Final Report for National Oceanic and Atmospheric Administration Human Dimensions of Global Change Research Program

May 24, 2002

Project Title: A Case Study of Burkina Faso; Opportunities and Constraints to Using Seasonal Precipitation Forecasting to Improve Rainfed Agricultural Production Systems and Livelihood Security in the Sahel-Soudan Region, Climate Forecasting for Agricultural Resources (CFAR) – Phase 1.

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NOAA Grant Number: Award Number NA76GP0327

Time period covered: 1 June 1997 through 28 February 2002

I. Preliminary Materials

A. Project Abstract

In 1997 Tufts University and the University of Georgia started the Climate Forecasting for Agricultural Resources (CFAR) Project, a multidisciplinary project with the goal of determining how farmers in Burkina Faso can use climate monitoring and forecasts to enhance agricultural sustainability and food security. CFAR-1 field research was based on participant observation, ethnographic interviews, and household surveys. It included a state of the art review of scientific climate forecasting, 2) an assessment of institutional capacity to produce and disseminate climate forecasts in Burkina Faso, and 3) field research in three agro-ecological zones of the country to establish the level of farmers' interest in and ability to use climate forecasts. In Summer 2000, CFAR and national partners delivered the seasonal forecast to three sites, and returned in February 2001 to ascertain farmers' behavioral changes due to the forecast and their impacts on production and livelihood security.

In the last 3 years, the CFAR team has supported related application and research activities related to climate forecasting in West Africa. In particular, the CFAR team has been an active participant in each PRESAO Forum on regional climate forecasting and organized an encounter of farmers and scientists during PRESAO 3, whose theme was *Application of Forecasts for the Benefit of Rural Communities.* The team has also been providing on-going technical advice to the NOAA-OGP Africa Program and to

ACMAD. Team members served as facilitators in workshops organized by ACMAD to train African meteorological, agricultural, and communication specialists in the implementation and evaluation of programs on communication of climate forecasts to rural users.

Relevant findings from CFAR previous research are:

- Farmers want and value scientific information, including climate forecasts. The most salient rainfall parameters that farmers want are: i) timing of the onset and end of the rainy season; ii) likelihood of water deficits, that is, rainfall distribution; and iii) total amount of rainfall. The relative importance of these forecast products varies according to the different agricultural strategies and crop requirements in various zones.
- The concept of rainfall forecasting is not new to farmers, who have a rich repertoire of forecasting techniques based on local knowledge. But they perceive local forecasts to have lost reliability due to increased climate variability during the last three decades. Farmers are used to combining information from a variety of sources and open to scientific information if it can complement their own knowledge and improve their quality of life.
- Farmers indicated that they need seasonal rainfall forecasts to arrive several weeks before the expected onset of the rainy season for them to be able to optimize their integration in planting decisions. However, since farmers stagger planting during the first half of the rainy season, forecasts provided after the onset may still be useful.
- The main strategy whereby households attempt to reduce risk is by diversifying production and livelihood systems, especially in the Sahel and in the Central Plateau. Responses tend to be minor modifications to the highly diversified and risk-averse production system rather than drastic changes that seek to maximize yields.
- Farmers have a range of response options available to them, such crop types, planting location, and water conservation techniques. They emphasized, however, that their ability to respond adequately to forecasts is hindered by resource limitations. Shortages of labor for key farming tasks and of land suitable for different rainfall scenarios, and lack of access to credit, viable seed, farm inputs and plowing equipment are the main constraints.
- Each adaptive strategy entails costs and compromises. Even when adaptations succeed in mitigating climate-related risks, they may expose farmers to other risks, reduce productivity, or strain labor and land resources. Understanding these trade-offs is essential in order to anticipate, and possibly prevent, potential negative impacts of forecast responses on environmental sustainability, household well-being, and social equity.
- In order for forecasts to be accepted by farmers, they need to be delivered by credible sources. This calls for a much closer inter-institutional collaboration between meteorological services and agencies that directly intervene in rural areas, such as extension services, development projects, and community-based organizations.
- Farmers identified local language radio programs as a good way to deliver forecasts with follow up meetings with extension agents or other intermediaries. Radio broadcasting would ensure widespread and timely coverage, while follow up meetings would enable farmers to ask questions and receive technical advice.
- The analysis of responses to and impact of the 2000 forecast indicated that, although farmers grasped the notion of probability, they did not fully appreciate the probabilistic nature of the forecast. Because the probability aspect may lend itself to manipulation by certain groups, who may magnify or minimize uncertainty according to what serves their interests, it is imperative to continue efforts to develop objective approaches and systematic tools for communication of probabilities and risks inherent in forecasts. Many farmers also misunderstood the forecast only covering the three months of July, August and September, its regional extent, and the use of analog years.
- In the three CFAR research sites, farmers blended the 2000 year scientific forecast with their own forecasts and local knowledge, which in some cases mitigated the negative impacts of the low

