

**Use and Usefulness: a Comparative Study of Seasonal Climate
Forecasting Systems in Drought-affected Regions of Latin America**

Final Report

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I. Preliminary Materials

A. Project Abstract

Droughts have often caused serious agricultural losses and human suffering in arid and semi-arid regions of the world. As the scientific capability to anticipate seasonal climate variability becomes more sophisticated and available to stakeholders, the use and usefulness of such information gains increasing attention on the agenda of social science research.

This proposed research aims at carrying out a comparative study of seasonal forecast (El Niño and La Niña) use in Brazil and Chile. A detailed comparison of policy applications and users' response in these regions—the state of Ceará in Northeast Brazil, and Coquimbo in northern Chile— will be carried out to assess current and potential seasonal climate forecast data use. Both policy analysis and ethnographic methods will be used to accomplish this task.

The study seeks to understand how seasonal forecasting—particularly the El Niño/La Niña forecasting—can be used by policymakers and end users, such as farmers, to mitigate the negative impacts of climate-related hazards. It aims to address the following research questions: How is local climate information generated and distributed to the stakeholder community? How do policymakers integrate climate forecast information into public institutions responsible for drought preparedness? How do such factors as local political cultures and belief and value systems affect the decision to use seasonal climate information? How do public institutions and private stakeholders (farmers, merchants, utilities companies, etc.) respond to drought? What policy practices appear capable of being disseminated across the different regions?

The advantage of the cross-country comparative framework proposed here is that political systems and the socio-economic livelihoods (and vulnerabilities) also vary, thus providing a framework for examining the dynamic between climate forecasts, policy decisions, and farmer response. In this way, an assessment of the use and usefulness of climate forecasting systems in contrasting socio-economic and political contexts is proposed in order to identify the best public and private strategies for mitigating the impacts of extreme climate variability. To the extent that climate information systems also vary (in terms of quality, frequency of forecasts and strategies of dissemination), it is possible to examine different interrelationships between climate information flows and mitigation policies. In this approach, the introduction of a common methodological framework for the comparative analysis of the use of climate information systems across the regions is proposed.

With this systematic research, an analytical approach that can be adopted throughout the region, to stimulate a more international arena for climate impact discourse, create a cadre of social scientists focused on climate issues, and identify practical and widely

applicable strategies for integrating climate information into a wider policy making framework is proposed.

B. Objective of Research Project

There are two primary objectives to this research. The first is to generate an analytical approach that can be adopted throughout the region and to stimulate a more international arena for climate impact discourse to identify practical and widely applicable strategies for integrating climate information into a wider policy making framework. The second objective, which applies to the Brazilian case is to develop and implement a method by which local level politicians and decision makers are able to integrate seasonal climate forecasts within their planning structures.

C. Approach

The research sets policymaking outcomes and farmer decision making as the dependent variables with climate information, local institutions, and climate vulnerability as the independent variables. We seek to establish the extent to which different forms of access to climate information will have an impact on the ultimate impacts of a severe climate event, given a political context and underlying levels of farmer vulnerability. As importantly, we intend to examine the dynamics of the decision making process itself. To achieve this objective, it is necessary that in each country a uniform methodological approach is adopted. Policy makers, scientists, local politicians and bureaucrats, and farmers will be consulted in order to link information to decisions (policies) to results.

While individual case studies of the role of climate information in alleviating the impacts of climate extremes have begun to demonstrate the value of social science research on climate variability, there is a lack of systematic comparative analysis across country experience, a lack which this proposal attempts to correct. Cross-national comparisons have already proven effective in illuminating the role that social and cultural institutions play in the application of scientific knowledge to policy making (Jasanoff 1997, Miller 1998). The lessons to be learned from a comparison of the use and usefulness of seasonal climate information in countries at different levels of development could be fruitfully applied to analyzing the successes and failures of particular policies in particular countries. They can also critically contribute to theory testing and building. More importantly, if we are to design effective institutions to mobilize science in support of global governance, we must better understand how different countries view science and its role in policy making (Miller 1998).

Public structures, such as agricultural ministries and civil defense agencies make and implement policies that affect end users. This step is where the proposed policy making analysis occurs. The ways in which information affects end users either directly or through the policy process will depend on the levels of vulnerability in the end user group, thus the need for vulnerability analysis. The actual use of the information in decision making is visualized in the last step, where the usefulness of information is

assessed by analyzing the actions or decisions related to climate impacts. This general sequence will be followed in each country study.

A previous Northeast Brazil project, also funded by a NOAA HDGCR program has developed a research methodology that can be adapted to the respective realities of the partner countries. This methodology has utilized a mixed methods approach that combines key-informant interviews with more formal survey techniques to identify the linkages between state level decisions and local level responses to climate variability. The following steps constitute the principal components of this approach:

- As a background prerequisite, the research team describes the nature of climate variability in the region under study, using available historical data on precipitation, rainfall, severe events, etc.
- Second, the team assesses the existing climate information systems and their targeted audiences, including the indigenous, or “ethno-meteorological,” sources of information.
- Third, key-informant and focus group interviews are used to identify the public role in climate mitigation, focusing on the agencies that produce and disseminate climate information and the state and local structures that prepare for or respond to climatic crises. It is particularly critical to document what information sources influence decisions and policies at this level.
- Fourth, the research team determines the level and determinants of the vulnerability of the potential information end users, primarily farmers and ranchers, but including merchants, local utilities providers, health providers, and other affected local institutions. In essence, a social vulnerability map is created.
- The final component of this process is the integration of the different data sources into an analytical framework that generates a model of the use of information in climate-related public and private decision making.

