and decide on a model for the season's forecast, FUNCEME releases the data both for its users in the government and to the public in general. Usually FUNCEME technicians and management hold private meetings to inform policymakers in the state government, especially in the areas of agriculture and emergency drought-relief (Civil Defense). FUNCEME also sends daily fax bulletins and posts information on the Internet.[10]

High raking officials such as the governor and state secretaries usually hold a meeting with FUNCEME's management prior to the beginning of the season before the forecast is released to the public. For example, in December 1996 FUNCEME's president and a few technicians met with the head and technicians of the Secretariats for Rural Development (*Secretaria de Desenvolvimento Rural* – SDR), Water Resources (*Secretaria de Recursos Hídricos* – SRH) and Civil Defense (CEDEC) to decide on the main strategy for agricultural and drought relief policymaking for the season. Although FUNCEME is an active participant in these meetings policy decisions are ultimately the concern of the Secretariats.

Next, FUNCEME releases the forecast information to the public through the media. In the past, FUNCEME has tried several methods of data release–including press releases, press conferences, and one-on-one interviews–with mixed results. Because of the political and cultural controversy related to climate forecast, public release of the information has become one of FUNCEME's main concerns. One recurrent problem is the gap between the scientific jargon used in the forecast release and what journalists believe attract readers. Indeed, the format of the forecast–and its release to stakeholders and the public–poses substantial problems for application. 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 not an explanation of probabilities, but rather a cognitive touchstone that facilitates *Decision-making.* FUNCEME scientists complain that their efforts to "translate" the technical jargon and convey the idea of probability yielded little results. Rather, the media has performed the "cognitive" translation in its attempt to satisfy a wider public, particularly if short, dramatic headlines can be employed. These headlines in turn instead of conveying the high degree of uncertainty that characterizes climate forecasting are often reduced to a deterministic "it will rain" or "there will be drought." Consequently, even when releasing correct forecasts, FUNCEME is the target of criticism for not "being right" most of the time. In addition, FUNCEME is constantly challenged by– and being judged against – other forecast producers and traditional methods of drought forecast such as rain prophets, 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 forecast emphasizing superiority of science to both rain prophets and local lay forecasters (Diário of Northeast Brazil 1997)[11]

In 1997 because climate conditions were particularly difficult to forecast, FUNCEME was cautious to release the forecast of "below average rainfall, irregularly distributed spatially and temporarily." When it rained in the beginning of the season, FUNCEME was harshly criticized for releasing a "wrong" forecast. By mid-season it stopped raining and FUNCEME's forecast was

[10] The governor has also access to real-time climate information through a computer terminal installed in his office linked to FUNCEME's computers (Tasso Jereissatti, governor of Ceará, personal interview, August 1997).

[11] In addition, rural labor leaders interviewed for thesis 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 an therefore were "ignorant" of the problems of Northeast Brazil and nordestinos.

proven right. However, the first impression of a "wrong" forecast prevailed despite the agency's efforts to rectify the situation. In consequence, FUNCEME management has drastically limited the agency's direct contact with the media and decided to adopt press releases as its primary method of forecast release.

FUNCEME also uses radio addresses and interviews to disseminate the forecast, especially to rural areas where the radio is the main source of information. The forecast is released both through the state public radio and through local stations. Often, FUNCEME's technicians favor the radio over newspapers because the former gives them the opportunity to speak directly to the public.

One consideration related to the dissemination of the information is the government's fear that a forecast of drought might spread panic and encourage social unrest even before there is any confirmation that there will be a drought. Since forecasts often carry a margin of error close to 50%, policymakers are justifiably weary of the possibility of the dissemination of an inaccurate forecast.[12]

V. Seasonal Climate Forecasting and Policymaking

V.1 Framework of Analysis

In an ideal world, seasonal climate forecasts would be made available to policymakers who would then produce enlightened policy support for agriculture and drought relief. Climate science is now able to predict the onset of ENSO and forecast drought in regions such as Northeast Brazil and Southern Africa up to six months in advance. With increasingly accurate forecasts, decisionmakers would 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). However, much less is known on the use of climate forecast data in public policymaking. Two analytical frameworks have been used to understand the use of seasonal climate forecasting by policymakers in Ceará; they are described next.

V.2 Knowledge and Policymaking

The climate forecasting literature often depicts the application of seasonal climate forecasting as an "expected" outcome of generating climate data without closely examining how the processes of data dissemination and policy implementation actually work. This expectation follows from the traditions of opportunity-driven or "pure" science in which the role of scientists is to stand apart from politics while producing impartial and objective knowledge for formal policy institutions (Jasanoff and Wynne 1998). Policymakers in turn, expect usable information to be readily applicable to their most pressing problems and perceive science-generated information as an authoritative and legitimizing policy tool. However, the use of science-based information in policymaking is often more complex than both scientists and policymakers hope for. Despite continued efforts from scientists and policymakers to keep their respective spheres of action distinct, the interaction between these two spheres usually reveals the hybrid character of science done for policy (Jasanoff and Wynne 1998).

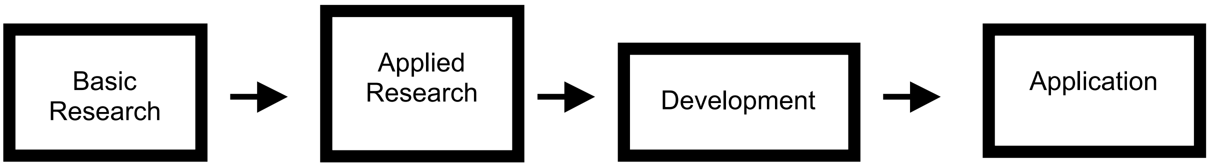
In addition, Weiss (1978) points out that these two groups are essentially formed by two very different social actors bound by different sets of goals and rules. Thus, researchers "are affected by the state of their science; its maturity in theory, knowledge, and method sets limits on the authoritativeness of their research" (1978:37-38). On the one hand, researchers often "choose and conceptualize problems in terms of the methodologies in which they are proficient " (Weiss 1978:45). On the other hand, policymakers tend to be in a hurry and show little patience with long-term aspects of basic research. Here, while researchers often have to contend with the politics of data application, policymakers are often constrained in their jobs by such considerations as stakeholders, political agendas, and application timeframes.

[12] Tasso Jerissati, personal interview, September 1997.

Carol Weiss (1978) proposes two basic models for the use of basic research in policymaking. Figure 6 illustrates the decision-driven model where policymakers when faced with a problem, either look for solutions in the pool of pre-existing research products or commission new research to meet their needs. In the first case, existing research might be only marginally applicable to the problem and a certain adjustment is necessary. Commissioned research in turn is expected to have direct application in *Decision-making*. In the second knowledge-driven model (Figure 7) "research is sometimes used for policymaking not so much because an issue requires elucidation but because research has uncovered an opportunity that can be capitalized upon" (Weiss 1978:29). This model assumes that the "sheer existence of knowledge presses it toward development and use" (Weiss 1978:30). Here, the solution, rather than the problem, provides the main motivation for policymaking (Kingdon 1985, Stone 1988).

Figure 6: Decision-driven Model of Research

Figure 7: Knowledge-driven Model of Research



(Weiss, 1978)

However, the use of scientific data as a policy tool will be challenged if it is either ignored by end-users or if its use has a negative effect on end-users. Research shows that carefully designed policies may be consistently ignored or boycotted by policy clients. One common reason found in the literature is the inability to design policies that meet the institutional values and beliefs of intended clients (Thompson and Rayner 1998). In other cases, technocrats are troubled by the social fact that people will culturally re-interpret facts rooted in technical expertise and science (Gerlach 1993).