II. Interactions

A. With Decision Makers

In both Chile and Brazil this project worked directly with decision and policy makers at both the local and state levels, and in Chile at the Federal level. In Chile these individuals included policy makers responsible for agriculture, drought mitigation and public policy. In Brazil these individuals were initially involved in key informant roles that informed our early conclusions and our methods for mapping and planning. In later stages these same individuals became partners in developing and carrying out the research tasks including participation in the baseline focus groups, expert groups, and planning workshops. The types of individuals included representatives from the State Secretary of Agriculture, *prefeitos*, *vereadores*, and other local community representatives such as persons from the local churches and farmers associations.

B. With Climate Forecasting Community

In both studies efforts were made to articulate with the wider climate forecasting community. In Chile the efforts were directed primarily at providing an understanding of what type of forecasting community existed and what products and services they provided. This community is comprised of University researchers as well as private sector meteorological firms that provide forecasts for private and public interests. In Brazil work focused on how the forecasts provided by FUNCEME could be successfully integrated into a drought preparedness and mitigation plan. By helping FUNCEME to better understand the needs and constraints of the forecast end-users the meteorological service can focus efforts on truly useful products and outputs.

III. Accomplishments

A. Research Tasks Completed

The first activities during included a series of field visits by all of the team members that were designed to introduce everyone to the different country contexts and environments as well as to further develop the framework and methods that underlie the research and analytical approach.

The first meeting was a ten-day field visit in October to Chile. The visiting team consisted of co-PIs Finan, Lemos, and Nelson; Brazilian colleagues, Dario Mayorga (Universidade Federal do Ceará) and Roberto Sergio Souza Farias (FUNCEME); and climate researchers from Mexico and Argentina. During the first two days, a climate and vulnerability conference was held at the University of Chile organized by co-PI Leon and team members Milka Castro and Miguel Bahamondes. This conference provided detailed descriptions of Region IV, of the state of climate forecasting in Chile, and the role of government in the mitigation of climate-based crises. The conference was followed by a field trip to Region IV, by land transport, over a period of five days. The team visited small-scale communal farmers (comuñeros) as well as medium and large scale growers of fruit and grapes for export. In La Serena the team made a presentation to a wide range of public officials responsible for agriculture, drought mitigation, and public policy in the region. During this trip to Chile, the Brazilians, Chileans, and the U.S. based project members had ample time to discuss the important climate issues and the research methodology in Chile.

The second meeting was a eight day trip from Chile to Ceará during the first week of December. The visiting team members from Chile included Leon, Castro, and Bahamondes. During this trip, the visiting project team was introduced to both the Universidade Federal do Ceará (Department of Agricultural Economics, primarily), to FUNCEME (the state climate forecasting agency), and to SEPLAN (the Secretariat for Planning, where all drought policy is formulated and coordinated). The entire project team then visited the field sites in Limoeiro do Norte and Boa Viagem, in the interior of the state. In each município, the group met with different kinds of farmers, local government representatives, and other informal leaders. At the end of the field trip, the

group met in Fortaleza to plan out the fieldwork and methodology in Chile. The opportunity to compare both study sites and approaches was extremely beneficial to both country teams.

In Brazil, during the first year the research team was able to create an effective research partnership between the state-level Secretariat of Planning, the Universidade Federal do Ceará, and the local-level Prefeituras. Following this organizational activity, the partners identified and trained additional team members, which was completed in December at the State Rural Extension training center over a period of three days. Over 20 people participated in this training, including team members from the local municípios. In January, intensive fieldwork was carried in Boa Viagem and in February, the município of Tauá was completed. This fieldwork involved field teams comprised of UFC project members and students, SEPLAN team members, and local partners. All travel support was provided by the State of Ceará. The purpose of the first round of fieldwork was to conduct baseline focus groups to understand the primary factors behind the population's inability to successfully prepare for and respond to the occurrence of drought. In addition, key informant interviews were carried out with decision makers and local politicians to gain insight into how they may be better able to use climate forecasts.

During the first year in Chile the team identified and trained the research team and developed their fieldwork strategy. During the month of April the core team (Leon, Castro, Bahamondes) returned to Region IV to conduct a rapid assessment of the proposed field sites. One of the major concerns was to define common research questions across the two countries (and regions) and to adopt similar methodologies that will facilitate cross-country comparisons and insights. It was decided that the sample of stakeholders would include both the small-scale comuneros and the export-oriented growers. Also, the research instrument used in Brazil was adapted to the Chilean context.