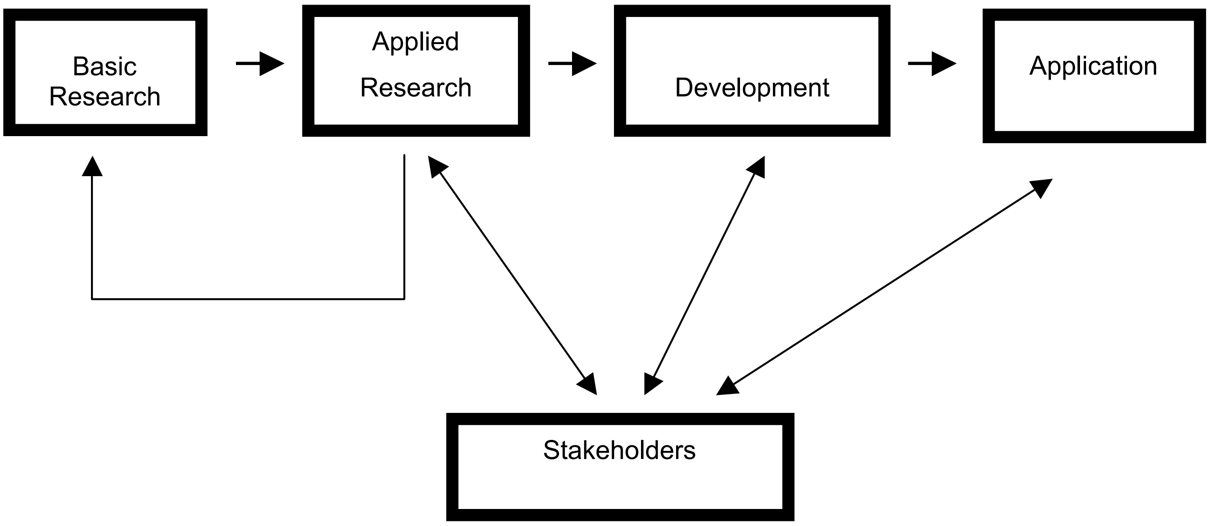
Orlove and Tosteson (1999) argue that the problem of applying El Niño forecasts involves the "fit" between the characteristics of the biophysical phenomenon, its informational format, and the institutions mobilized to deal with the impacts of climate variability. Therefore, it is not enough to disseminate information and expect that social action will ensue. To effect social action, three aspects of social structure must reinforce each other (Giddens 1994 and Collins 1981 cited by Westley 1995): "structures of signification" (the interpretive schemas that give meaning to activities); "structures of legitimization" (the rules and norms that organize the activities that make up our day-to-day lives); and "structures of domination" (the allocation of resources and *Decision-making* power that govern the ability to take effective action). For example, scientific information is useful to formal planning processes if packaged in such a way that is consistent with the belief that the relationship between organizations and the environment is one of "instrumental rationality" (Westley 1995:396). Similarly, if scientific information does not fit end-user values and belief systems, it will be likely ignored. Finally, if users do not have the material means to respond to policy, no action is likely to ensue.

Moreover, individual *Decision-making* processes are influenced not only by rule-driven routines, procedures, conventions, roles, etc., but also "the beliefs, paradigms, codes, cultures, and knowledge that surround, support, elaborate and contradict those roles and routines" (March and Olsen 1989:23, 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: 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: 38 cited by Thompson and Rayner 1998). Evidence from our fieldwork seems to corroborate such a proposition. In Ceará, rainfed farmers seem more attentive to climate forecasts delivered by local "rain prophets" found through the countryside than to those released by FUNCEME, the science representative. While the literature on forecast application proposes different means of improving data communication through the education of users, less emphasis is put on the education of data producers to users' needs. However, data from the field in Ceará suggests that as important as educating users, it is for information producers to seek to understand users' needs.

Thus, an alternative model of policy application for science-generated information would have to acknowledge the critical role played by stakeholder feedback to information producers and policymakers. Figure 8 shows the science-policy-stakeholders interactive model.

Figure 8: Science-policy-stakeholders



Other factors also influence the ability of users to apply data. Differences in the scale and resolution of information (e.g. from coarse resolution at the global/national to high resolution data at the regional/local level) create some of the more puzzling constraints for the application of climate forecasting in policymaking. Looking at different examples of policy failure, Cash and Moser (1998) discerned a common trend: the existing information and *Decision-making* systems in place to support their management were inadequate for dealing with the cross-scale nature of the problem. That is, existing policy systems were not equipped with the expertise to apply low resolution global data to gain insights on local level problems. In the case of seasonal climate forecasting, while climate forecasters use large scale models to make low-spatial resolution long-term predictions, in general policymakers wish for high-spatial resolution information that is relevant at the local level, especially for agricultural and drought-relief purposes. Although the notion of "downscaling", that is, extrapolating low-resolution data generated at large scale levels to specific small-scale geographic regions, has become a common aspiration of policymakers everywhere, it is not well understood that state of the art climate forecasting information is still far from the level of temporal and spatial accuracy expected by users at the local and farm levels (Cane 2000). Thus, the use of scientific information in policymaking is critically affected by factors inhibiting the integration of information and policies across scales, that is, from data producers at international and national levels, to policymakers at a state level, to farmers at the local level.

In addition, other factors such as distinct professional cultures (Weiss 1978), lack of trust and social capital, a sense of disenfranchisement (Cash and Moser 1998), and a widespread perception that the information is useless because it does not conform to user perceptions of their needs (Lemos and Tucker 1998) also play a role on users' willingness to seek and use forecast information in their *Decision-making*. Here both information uncertainty and probabilistic character are likely to affect the way users perceive its usefulness. Thus, probabilistic information is difficult to assimilate because people do not think probabilistic or do not estimate probabilities well (Gigerenzer and Hoffrage 1995 cited by Stern and Easterling 1999: 75). Similarly, "(U)ncertainty in climate forecasts, due to poor input information, imperfect climate models, and the inherent unpredictability or many situations, means that forecasts carry the risk of being wrong." (Stern and Easterling 1999:75). Finally, uncertainty also concerns climate information lack of temporal and geographic specificity. For example, farmers will perceive as "wrong" forecasts released for the whole state of Ceará because it cannot be used by end-users in the very specific geographical and temporal contexts of their planting decisions. In this case, even if the forecast is accurate it will be perceived as "wrong".

Difficulties of communication between scientists and policymakers (Offut 1993, Barnabo et. al 1993, Weiss 1978) and in turn between policymakers and end-users can also be a serious constraint to data use. As discussed above, the latter link can be particularly problematic when the media constitutes the principal means of communication between the producers of forecasting information and the public. Different technical jargons and different styles of dealing with information 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 forecasting information and the media's pursuit of powerful deterministic headlines. In the best-case scenario, the media acts as an additional source of data interpretation that may or may not misrepresent the nature of the forecast. At its worst, the media's treatment of the data distorts the forecasting 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).

V.3 Technocratic Policymaking and Political Insulation

Many of the essential qualities people associate with science—thoroughness, objectivity, the search for truth, and rationality, to name just a few—are also the most desirable characteristics of efficient and effective policymaking sought after by Ceará’s policymakers, especially mid-level professionals locally known as *técnicos* (technicians).

Within the rational conception of science and *Decision-making*, the process of making policy resembles the classic scientific experiment in which first decision makers recognize a problem, then examine alternative solutions and finally select the one which maximizes the attainment of the desired goal (Stone 1988, Feldman 1989). In their quest for problem solving, decisionmakers must critically rely on expertise and science-generated tools. Although this model holds obvious appeal to policymakers, many scholars have pointed out the obstacles to this form of *Decision-making* in policy implementation (Lindblom 1959, Kingdon 1985, Stone 1988, Feldman 1989). Yet, recognizing that reality is more complicated than rational modelers assume is not equivalent to saying that science-generated information has no place in policymaking. Rather than being used as rationalists presume, research information might play different roles including contributing to the definition of policy alternatives (Kingdon 1985), enhancing information through interpretation (Feldman 1989), and providing “political ammunition” to *Decision-making* (Weiss 1978).