In January of 2002, the Co-PIs and field team from Brazil, Chile, and Arizona met in Tucson AZ for a five day workshop. This was the first time that all of the investigators were able to meet after the research was initiated. The workshop was divided into three parts. During the first two days, each country-team presented the research carried out in Year One and their preliminary findings. The following two days were devoted in part to comparing and refining methodologies. In addition, there was significant discussion on points of comparison of the institutional, physical, and social environments, highlighting both similarities and differences to focus further analysis. During the final day the participants outlined a work plan for the remainder of year two and year three. The work plan outlined areas of continued research, as well as future meetings. After that, part of the team went on a short trip to Sulphur Springs, Arizona, where field research focusing on climate variability and farming is being carried out in the context of the Southwest Climate Assessment (CLIMAS).

In Year Two, field activities initiated in August 2000 in Brazil were continued. The previous three years of research in Ceará (1997-2000) succeeded in identifying the vulnerabilities of different farmer groups throughout the state. Since this research

revealed that the most vulnerable groups of farmers are those who benefit least from climate information, the research focused on the use of climate information by local policymakers. The research question was defined as: How could a município leader, the prefeito (roughly, mayor) use climate forecasts to mitigate the impacts of drought? The research strategy then was to ascertain the kind of information tools that the prefeito would need to do such proactive drought planning.

To achieve this strategy, we designed a method of “vulnerability mapping” at the município level in order to use as a planning tool. In July and August visits were made to Tauá and Boa Viagem municípios in order to validate and refine the vulnerability maps created based on the first year baseline fieldwork. In both municípios the maps were presented in public forums. Participants included the prefeitos (mayors) and other municipal representatives, as well as church and community leaders, members of the extension service, and interested members of the local communities. The purpose of the forums was to present the maps and generate feedback to determine whether our vulnerability maps based on the sample communities accurately represented vulnerability according to the município residents. Based on the feedback from the participants, changes were made both in the methodology and in map interpretation.

In addition, fieldwork was carried out in Limoeiro do Norte, the third sample município, by team members from the Federal University of Ceará, FUNCEME, and SEPLAN (the Secretariat for Planning). Vulnerability maps were developed based on this work and, as in the other municípios, presented in a public forum. Based both on the participatory methodology and the feedback from the forums, we developed survey questionnaires to be applied in the remainder of the communities in the pilot municípios. The questionnaires were developed as a part of an effort to simplify the mapping procedure in order to institutionalize the process and ease its inclusion in a more massive state-level effort to map the vulnerability to drought of Ceará.

In Chile, the purpose of the research was to define the vulnerability of different rural stakeholders to climate variability and to document the public role in relation to climate-based crisis. Research work focused primarily on the vulnerability assessment activity. During the month of May, team members Leon and Bahamontes applied the quantitative and qualitative survey to the proposed field sites. The sample of stakeholders includes small-scale comuneros and individual landholders, as well as a few export-oriented, larger growers. The survey was thus applied to different categories of farmers, according to a) land tenure regime (i.e. communal and private), and b) origin of irrigation water (i.e. from reservoirs on one hand, and rivers, streams, or springs on the other). Also, the research instrument used in Brazil was applied to the Chilean context, since one of the major concerns was to define common research questions across the two countries (and regions) and to adopt similar methodologies that will facilitate cross-country comparisons and insights.

Sampled households from the Comunidades Agrícolas include three sites—Carquindaño (municipio of Canela), El Tome (municipio of Monte Patria), and El Durazno (municipio of Ovalle). Some households in the Comunidades Agrícolas may have water rights to

rivers, but the general rule is that they depend on less secure sources for irrigation such as streams and springs, to which they have historical rights.

Private small-scale properties, depend on a river for irrigation water, were surveyed in the municipio of Río Hurtado. Other small-scale growers in the municipio of Monte Patria, but depend on a reservoir were surveyed in the area known as Guatulame. These households appear as less vulnerable because droughts have never been so intense to dry up these watercourses. Nonetheless, distance to markets in Río Hurtado seems to be a key issue. Data collected through the survey is in its final phase of processing.

To examine the use of climate information at the state level, the research team applied an in-depth questionnaire to a sample of 30 mid-level técnicos (in Brazil) and 34 (in Chile). The main goal of the questionnaire was to go beyond the consolidation of information on user's needs and constraints for data use and build policymaking models which highlight where state-of-the-art climate forecasts information can be incorporated into resource decision-making. Following a methodology developed by Steve Rayner, Denise Lach and Helen Ingram in their comparative study of water management in three U.S. water resource systems, we identified conditions beyond improved information reliability, accuracy and skill, which would increase or constrain the use of seasonal climate forecasting in the areas of agriculture, water management and disaster relief in Ceará and Chile. The idea was to examine not only data use constraints related to climate information characteristics but also to the policy systems themselves, identifying institutional, political, and cultural limitations and opportunities that shape water management in Chile and Brazil. This component of the study aimed at complementing research carried out from 1997-2000 in Ceará and building up a database that could be compared to Chile.