From a policymaker's point of view, there are obvious advantages to gain from the technocratic model of *Decision-making*. First, because policy tools originate in “hard” research science—therefore requiring technical expertise for their use—they can insulate policymakers from political meddling and efforts by powerful interest groups to influence policy implementation and outcome. Second, technocratic *Decision-making* is also understood as increasing legitimacy and feasibility and reducing dissent (Jasanoff 1990, Ezrahi 1990). Third, technocrats believe technical insulation will decrease policies' vulnerability to criticism from non-technical people and politicians (Steel et al. 1993).[13] Finally, scientific *Decision-making* holds the promise of value-free decisions about public policy, therefore, bypassing the messiness of dialogue and negotiation (Jamieson 2000).

Technocratic *Decision-making*, however, may defy basic precepts of democracy by limiting the number of participants and policy alternatives and rendering technocrats unaccountable to elected officials and clients (Etizioni-Halevy 1983). Indeed, when trying to gain political advantage, groups may be tempted to exaggerate or distort information when that information serves to support the interests of one group over another. In this process, information is neither neutral in terms of power relationships nor institutional structures. As technical analysis becomes more prominent than other informational input (including opinions and interests of non-technical sources), it may "squeeze out other forms of information, *Decision-making* routines, and claims" (Healy and Ascher 1995: 13).

In Brazil, the tradition of technocratic *Decision-making* goes back to the 1930s when in consequence to the modernization of the state, a strong bureaucracy emerged based on the multiplication and expansion of both public and private organizations. While the classic Weberian model describes a pattern of separation of politics and administration that at the same time praises bureaucracies legal-rational superiority and cautions about the danger of such superiority to breed arbitrariness and unaccountability (Reis 1990), in Brazil, the line between politics and bureaucracy has been purposefully blurred. This has been particularly the case in the 1960s and 1970s when political leadership (both democratically elected and authoritarian) attempted to insulate bureaucratic systems as a strategy to foment development. Edson Nunes and Barbara Geddes (1987:104) define Brazil's bureaucratic insulation as "the capacity [these] organizations have to maintain their organizational integrity and to pursue their own goals." They can enter coalitions and cooperative relationships with other organizations and limit the capacity of outside actors to define or subvert their goals. The technocracy differed from traditional bureaucracy to the extent that its performance depended on specific technical and professional expertise. They also operated from decentralized agencies (public and mixed enterprises and autonomous entities) that were relatively insulated from practices such as clientelism, nepotism, spoils systems, and corruption (Nunes and Geddes 1987).

On the one hand, Geddes (1990) proposes that insulation contributes to effective implementation of policy because it preserves the material and human resources and the commitment necessary to implement reform. This, in turn, increases state capacity and hence autonomy. Still, "capacity-enhancing reforms (…) occurs only when the political leaders who must initiate them can expect to benefit from the reforms enough to outweigh the cost of loosing the electoral advantages provided by the distribution of patronage" (Geddes 1990:218). Therefore, it is not surprising that the most encompassing period of bureaucratic insulation in Brazil coincides with that of authoritarian ruling.

On the other hand, tensions between insulation and accountability have had a lasting, mostly negative, effect on Brazil's democracy. Reis (1990:23) argues that "the technocratic political forms adopted made a decisive impact on practices and institutions, while also leaving deep marks on values, attitudes and beliefs relative to the public sphere. In other words, that in Brazil we lived until recently under the logic of 'bureaucratic authoritarianism' has continuing implications for the patterns of interaction between administration and politics."

Both perspectives permeate the Ceará case study. The application of scientific information such as seasonal climate forecasting, in principle, provides policymakers with an apolitical, precise tool that serves as the basis for a technocratic model of policymaking historically grounded in Brazilian tradition. Furthermore, as a policy tool, climate forecasting holds the promise to mitigate and prepare for natural hazards previously perceived as unpredictable and therefore not conducive to pro-active planning. In both senses, policymakers may perceive the emergence of science-based tools as a highly desirable policy option. Yet, in Ceará, technocratic insulation might become increasingly untenable in the context of political reform and democratization. Moreover, attempts to insulate the

[13] In a comparative study between bureaucracies in the United States, Korea, and Brazil, Steel et al. (1993:423) report that Brazilian civil servants have the highest level of support for technocracy although their support for outside influence on policymaking (from elected officials and voters) was also high (66% and 73.4% respectively).

process can backfire and produce exactly the opposite effect, that is, excessive politicization of the policy process and unnecessary discredit of specific policy tools.

V.4 Policymakers as Forecast End-Users

In this section, we analyze three state-level public drought mitigation policies that systematically integrated the FUNCEME forecasts. The first is the seed distribution program administered by SDR –*Hora de Plantar* ("Time to Plant"); the second is the emergency drought relief program administered by SAS through CEDEC; and the third is the water management system at the state level, in particular reservoir management, administered by SRH and its operational agency Water Resources Management Company (COGERH).

In Ceará, the relationship between the scientific prediction that emanates from FUNCEME and policymaking apparatus of the state can be described in terms of three main steps. As described above, to begin, FUNCEME's climate division formulates a forecast based on an array of primary data received from climate institutes in the U.S., Europe, and Brazil. The second step in this process is the public delivery of the forecast. Above, we have already suggested that policymakers have not always appreciated the probabilistic character of the FUNCEME forecasts. It is equally true that other sectors of society, including both media and end-users, have cast the forecasts in their own interpretative frameworks with often undesirable consequences for FUNCEME. Third, forecast information is "applied" in specific policies geared to mitigate and/or respond to drought events. Next, we examine such policies in detail.

V.5 Hora de Plantar

The *Hora de Plantar* Program, started in 1988, has relied heavily on climate and soil information provided by FUNCEME. *Hora de Plantar* aims at distributing high-quality, selected seed to poor subsistence farmers in Ceará and maintaining a strict planting calendar. The program's combined stated goals are: (a) to increase the availability of high quality seeds for the main crops in the state aiming at increasing production levels and productivity; (b) to meet the demand of farmers (with or without land) for high quality seeds through a lending system available in a timely fashion; (c) to increase the production of high quality seeds within the state; (d) to disseminate the use of high quality seeds through the technical support of extension services and widely available use of adequate technology (Governo do Estado do Ceará 1997). The *Hora de Plantar* program was initiated during the first government of Tasso Jereissati and was hailed as a successful use of seasonal climate forecasting in policymaking. 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." Remembering that farmers tend to plant with the first rains (sometimes called the "pre-season") and often have to replant, the goal of this program was to use scientific information to orient farmers with regard to the true onset of the rainy season.

The scientific information was provided by FUNCEME in two forms. First, the conceptual model described above issued a probability forecast of the upcoming season; second, a soil humidity model developed by FUNCEME generates estimates of soil humidity across all the *municípios* of Ceará (Andrade 1995). When soil moisture is sufficient to support growth, the *município* was deemed ready for seed distribution (see detailed description below). At this point, SDR authorized 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 assured that farmers associated the releasing of seeds with the scientific information of FUNCEME. In the public perception, FUNCEME "announces" the winter, and then SDR releases the seeds. Often, in specific regions were rainfall is sufficient for farmers to plant following their traditional practices, government seeds are not available.

For the farmers, the perceived basis for seed unavailability is that FUNCEME has not yet sanctioned their distribution based on the existing scientific information. These situations create a dynamic tension not only between farmers and policymakers, but also between FUNCEME and SDR.