The final year of work in Brazil focused on finalizing the vulnerability maps and using the maps in public forums as a basis to design short and long-term drought planning. Once the team felt comfortable with the variables and methods used in creating the test maps a simplified method was initiated to cover all of the communities in each of the 3 pilot municípios. This was done through a series of district level expert meetings. Based on the information generated, município level maps were produced that represented the vulnerability of each community. Following completion of the maps, the teams returned to each município for a series of working forums in which community members and representatives worked through a series of exercises based on the maps to create a list of priorities in terms of drought response and drought preparedness activities. These lists and supporting information were then presented in a plenary session with the local government officials for feedback and a discussion of how these priorities could be incorporated into the município drought and development plans.

During the last month of the project the team organized a major, two-day workshop of stakeholders and policymakers in August. With over 80 attendees, the conference was widely disseminated over newspaper and television.

The final efforts in Chile went into the production of a Chilean policy seminar/conference that united team members from the US and Brazil with policymakers and local planners to discuss the impact of climate variability, climate vulnerability of the different sectors of Region IV, and the role of policy in mitigating drought. This seminar initiated the development of a proactive approach to climate planning, specifically to exploit the significant potential of climate forecasting.

B. Research Results

Drought Planning using a Participatory GIS:

- Provides more effective drought response by incorporating climate forecasts
- Democratizes the planning process
- Visualization is a common language
- Empowering
- Information is more credible and acceptable to policy makers

Policy Linkages

- Policymaking organizations supported by a strong technical mission and guided by clearly-stated goals, job evaluation criteria, and regulations will be more flexible to adopt and promote techno-scientific information in decision making;
- Organizations with adequate financial and human resources and with a history of innovations are more flexible to adopt techno-scientific information in their decision making processes;
- Innovation prone organizations with high personnel commitment to public participation are more likely to use techno-scientific information as a tool to democratize decision making;
- Water management organizations rooted in traditionally clientilistic strongholds with a history of conflict over resources are more likely to use techno-scientific information to insulate decision making from stakeholders;
- Users with better access to sophisticated communication sources such as the Internet and with a wider range of technological choices to adapt are more likely to incorporate techno-scientific information in their decision making;

C. Elaboration of Key Findings

The findings from this research have importance for each of the countries as well as for comparison purposes. The important climate information for both countries relates to precipitation. In Brazil the critical information is the amount, timing and duration of rainfall. In Chile the most relevant information relates not only to rainfall, but also due to the reliance on irrigation from snowmelt, to winter snowfall levels. The important points of comparison and contrast between the Ceará and Chilean case that became apparent include:

Farmers are not the proper level to target climate forecasts. This is true in both country contexts. While all farmers show interest in having access to climate information there are few that have the available resources and opportunities to take advantage of the information. This issue of targeting forecasts is of greater interest in Brazil where there are public sources of climate information. There is not the same level of access to climate information in Chile where the information is generated by private firms and is sold to the end users. But the lesson is just as valid. In Chile as in Brazil, efforts to create climate information products should focus on the policy makers at both local and state/federal levels.

The simple existence of climate information does not necessarily lead to its use or proper use by decision makers. While it seems a simple insight, this is not understood by a majority of the information producers.

There is no effective, state-funded climate forecasting infrastructure that contributes to public policymaking in Chile, in contrast to Ceará where the public investment in forecasting systems has been exceedingly high. On the other hand, Chile has an active private market for forecast information that does not exist in Brazil. Despite indications that some private forecast users have paid during several years for this service provided by one climatologist from the University of Chile, the information has not been utilized in the decision making process.

The overall public role in mitigating climatic crisis appears much reduced in Chile, while in Brazil a drought engenders a widespread public response. In both countries the overall public role in mitigating climatic crisis is limited to crisis management. The public sector usually redirects its funds in order to assist those in need during a drought. In Chile, droughts can be officially declared as such only after two consecutive years with below-normal precipitation. This official recognition triggers the public response, which is usually oriented to providing basic goods and services such as water pumps, hoses, and free transportation for the cattle. Public funds can also be utilized for improvements of infrastructure such as irrigation canals. Nonetheless, it appears that the aid is not necessarily oriented to the most vulnerable households within the study area, but to those enjoying higher political clout. There is definitely no proactive drought planning, at neither the governmental nor the community level. In neither case is proactive drought planning well advanced.

The nature of vulnerability in Chile mostly involves issues of water management and water rights negotiated among stakeholders, while in Brazil the water management is much more centralized and politicized.

Specifically in the case of Ceará, this project has had a major influence on policymaking in the state of Ceará. First, it has demonstrated that the appropriate use of climate forecasting as a “new technology” in the hands of policymakers must be learned over time. It is only now that policymakers in the state are beginning to use climate forecasts as a planning tool. The change in perception away from drought as an abnormal climatic event toward drought as part of the reality of a semi-arid environment has pervaded most levels of state government. Thus, the widely accepted goal is to not be caught unawares in the advent of the next drought, but to plan as if drought might occur next year. Then the forecast becomes a trigger in the process, mobilization a series of actions designed to mitigate the impacts.

Local vulnerability maps are effective tools for planning at the local level. They present an objective and transparent reality with regard to climate variability. It is possible that local governments will set priorities in response to other kinds of realities (i.e., political ones), but they do so in the face of very public information about where the greatest vulnerabilities lie within the município. It is an immense change to see local authorities talk about vulnerabilities and drought planning.