The program starts with the acquisition of high quality seeds and their distribution to regional centers where it is stored until the determined "time to plant." To qualify for seeds, subsistence farmers register with the program at the local rural extension agency (EMATERCE). Each registered farmer is elegible to receive enough seed to plant a maximum of two hectares, based on the following:

Rice (sequeiro)	15 kg/ha
Beans var.1 (mixed cropping)	05 kg/ha
Corn (mixed cropping)	10 kg/ha
Beans var.2	20 kg/ha

(Governo do Estado Do Ceará 1997: 4)

Since 1992, SDR has used a computer-based soil humidity model developed by FUNCEME called MUSAG (Andrade 1995).[14] This mathematical model, used to calculate soil humidity, incorporates seven main physical parameters: soil humidity, daily precipitation, evaporation, maximum water retention capacity of the soil, water infiltration capacity, run-off, and water percolation. FUNCEME monitors rainfall daily at 184 rain stations located in each municipal county seat within Ceará. Then FUNCEME *técnicos* enter the data into the model, which calculates the level of soil humidity and its ability to retain enough moisture for plant growth (Andrade 1995). From the model, FUNCEME establishes the number of days that will take for the soil to lose the moisture gained from the last rainfall. FUNCEME then maps the *municípios* whose soils can withstand at least eleven days without rain and sends this information to the SDR who in turn authorizes seed distribution for these *municípios* (Andrade 1995).[15] Here it is important to emphasize that despite the fact that seasonal climate forecasting is not included in the model, there is a widespread perception among the public and *Hora de Plantar* clients that seed distribution is directly connected to FUNCEME's seasonal climate forecasting. Indeed, FUNCEME *técnicos* claim that forecasting information affects the criteria for seed distribution because in years of below average rainfall forecast, the number of days can be reduced so that farmers can take advantage of any opportunity to plant.[16]

A drawback to MUSAG is that results derive from rain gauges located in the municipal center, represent the entire municipality. The high spatial variability of rainfall in the region means that areas removed from the municipal center likely experience significantly different rainfall patterns, and therefore, require seed at different periods. When FUNCEME first conceptualized the soil humidity model, technicians believed it would facilitate the establishment of a stable agricultural calendar that could inform the *Hora de Plantar* program in deciding the best time to distribute seeds, and thus improve rural livelihoods. Upon closer examination however, they realized the difficulty of producing a definitive agricultural calendar for the entire state of Ceará, since the best days to plant vary between years and regions. Therefore, every year SDR reevaluates the climate and soil information to decide when to release the seed (Andrade 1995). Critics of the model also maintain that at the level of skill (temporal and geographical distribution of rainfall) currently available, seasonal climate forecasting makes the information useless for the kind of precise information required to decide on a specific day and region to distribute seeds.[17]

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[14] Evaluation of soil humidity is vitally important to agriculture, particularly in the semi-arid farming regions. In the state of Ceará, about 90 percent of the area is classified as semi-arid. Water deficits occur frequently and constantly threatening subsistence agriculture production. The small farmer depends on rainfed agriculture for his subsistence, and therefore experiences a high vulnerability to dry spells and climate change.

[15] *Hora de Plantar* distributes four kinds of seeds: corn, rice, and two kinds of beans–a fast growing type more suitable to short growing seasons– and a slower growing type with higher productivity and market value. Beans, corn, and rice are the principal crops of small farmers in the Northeast.

[16] Personal communication 1997.

[17] In addition, critics have pointed out that the model relies on insufficient, outdated, and low quality data especially regarding soil surveying. For example, the soil map currently available was put together in the late 1970s at a scale of 1:600,000 km^2 and is clearly too coarse for the kind of specific planting advice model-runners want to give out to

Once the Secretary of Agriculture authorizes the distribution of seeds – for each individual *município* – EMATERCE set the date for farmers to come claim their seed at their respective EMATERCE offices**.** In exchange for the selected seeds, farmers "pay" the government with grain harvested during the previous season (the same amount of the seeds they receive) or receive credit to be paid the following year. EMATERCE offers seeds to farmers at fifty percent of normal market price.[18] In 1997, the government set its goal to distribute 2,300 tons of improved bean, rice, and corn seed to 130,000 small farmers (Governo do Estado do Ceará 1997). According to the State government of Ceará, EMATERCE offers technical assistance to farmers, helping them at every stage of production, from planting to storage (Governo do Estado do Ceará 1997). Figure 8 shows *Hora de Plantar Decision-making* map.

The *Hora de Plantar* program has been presented as a symbol of policy support for agriculture. Since it was the most visible SDR initiative in the state, the program was deemed a failure of agricultural policy if seeds were not in place when farmers judged it time to plant. In this context, FUNCEME frequently played a scapegoat role (Diário do Nordeste 1996, O Povo 1997).

The analysis of the 484 households in the sample demonstrated that the *Hora de Plantar* program is not as critical a policy support as the intensity of public discourse would indicate. Some of the farmers interviewed had never heard of *Hora de Plantar*, suggesting a partial failure in the dissemination of information about the program. In fact, only 54 percent of the sample had ever used government seeds and only 40 percent was registered during 1997. Farmers gave various reasons why they were not registered. For example, a significant number of the farmers complained that the improved seed arrived late in time (43 percent). The other major disadvantage of *Hora de Plantar* mentioned by farmers is the complications of acquiring seed. Bureaucracy and red tape muddle the process of seed distribution. Farmers complained about too much paperwork, long waiting lines, and requirements for identification and other documents that many do not possess. They also disliked having to travel to the municipal center for the seed, either because they cannot afford to travel there, or because it is too far to go. In other words, the trip sacrifices valuable work time (15 percent of the sample complained about this type of problem). Many farmers also complained that the quantity of seed distributed was insufficient to feed their families.[19]

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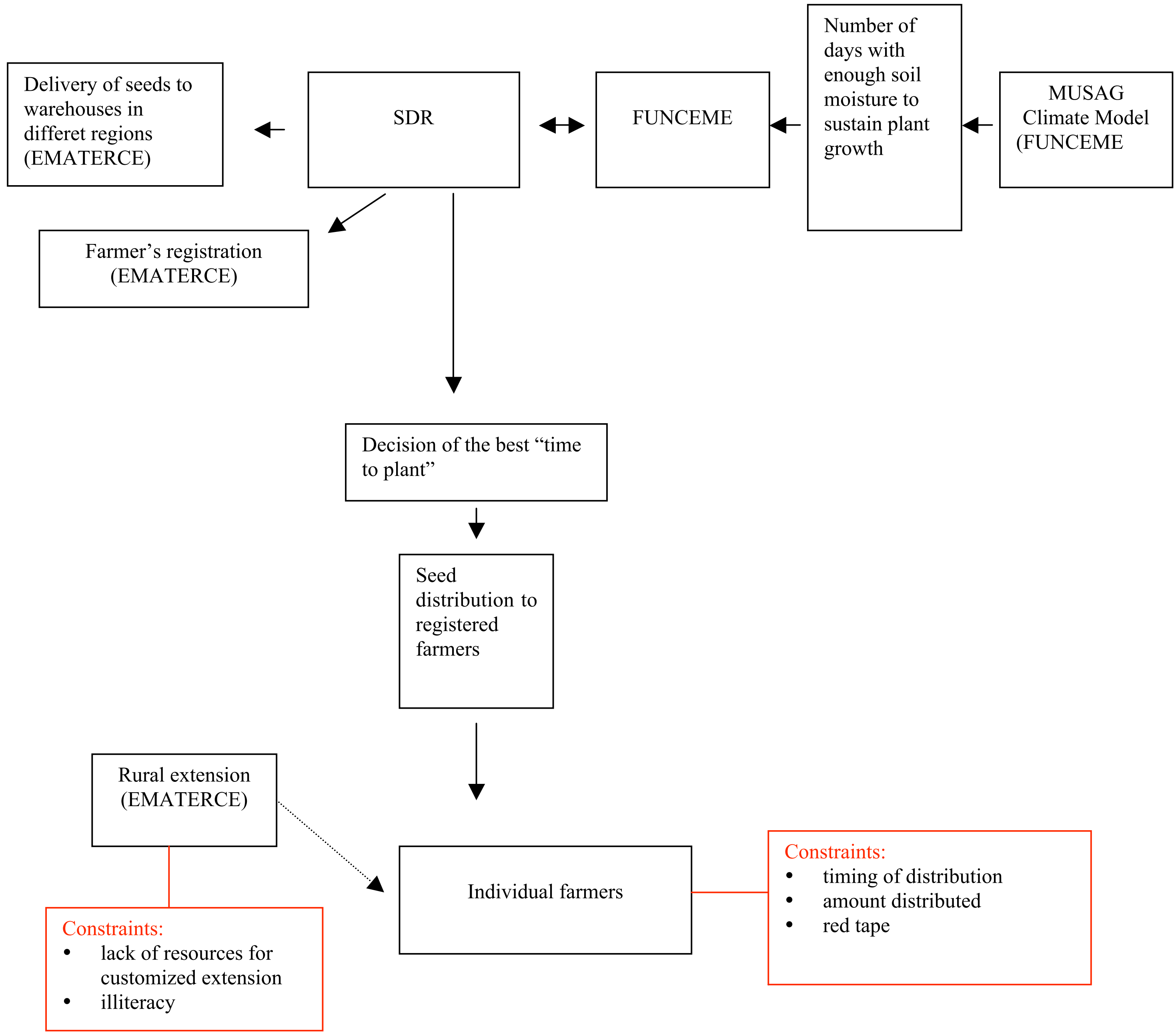
farmers. Personal communication 1997, 1998.