The focus on local vulnerabilities and planning has also change the way state offices do business. It was standard procedure for state planners to develop state-level programs, and then seek municípios to participate. With this project, the municípios develop the plans, and then pass them onto state offices for resource allocation decisions.

The project has developed a methodology for research and planning that is unique in climate applications. The methodology for vulnerability mapping uses a GIS framework for organization of data layers and includes all the secondary data (on water sources, infrastructure, drainage, land use) available in state planning offices. With this basic data set, the methodology has designed a community sampling process and a participatory research approach to involve local populations in the actual definition of their own vulnerability.

Regarding institutional analysis of drought planning at the national and state level, findings indicate that the use of climate information in decision making is affected both by broader formal institutional arrangements such as legislation, level of decentralization, and access to information as well as informal arrangements such as organizational culture and individuals’ commitment. On the one hand, Chile’s more centralized policy system seems to less conducive to the kind of flexibility needed to incorporate innovation in decision making, especially in drought planning at the local level. On the other hand, as far as water management is concerned, the higher level of privatization in the system in Chile might make it more willing to adopt innovation that can increase profit margins. In addition, the lack of an institutionalized system of climate forecasting production and communication is a clear impediment to its use in drought planning. In Brazil, recent

institutional change, especially in the water sector towards a more participative and open process, has created the opportunity for the incorporation of climate information in water management decision making at the watershed level.

D. List of Publications and Presentations

Society for Applied Anthropology 2002. *The dynamics of vulnerability: three years of drought among subsistence farmers in Ceará, Northeast Brazil.*

Society for Applied Anthropology 2004. *The Marriage of Technology and Democracy: Reducing Vulnerability to Drought in Ceará, Brazil*

IV. Relevance to the Field of Human-Environment Interactions

A. For Use of Climate Information in Decision-Making

This research contributed to a greater understanding of how climate information can be better incorporated in decision-making both in terms of inter-regional insights as well as country specific lessons. The Brazilian study was especially successful in making inroads in how policy makers can take advantage of climate information to better the efficiency and effectiveness of both short and long term policies. The research provided both theoretical and operational frameworks as well as tested methods for including short-term climate forecasts into local and state level responses.

While the forecasts have been produced for the last 15 years the government made ineffective use of the information available. By providing a framework in which planning actually occurs there is the opportunity for ex ante activities rather than the ex post activities that were the norm. By providing the tools and a forum for public discussions of vulnerabilities to drought, identifying the worst off populations and why they are the worst off, policy makers can begin to prioritize the types of activities and the geographical targeting of those activities.

Some policy makers display reticence in using climate forecasts to initiate activities, primarily due to the expenses involved. Climate science is not an exact science. Policy makers do not always like to deal in probabilities when it involves large-scale mobilization of physical and financial resources. Therefore the idea of basing a large-scale response on an inexact forecast has a limited number of detractors. However, many others recognize that first, responses do not have to be sudden and complete. When a forecast for less than normal precipitation is released responses can be gradual and can increase or decrease depending on future forecasts and actual rainfall. Second, initiating activities in response to a forecast is a much cheaper way of helping a population than waiting to respond until after the population has been seriously impacted.

In the past climate forecasts were often anticipated in the same way one might anticipate a doomsday prediction. This is true for politicians as well as the rural populations. This

project has made inroads into helping the public and policy makers understand the critical role that climate forecasts can play in mitigating impacts of climate variations. Rather than view forecasts in a negative light, forecasts are beginning to be understood as a tool that can be exploited to reduce the likelihood of negative impacts due to drought.

B. Building on Past Research

This project was based on previous Human Dimensions research carried out in Brazil and in Chile. The Chilean work was funded under an NSF Doctoral grant that looked at farmer vulnerability to drought in Region IV of Chile, in the Coquimbo area. The past work in Brazil was supported by NOAA's HDGCR and was focused on understanding how climate information was used by policy makers and by farmers in the interior.

C. Contributions to the Following Areas

i. Adaptation to long-term climate change

The first step in adapting to long-term climate change is for policy makers to realize that climate is a legitimate topic to include in their policy debates. This project has contributed to this realization and the change in rhetoric at the state and local levels. The shift in the approach to drought was that rather than trying to 'solve' for drought the decision-makers began to talk about 'living with' drought. This shift in rhetorical perspective gives the state much more leeway in its ability to plan for eventual droughts. In addition to adding to this shift, this project also helped policy makers to recognize that droughts cannot only be considered from a technological perspective that focuses solely on water storage as a drought response, but that drought and other climate impacts are as much a result of socio-economic processes as any climatological phenomenon.

ii. Natural hazards mitigation

The methods developed in this project incorporate short-term climate forecasts into the process by which the state and local governments respond to drought. Previous drought mitigation efforts were triggered by a threshold of human suffering measured by production losses, lack of drinking water, out migration and social unrest that can include sacking food warehouses and blocking highways. Timely and well thought out responses to natural hazards will result in a significantly improved level of service delivery and a reduction in the level of human suffering that has traditionally resulted from drought.

iii. Developing tools for decision makers and end-users

A primary output of this research is the theoretical and operational framework for planning for drought as well as long-term goals. The state of Ceará has shown significant interest in the framework and it has been incorporated into the rural development strategy. A vulnerability map is a visual tool that aside from the participatory and representative nature of the information portrayed, is something that is accessible to almost everyone. In a region characterized by high levels of illiteracy a visual tool makes

a striking contribution to transparency and increased understanding between policy makers and local populations.

iv. Sustainability of vulnerable areas and/or people

The project recognizes that simple mitigation of drought or natural hazards does not contribute to any type of long-term stability or sustainability in terms of a population's livelihoods. For this reason the research framework has emphasized the equal importance of long-term development planning. In the past a primary constraint to sustainability of development programs and their outcomes was the occurrence of drought. Because drought was not planned for the occurrence served as a major set back to development goals. This project incorporates the reality of drought within the overall development approach. By doing so the types of policies and plans developed by the participatory groups and local and state decision-makers stand a better chance of achieving their long-term goals.

v. Role of public policy in the use of climate information

There are two principal groups of end users that were considered in this research, rural farmers and public policy makers. In both countries the vast majority of farmers are too resource poor to be able to use the forecasts. Therefore, one of the conclusions of this research is that the policy arena is precisely the context in which climate information can make a strong contribution to reducing the impacts of climate variation. The Brazilian case has provided a framework and methods for joining public policy and climate information to reduce both short and long term vulnerability to drought in the region.

D. Suggestions for Future Research

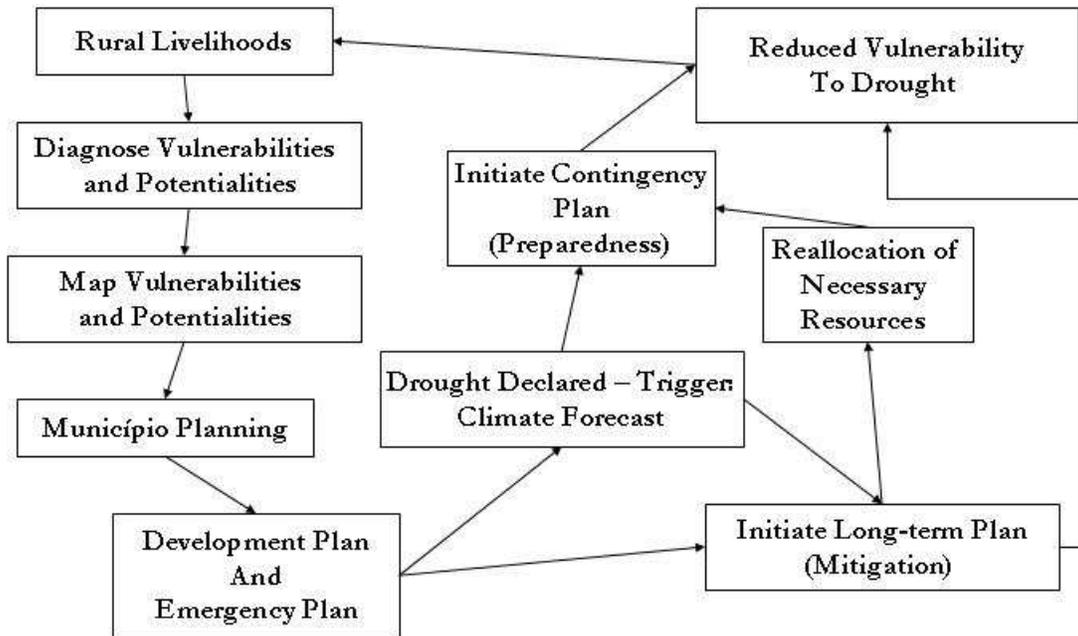
There currently exists a great opportunity in the State of Ceará to move even further with this type of research. The fact that the State has already incorporated the framework into its rural development plans for 2004 demonstrates the high level of interest. However, the State does not have the technical capacity or understanding to actually implement this type of work. In light of this future work in this region should include:

- Capacity building at the local and state government levels for individuals that would be involved in implementing the State's plan
- Training for local and state level policy makers on the potential contributions of climate information
- Additional research into successful policies at the local level, including a focus on irrigation districts