[18] Interview with the Secretary of Agriculture.

[19] A 1997 article in the capital newspaper echoes the results of our interviews. It leis the two gravest complaints with *Hora de Plantar* are the late delivery of seeds and the small quantity of seeds distributed, exacerbating crop losses during dry years. "Atraso na distribuição de grãos selecionados prejudica plantio," O Povo, 19 June 1997.

Figure 9: *Hora de Plantar* Decision-making Map



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.

Finally, farmers strongly resent *Hora de Plantar*'s planting calendar and its imposition over their own best judgment. According to one farmer "even if I plant and lose, at least I have a chance. When I don't plant, I know for sure I won't have what to eat." This situation is particularly difficult when it rains and farmers do not have seed. Both extension *técnicos* and rural workers union leaders interviewed for this study agree that this is the "worst possible scenario." Although the result is the same–lost crops–in most cases, farmers prefer to plant and loose than not plant and be surprised by rain. Thus, at great sacrifice, most farmers store their own seed from one season to the next so as not to depend on *Hora de Plantar*.[20] Despite the shortcomings of the *Hora de Plantar* seed distribution program, some small farmers did recognize the advantage of genetically improved seeds and praised the program as a help to those who have no seed or cannot afford to buy it on the market. Table 8 shows the level of participation in *Hora de Plantar*.

Table 8: Participation in the *Hora de Plantar* Program

Município	**Previous Participation % HH**	**Participation in 1997 % HH**
Limoeiro do Norte	56	37
Barbalha	67	47
Parambu	43	21
Boa Viagem	64	54
Itarema	53	43
Guaraciaba do Norte	44	42
Total	54	41

As mentioned earlier, in 1997, climate signals were particularly difficult to interpret, and FUNCEME released a cautious forecast of "below average rainfall, irregularly distributed spatially and temporally. " Although the government proclaimed that all seed would be distributed throughout the state by January 18, EMATERCE began to distribute seeds towards the end of February, reaching some *municípios* only in April – after the planting season had essentially ended and harvest had begun.[21] As a result, many farmers did not wait for the government's distributed seed and planted their own seed. By the time the seed arrived, 40 percent of the already planted grain had already begun to germinate (O Povo 1997). For those who waited for the seed, there was little hope of

[20] Personal communication, 2000.

[21] Anonymous, "Distribuição de sementes beneficiará 120 mil agricultores no Interior," Tribuna do Ceará 4 January 1996.

gaining a harvest because the rains have stopped.[22] In fact, rain fell in many *municípios* in January, but FUNCEME considered this a “pre-season anomaly." Because SDR postponed seed distribution until later in the season despite the early rainfall, 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.

While the management of FUNCEME has attempted to disengage itself from the decision of whether to launch seed distribution or not, until recently, SDR policymakers continued to rely on the soil moisture and forecast information to liberate the distribution of seeds. 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.[23] In addition, by relying on "scientific" tools to make planting decisions, SDR could insulate the process from its clientele (see section VI.3). Finally, policy-maker "fascination" with scientific tools and the guise of legitimacy and rationality they bring to the policymaking process diverted attention 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 in the attempt to mitigate drought in Ceará.

V.6 Emergency Drought Relief

Another main user of climate information is CEDEC, the state civil defense agency responsible for 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, CEDEC 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). This response typically comprises the distribution of food baskets among severely affected households, provision of drinking water, and organization of work fronts to employ heads of households who loose their main source of income as a result of drought. However, traditionally, emergency drought relief has been one of the most politically charged policymaking process in Northeast Brazil.

The political implications of the distribution of emergency relief resources are three-fold. First, work fronts have customarily played an important political role in Ceará's rural areas. Usually the last means of survival for many poor families, the work fronts have been the target of much criticism and controversy. These fronts have been a powerful bargaining instrument to local political bosses who through classic *clientelism* exchanged votes for placement in work fronts. In addition, many of the construction projects carried out by the fronts would either be located within powerful individuals' proprieties (e.g. water reservoirs and dams) or directly benefit their interests (e.g. roads, water channels, etc.). Similarly, the distribution of water trucks and food baskets were often used for political and economic gain. The costs of trucking water can add up quickly since most of the communities in distress are located far from urban centers or water sources. In many cases, tank trucks are contracted and in the past, local governments would bill the state government by the distance traveled by each truck. To make matters worse, there was little monitoring and the billing system was greatly vulnerable to fraud and abuse. Finally, under official emergency status, local governments dramatically increase not only the amount of their budgets through the injection of federal and state emergency funds but also their discretion over them; they are not required to follow usual spending procedures and are allowed to shift budget allocation from one area to another without

[22] This mostly includes farmers who do not grow their own seed and/or cannot afford to buy see on the market.
[23] 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 (Tribuna do CearáCosta, 1997). The public and institutional reaction to FUNCEME indicates the agency's inability to disentangle itself from the "politics" of policymaking.

approval from the legislature. Therefore, local elites have a keen interest in keeping their ability to declare emergency and locally distribute relief resources unchallenged.

As suggested earlier, the new system, which started in the late 1980s but was constantly changed throughout the 1990s, improved the old clientelistic model in several ways. It democratized local instances of decision by installing *município*-based committees that are responsible for identifying the neediest families in each drought-affected community. By the early 1990s, the committees' coordination was transferred from EMATERCE's extensionists to Civil Defense *técnicos* who supervised their workings and closely monitored emergency fronts' implementation. Community representatives in the committees–now called COMDECs (Civil Defense Committees)–generate a list ranking the families of each community according to need. These lists are then prioritized within the *município* and used as a basis for the distribution of jobs, food baskets, and water trucks. CEDEC also introduced a statewide ranking of *municípios* affected by drought based on "techno-scientific criteria." The ranking was then used both to select different *municípios* to receive emergency relief and to challenge local politicians' claims and attempts to "pressure" state officials to include their strongholds in the program. Hence, CEDEC's strategy seeks to eliminate the corruption excesses associated with the "drought industry" by using objective scientific information that FUNCEME provides as a means of avoiding political favoritism and clientelism

It is important to observe that the FUNCEME-generated information used by CEDEC is not the seasonal forecast, but rather actual rainfall and vegetation data. Civil defense officials do report an interest in seasonal predictions, but only as "background information." Nonetheless, CEDEC's management recognizes the potential of the use of seasonal climate forecast for drought relief in two ways. First, future improvements in forecast accuracy will provide a valuable tool to plan for emergency relief policy proactively rather than reactively, as is the current situation. Second, at the *município* level, policy and decision-makers have expressed an interest to use improved forecasting in the planning of local drought relief policies. Third, the use of scientific information has the potential to insulate policymaking from the most negative aspects of traditional clientelistic politics in Ceará (see section VI.3).

V.7 Water and Reservoir Management

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 *município*s that are located far from the state's water resource infrastructure and depend almost exclusively on wells and small reservoirs (*aguadas*) for water supply. The wells and *aguadas* can barely sustain water supply during periods of mild water deficit–which in Northeast Brazil occur 80 percent 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 water supply infrastructure in the state is located around the capital city of Fortaleza and close to the region's few perennial rivers and 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 percent of their capacity to consumption.[24]

Indeed the potential for the use of climate forecast at GOGERH is high and the agency has been consistently trying to incorporate this kind of information in its *Decision-making*, especially year-to-year reservoir management (F. Viana, personal communication, 2001). Yet, seasonal climate forecasting lead-time, that is, how soon FUNCEME is able to release its regional assessment is perhaps the main constraint for its use by 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

[24] In addition, reservoirs loose approximately 3,000 mm/yr of water to evaporation, making the need to conserve water even higher.

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 (personal communication, 1997).

The information is more useful concerning infrastructure planning and maintenance where the risk of a "wrong" forecast is attenuated by their little immediate impact on livelihoods and their potential for long-term positive effects. For example, after a mildly dry season in 1997–when rainfall failed to restore reservoir capacity–and 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 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.

V.8 Technocratic Insulation: A Tale of Two Policies

In principle, both *Hora de Plantar* and Emergency Relief use a widespread range of science-based information including climate forecasts. While the benefits for farmers from the *Hora de Plantar* program are somewhat ambiguous, the dynamic tension between the use of climate information and policymaking well illustrates the dangers creating policy around great uncertainty in a highly charged political context. General knowledge of rainfed farming would suggest a major flaw in the *Hora de Plantar* program, which is in fact confirmed in our field research. As argued above, subsistence farmers have acquired generations of indigenous knowledge that they apply to their rainfed livelihoods, and ignorance of when to plant is not the major constraint to successful production. The attraction of the *Hora de Plantar* program has not been the drought-resistant quality of the seed, but rather the accessibility to seed when it is scarce or for replanting (which are frequent)

By keeping the planting calendar, SDR, in essence, decides for farmers when it is the best time to plant. Here SDR's *técnicos* believe that their methods are consistently superior to farmers who if left to their own devices either waste the seeds by planting at the "wrong" time or eat them in periods of food shortage. The latter argument is easily dispelled by the fact that most farmers do save their own seed from one year to another. According to one farmer: "When SDR says we eat the seed, it shows no respect for the farmer. If we save two liters of our own seed no matter how bad our condition is, why would we eat the government's seed?" If a farmer believes he has to plant in a certain time, he has to be respected."

At first glance—especially considering the limitations of the soil-climate model—it seems to make little sense for SDR to assume the risk of making such a high stake decision. However, a closer look reveals that SDR does not have much to loose. First, farmers and their families, who may end up with no crops or food at the end of the season, bear the worst consequence of failure. Second, FUNCEME's *tecnicos*—who the media, policymakers, and the public in general have consistently blamed for their "wrong" forecasts—endures the brunt of the negative publicity for failure (Lemos et al. 2001).[25] Indeed farmers often believe FUNCEME is responsible for both lack of seeds and rural credit. In interviews, bank managers and extension agents admitted offering FUNCEME's forecasting as the reason to deny credit and seeds to farmers.[26] In addition, in 1996 the state legislature held hearings on FUNCEME's work during which a few representatives questioned the need for the agency to exist.

Therefore, although SDR has the ultimate responsibility for generating and enforcing the planting calendar, it has been able to "shift the blame" to FUNCEME. This strategy works precisely

[25] FUNCEME scientists have repeatedly and unsuccessfully attempted to communicate the probabilistic nature of their forecast. By most accounts, the agency has been consistently hurt by bad publicity related both to seed and credit distribution.

[26] In 1997, for example, it was reported in the media that in a public protest in the city of Tauá, local farmers marched into the city central square carrying a coffin with FUNCEME's name on it. They wanted to "bury" the agency after the local bank refused them credit allegedly based on FUNCEME's forecast of low rainfall for the region.

because SDR *técnicos* are able to protect themselves under the umbrella of expertise. Yet, while this strategy may shield SDR in the short run, it has been tremendously detrimental to FUNCEME and has significantly eroded the public's trust in forecasts in general. Farmers interviewed for this study often reported that upon receiving FUNCEME's forecast they are inclined to believe that exactly the opposite forecast will be true. For example, according to one farmer "every time FUNCEME tells us it is going to rain, I know there will be a drought coming." During the three years of drought that coincided with the field research for this study, the research team heard many different versions of this type of statement. FUNCEME forecasts also consistently fared lower than traditional methods of prediction in users' trust in our survey sample. Table 9 shows the sources of forecast information by *município*.

Table 9: Sources of Climate Information by *Municípios*

Município	**Knowledge of FUNCEME Activities**	**Belief in FUNCEME Forecasts**	**Knowledge of *Profetas* and Traditional Experiences**	**Receive Climate Information**
	% HH	**% HH**	**% HH**	**% HH**
Limoeiro do Norte	99	5	79	86
Barbalha	67	10	85	85
Parambu	95	6	80	84
Boa Viagem	90	4	86	86
Itarema	51	3	79	74
Guaraciaba do Norte	44	4	72	75
Total	75	6	80	82

Regarding drought relief, on the other hand, the use of climate-related information played a positive role in enabling policymakers to keep the program from "political meddling". As discussed earlier, the drought emergency relief program had gone through a successful reform which dismantled the traditional network of clientelism and corruption that plagued its implementation. However, transition from the clientelistic model to the new more democratic COMDECs was not smooth. Although since the beginning Civil Defense as an agency had the support of the governor to reform the system, in practice, implementation proved complex. Not surprisingly, local political bosses fiercely resisted Civil Defense's new model and attempted to undermine the new model either by "capturing" local committees and trying to control their membership or directly lobbying the governor to curb the *técnicos* actions in their strongholds.[27]

Although Civil Defense *técnicos* are quick to praise the governor for resisting such pressure, they soon realized they needed more than state government support to deal with the day-to-day politics of resource distribution in Ceará's many *município*s. One particularly difficult task was to

[27] For example, one técnico pointed out that the situation can get so politically charged that Defesa Civil official cars have to be disguised (usually they carry the agency's logo on their doors) so as to avoid problem and potential violence. Personal communication 2000.

challenge local political bosses on their turfs–some of them many times removed from the direct sphere of influence of the state government. On the one hand, *técnicos* were mostly perceived as outsiders to local politics and their mandate tended to dissipate in the context of local politics. On the other hand, the governor's reliance on these local politicians for electoral support places the *técnicos* in a delicate position.

It is in this context that the use of science generated information, especially climate information, played a critical role in facilitating the implementation of Civil Defense's new approach to drought emergency relief. Indeed, Civil Defense *técnicos* were able to shield themselves under the cloak of science to challenge the old clientilistic model.