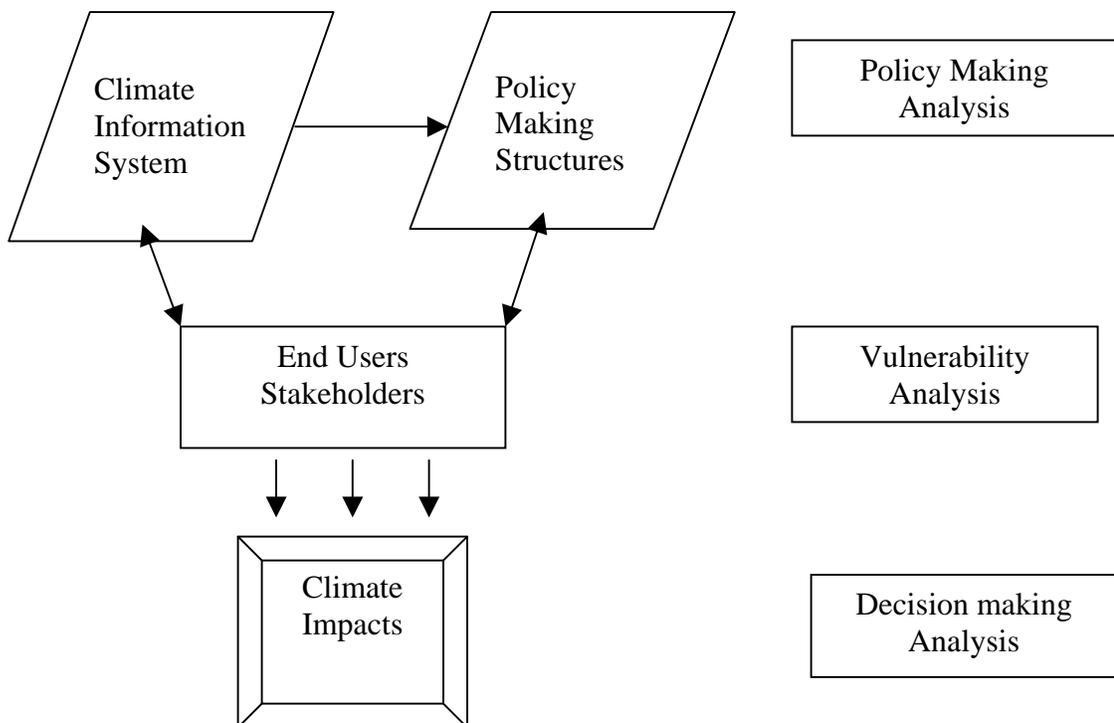
V. Graphics

Mapping, Planning and Drought Response Model

PGIS and Drought

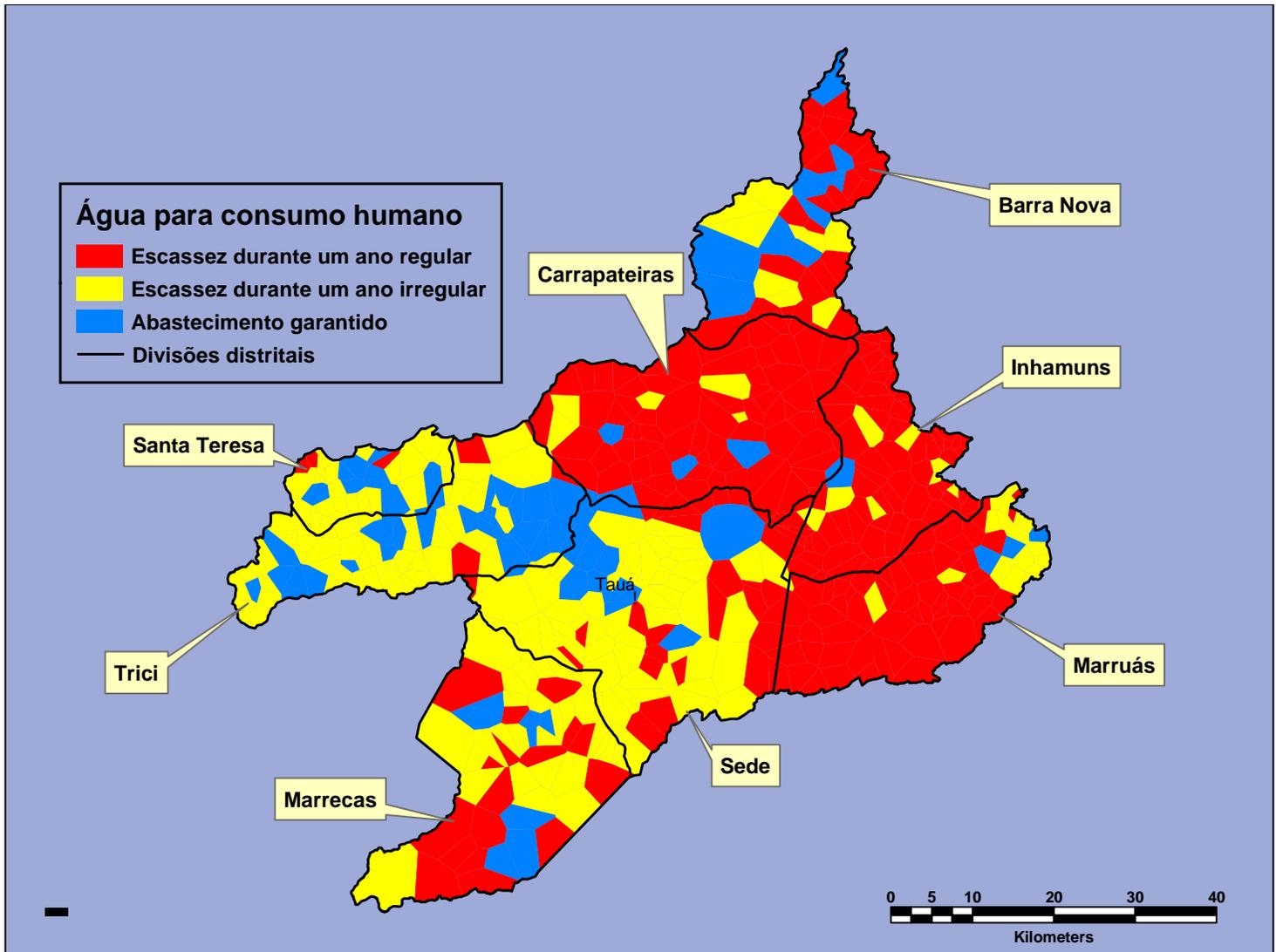


A visual model of information use and usefulness



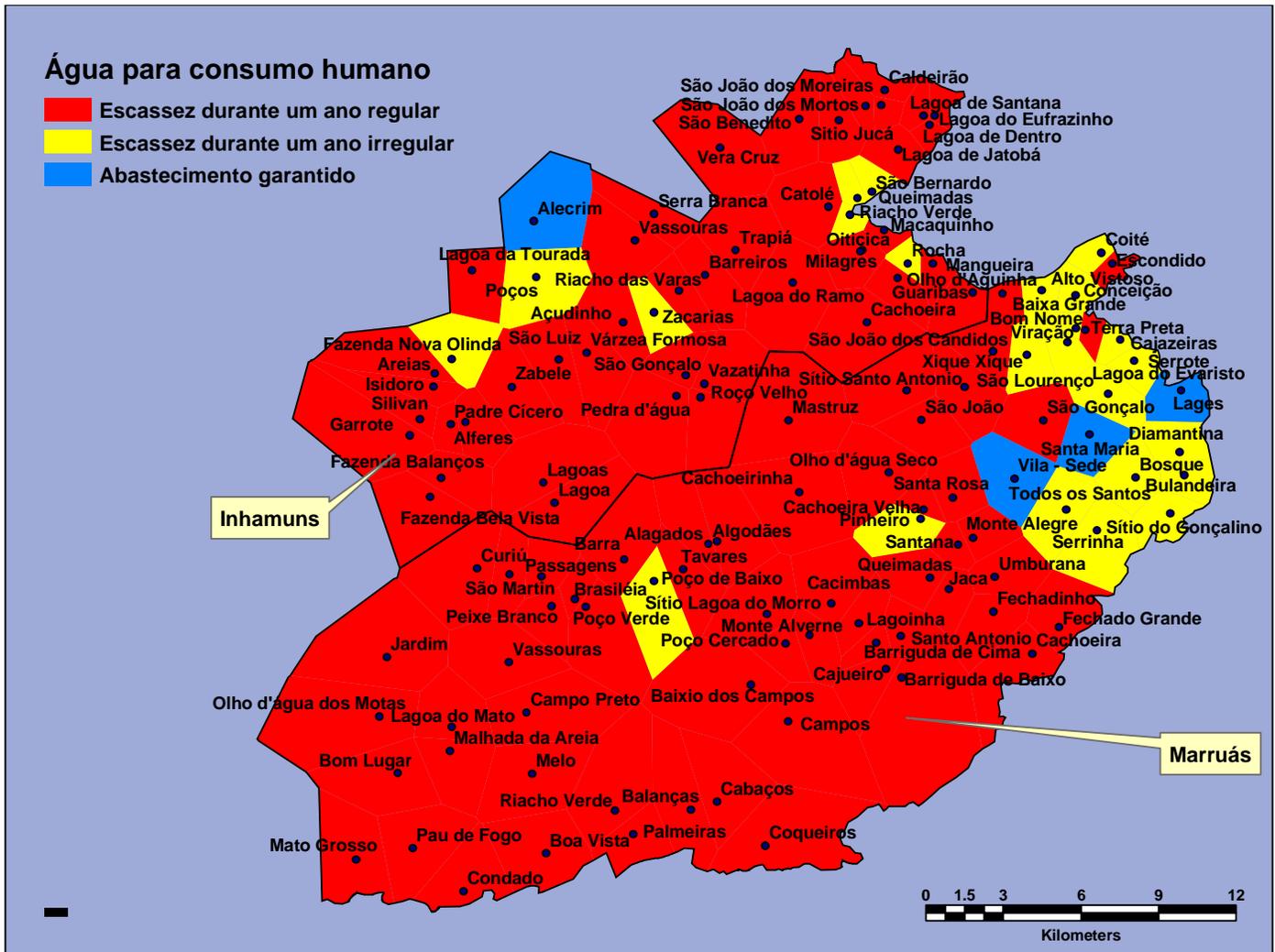
Examples of Vulnerability Maps

Map 1



Map 1 presents the state of water for human consumption for the município. The red areas indicate communities that experience difficulties with water every year. Yellow represents areas that have problems only in drought years, and blue portrays the communities that never have problems.

Map 2



Map 2 also represents water for human consumption but at a resolution that displays the communities themselves.

Planning sessions





Expert focus groups