A particularly innovative initiative was the creation, in 1997, of a need-base ranking of all the *município*s in the state for emergency relief. As described earlier, *técnicos* from the state Civil Defense agency established a series of criteria to rank *município*s according to their vulnerability to drought and need for emergency relief. These criteria included rainfall quantity and distribution, runoff, yield losses by *município*, vegetation index, and social unrest. All of the data used in this model–with the exception of the social unrest and crop yields– is provided by FUNCEME. Here again seasonal climate forecasting, although not directly used in the model, is described by *técnicos* as "background" information that warns them of the need to activate their local capabilities to implement the emergency program. Furthermore, high-rank policymakers at the Secretary of Planning and Civil Defense expect that in its next incarnation, the program will rely on seasonal climate forecasting to plan for drought. A new proposal to re-structure the emergency program calls for the implementation of a system of permanent response whose main goal is to decrease vulnerability to climate variability. In this case, seasonal climate forecasting has the potential to contribute to early preparation and budget planning.

After *técnicos* from Civil Defense establish the ranking of *município*s according to need, they prioritize the implementation of emergency relief. Next, the *município*s at the top of the ranking are allowed to declare drought emergency, which in turn qualifies their local governments to receive relief resources.

Here, climate information provides Civil Defense *técnicos* with sufficient weight to face political challenge from local politicians to their program. According to one técnico, the creation of the ranking has enabled him to challenge local mayors' claims of distress by confronting them with detailed compilation of crop losses, rainfall distribution, and runoff. The satellite pictures showing crops and vegetation and computer-generated maps showing rainfall distribution are particularly compelling as "proof" why such a *município* is not getting help or why another one has the priority. "Now, when they come knocking at my door and I show them the numbers, it is not I anymore saying 'No'."[28]

The different behavior of SDR and Civil Defense can be partly explained by their different approaches to drought policymaking. Both SDR and Civil Defense recognize that their reputations hinge on their ability to implement policy that addresses the devastating effects of drought in Ceará. Their means to implement it, however, are markedly different. Whereas Civil Defense strives to promote inclusionary approaches, SDR alienates its clientele and shifts the blame for failure to FUNCEME.

While SDR is a highly hierarchical institution, Civil Defense follows a much looser pattern of organization.[29] On the one hand, Civil Defense *técnicos* are very open and candid about the difficulties of changing the distribution of emergency relief in the state. They carry great pride in their work and consider themselves almost as crusaders for the governor's reformist approach. They are fiercely protective of their program and recent changes introduced by the governor–who transferred control of the program from Civil Defense to the Secretary of Planning–have left many of

[28] Personal communication 1998.

[29] This difference was clear when I tried to schedule interviews with both agencies. While I had no problem contacting and talking to Defesa Civil técnicos as many times as I needed in the three years I carried out field work in Ceará, the process was much more complex regarding SDR técnicos. In my first contact with *Hora de Plantar* técnicos, I was unable to talk to them separately. The interview was carried out as a group, but most of the information was provided by the head of the division. When I tried to contact a new group of técnicos at a later occasion, I was referred to their superiors for a formal authorization. I was advised to write a memo explaining the nature of the interview and my research.

them disappointed. They resent the hierarchy of the new system and fear for the future of the program.

On the other hand, SDR mid-level *técnicos* were more cautious in not contradicting higher ranked technocrats within the agency. Most of the *técnicos* interviewed were agronomists transferred from SDR's extension agency. Other SDR personnel involved in *Hora de Plantar* were also interviewed, especially extension agents responsible for registration of farmers and distribution of seeds at the local level. Their demeanor was more relaxed than *técnicos* in the capital and their commitment with the clientele higher. Most of the local extensionists disagreed with SDR's policy to keep the strict planting calendar. For example, an extension agent argued that his greater "experience" with farmers' work and way of thinking as well as his witnessing of their difficulties had convince him that farmers should be able to make their own planting decisions. In his view, (which was shared by other extension agents) SDR should increase resources at the field level so that extension agents could provide better support and advice to farmers enabling them to make better-informed decisions at their own discretion. Even SDR mid-level *técnicos*—who were much more careful on the kind of information they volunteered—pointed out that in cases of high uncertainty they thought it better to let small farmers decide when to plant based on their own experiences and local conditions. In 2000, this belief led SDR to authorize the distribution of seeds directly at the beginning of the rainy season, before FUNCEME's forecast had been released, leaving the farmers to decide when to plant. Still, a few higher ranked technocrats at SDR remain convinced that early distribution of seed is a "waste".[30]

Therefore, while climate information allowed Civil Defense to dispel some negative aspects of the politics of drought policymaking in Ceará, *Hora de Plantar*'s design insulated SDR from both farmers' participation in their own planting decisions and–by shifting the blame to FUNCEME–held the agency unaccountable to failure.

V.9 The importance of context in seasonal climate forecasting information use and production

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

[30] Personal communication, 2000.

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.

The quest for a technocratic policymaking model has historically lured and eluded policymakers in Ceará. Since the early 1990s, a new crop of drought policies based on seasonal climate forecasting has been implemented in the areas of agriculture and emergency drought-relief. The two programs analyzed here tell a different story of the use of climate information in policymaking.

The first program, *Hora de Plantar*, distributes high quality seeds to subsistence rainfed farmers according to a strict planting calendar based on a soil-climate model that establishes the "best time to plant" in different geoclimatic regions of Ceará. Despite model limitations and high levels of client dissatisfaction, policymakers responsible for program implementation believe in the superiority of their methods over farmers' best judgment. Although it makes little sense for technocrats to make risky planting decisions for farmers, the rewards for SDR are two fold. First, the agency bears little risk for its decisions since the farmers and their families are the ones most vulnerable to famine in case of crop failure. Moreover, by shifting the blame for failure to FUNCEME and its forecast, SDR defuses criticism to its implementation of the program. Second, SDR is able to insulate its policymaking process from outside meddling, especially from clients. However, such insulation comes at the expense of both FUNCEME's and forecasting information's credibility.

The second program, Emergency Drought Relief, has undergone significant change in the past decade. From a clientelism and corruption infested program, it is now considered one of the best examples of Ceará's new progressive politics. However, the extent and reach of such changes were not easy to accomplish. Although the program had the state government's support, its implementation in the context of day to day local politics was constantly challenged by the pattern of clientelistic politics historically dominant in drought-relief policymaking in the Northeast. Here the use of climate information critically enhanced the ability of Civil Defense *técnicos* to democratize emergency relief implementation both in terms of community participation and equitable distribution of resources.

Five conclusions of broader significance can be drawn from this discussion. First, the Ceará case demonstrates that in politically charged policymaking environments, the use of climate forecasting information may go beyond its problem solving function to influence broader issues of accountability and democratization, especially in the context of authoritarian policy systems in less developed countries. Indeed, climate information can be used in ways–both positive and negative–significantly different from the use information producers intended. The Ceará case further suggests that the value of the information is only partially dependent on its quality since, even at very low skill, climate information can be used to further policy agendas not necessarily associated with information producers' original goals. These findings question the assumption that better data use will undoubtedly follow improved skill.

Second, different from the Brazilian traditional technocratic model–in which insulation is engendered mostly through political leadership–in the cases examined here, government support was necessary but not sufficient to guarantee policy implementation. Thus, in circumstances where political leadership is vulnerable to electoral politics (e.g. democracies), science-based information may function as a critical factor enabling policymakers to avoid political meddling and corruption of policy intended goals. Consequently, in some cases, science-generated policy tools may be pivotal to enhance agency capacity to implement public policy.

Third, the use of science provides technocrats with a unique opportunity to “shift the blame” of policy failure elsewhere. For example, because climate forecast information is highly uncertain, policy failure can always be attributed to information lack of spatial and temporal skill. Although this position suggests a paradox between technocrats’ beliefs in the superiority of science-based information and their willingness to blame it for failure, their rationale is justified by what they perceive are the risks of working at the frontier of scientific knowledge.

Fourth, attempts to insulate policymaking can backfire and create exactly the opposite effect, that is, excessive politicization of the policymaking process and unnecessary discredit of science-generated information. By pushing for the use of experimental information as an operational tool, policymakers and information producers may compromise their problem solving potential as skill improves. Thus, policymakers and knowledge producers must take stock of the costs associated with the "operationalization" of predictive science. Decisionmakers crossing the barrier between science and policy in this case must be aware of the unwarranted and many times negative consequences of such move and their implications for the future.

Finally, the two cases examined in this article illustrate the importance of context–political, environmental, economic, and cultural–in the use of science-generated policy tools. In addition, they suggest that the value of such tools may go much beyond their inherent quality or ability to improve in terms of skill. Therefore, it is necessary for both information producers and policymakers to be keenly aware of the context where science-based tools are to be applied.

VI. Vulnerability of Rural Populations

VI.1 Background

The nature, indeed the definition, of drought is highly scale-sensitive. At a regional level, where climate science feels most comfortable, drought is defined in terms of precipitation and evapotranspiration, measures that objectify the phenomenon as purely climatic thus excluding any human dimension. At a local level, however, rainfall is only part of the drought equation, since two households subjected to the same rainfall regime may suffer radically different, even opposite, impacts. At this level, then, drought is as much a socio-economic phenomenon as a climatic one. To understand the variability in climatic impacts on local populations, social science has employed the concept of vulnerability (Ribot et al. 1996; Liverman 1989; Davies 1996:27), building upon the earlier contributions of Watts (1983), Corbett (1988), and others. Vulnerability is, of course, a negative condition in that sense that its absence becomes a desired social goal. But in the dynamics of drought response, vulnerability serves as an important heuristic concept for assessing both the sensitivity to climatic extremes (e.g., the destructive consequences) and the resilience of households (e.g., the capacity to recuperate from disaster).

Thus, the impacts of drought in Northeast Brazil, and in particular in the state of Ceará, are determined as much by the social and economic characteristics of the region as by the physical intensity and pattern of climate anomalies. In order to understand how seasonal forecasting can be used to mitigate negative socioeconomic effects of El Niño-related droughts, it is necessary to examine the origins and patterns of vulnerability in the region and the ability of different groups to obtain, understand, and respond to drought forecasts. It is also necessary to understand the coping strategies used by the rural population during previous climate-related disturbances. Several studies have documented the extreme vulnerability to recurring droughts of regional social systems in Northeast Brazil (Magalhães et al. 1988, Magalhães 1992). Less is known about coping strategies at the family and community levels. In order to determine the impacts of seasonal climate forecasting, we need to understand pre-existing strategies for coping with drought.

The notorious "drought polygon", which embraces all or part of nine states in the Brazilian Northeast, is a homogeneous physical concept that masks wide social inequities among the individual members of its population. Landless sharecroppers and independent smallholders still constitute the majority of the rural population, while land and wealth are concentrated in the hands of a small, politically influential group of families. The livelihood and vulnerability of the population are determined by access to land, cattle, employment, and capital (Johnson 1971). With these differences in opportunity and thus in levels of vulnerability, different segments of the population have devised different coping strategies for dealing with drought and the uncertainty that it imposes on socioeconomic *Decision-making*.

At a finer scale of analysis, anthropological household studies (e.g., Baro 1997; Finan 1994) have sought to identify and quantify the factors that would permit a classification of households based on relative levels of household vulnerability. This body of research has also depicted the strategies that different households employ to cope with climate-based transitional crises. At a regional analytical level, research has tended to focus on public policy and its role in drought alleviation (e.g., Wilhite 1987; Magalhães 1993) or as Carvalho (1995) has put it, to discover how society can "live with drought". In reality, the process of adaptation to extreme climate variability entwines both public initiative and private inventiveness in an interactive way. While levels of vulnerability vary across the population and across time, both public officials and local households seek to solve the puzzle of drought. In some cases, public decisions articulate well with local adaptive strategies; in others, public policies may reinforce local vulnerabilities by increasing dependency relationships.

VI.2 Socioeconomic Characteristics

The demographic characteristics for the sample population are presented below in Table 10. Some of the data, such as family size, tends to be consistent between the *municípios*. There has been a significant decrease in the size of households throughout Brazil over the last several decades and this is born out in the sample region as well. Literacy rates however, are much lower than the national level of 83%, though the inter-*município* averages reveal a fundamental difference in the amount of focus placed on education. More significant, though is the percentage of individuals that have completed primary school. Numbers are higher among the younger populations, a 25% completion rate for individuals 16-30 compared with 4.2% for those greater than 30, indicating a higher completion rate for youth. The overall rate of 11% however, is a limiting factor that hampers the ability of families to expand the number of income generating strategies. The low level of education results in low skilled workers and low paying employment.

Table 10: Demographic Information by *Município*

Município	**Family Size**	**Age of Head of HH**	**% Population**		**Educational Level**		**% HH Receiving Remittances**
			age 15	age 50	% Family Primary Complete (>15)	% Family Literate (>15)	
Limoeiro do Norte	4.8	51	3	4	17	76	15
Barbalha	5.5	55	3	1	20	73	27
Parambu	5.2	50	9	4	8	65	41
Boa Viagem	5.0	47	6	7	7	71	34
Itarema	5.9	49	1	9	9	66	28
Guaraciaba do Norte	4.8	51	0	9	6	62	42
Average	5.2	51	9	4	11	69	31

The diversification of income generating strategies is due to the fact that much employment in the region is based on, or related to, rainfed agriculture. Employment is seasonal and in order to maximize year round income a variety of sources are exploited. While more evident in the poorer households, diversification is found at all levels of the sample and demonstrates that in an agricultural based economy with an unpredictable climate, diversification of income is essential for all segments of the population. The sources of income include daily labor on farms and ranches, food processing, cutting and selling of firewood, and rock quarrying, among others. While this diversification is necessary even in normal years, in dry years when agricultural jobs dry up along with the water, it becomes crucial.

Table 11 presents a breakdown on the types of income sources. The most significant source of income is social security. Farmers are eligible for social security after 25 years of work but need to be at least 50 years of age to be eligible. An average of 36% of the households had at least one resident receiving social security and of these, over 40% had more than one person. The value of the income is equal to one monthly salary, equivalent in 1998 to US$ 76 per month. While seemingly little, this source of income is significant, consistent with, and independent of climatic conditions. To earn a minimum salary it is common for an agricultural worker to work six full days a week. Such steady employment is difficult to encounter. As a result, households with a social security recipient have a per capita income 73% higher. Social security serves not only for the needs of the immediate household but during times of scarcity also becomes important for nearby relatives and neighbors who may have no source of income.

One frequent source of income is migration to the *município* centers, state capitals, and to the south of Brazil. Migrants seek employment and send remittances to the family in the form of cash or consumer goods. The number of households dependent, to varying degrees, on this type of financial assistance is large. Some households receive remittances on a weekly or monthly basis, and others more infrequently. But the fact that 31% of all the households participate in this type of economic exchange highlights its importance as a strategy. While the high percentage of people sending remittances indicates a significant rate of migration on a continual basis, the onset of drought stimulates a much higher rate of exodus. During normal years the majority of the migrants who assist with household expenses are the children who head to urban centers to look for wage labor. In times of stress the outflow of people still consists of sons and daughters but there is an increase in the number of household heads and entire families. While some of these groups migrate permanently, the household heads generally return before the beginning of the next agricultural season.

VI.3 Agricultural and Livestock Systems

Virtually all of the households interviewed were involved with agricultural production to varying degrees. The variation in degrees of involvement in agriculture indicates a wide range of strategies undertaken by households for advancing the well being of family members. Those few households in 1998 that did not cultivate were commonly retired farmers who lived off of pensions with the help of extended family, or they owned a commercial establishment from which they made their living.