probability forecast occurring.

- Even though the low probability forecasted rainfall event occurred in 2000, overall farmers remain very interested in receiving and experimenting with forecasts.
- Our research identified three major unanswered questions regarding the application of climate forecasts for improved livelihood and production systems in the Sahel-Sudan region: 1) How can we best explain scientific information, particularly the probabilistic nature of the forecast, to farmers? 2) What additional information or resources must accompany a forecast, and how should such information and resources be made available to farmers? 3) What is the optimum role of intermediaries in forecast dissemination, and who are the best intermediaries for forecast dissemination.

B. Objective of Research Project

The overall objective of this project was to identify constraints and opportunities, both at the institutional level and at the community level, for utilizing seasonal climate forecasts for improving agricultural production and livelihood security of farm families in the Sahel-Sudan Region. Sub-Objectives: The research plan has five sub-objectives relating to the overall objective. These include: (1) to determine the state of the art in seasonal precipitation forecasting in Sahel-Sudan, lead times, accuracy, and presentation of forecasts to the various kinds of institutions and groups; (2) to develop a better understanding of the information systems of relevant institutions and non governmental organizations (NGO) to determine how best to introduce climate forecasts in their programmatic planning and implementation; (3) to assess how scientific forecasts can be introduced in ways that improve livelihood security among farm families living in different agroecological zones and engaged in different survival strategies; (4) to conduct a Workshop in Burkina Faso to present and refine research results, and facilitate flow of information among relevant institutions and representatives of farming communities; and (5) to extrapolate research results to the rest of the SS and identify and prioritize further research needs.

C. Approach

The research was carried out in 5 tasks which are summarized below.

Task 1. State of Art in SS Seasonal Forecasting: Information was obtained from forecasting groups on methodologies, lead times, skill level, testing, and any operational experience. Information was also collected on the possibilities for numerically and spatially precise forecasts with high risk versus more generalized forecasts with low risk.

Task 2. Institutional Analysis of Provincial through International organizations and NGOs. An institutional analysis was conducted of provincial through international organizations and Non Government Organizations (NGO) to determine: (1) the effectiveness of their information systems for processing and using a seasonal forecast; (2) how past seasonal forecasts have been used; and (3) their opportunities for using forecasts. This was done through conducting interviews of all institutions during the first year of the research.

Task 3. Field Research. This task constituted the core of this research effort. The research strategy followed a rolling design whereby expansion built systematically on insights from fieldwork, while also allowing for follow-up in the previous sites. The CFAR project selected three villages as research sites, Bwahoun in the Southwest, Bonam in the Central Plateau, and Koria in the Sahel. These areas represent the three main climatic conditions of the country, with the Southwest site benefiting from 5 to 6 months of rain, the Central Plateau site receiving 4 to 5 months with a long term average of 617 mm, and the Sahel site only 3 to 4 months with a long term average of 476 mm. Research was conducted between January 1998 and October 1999 in the course of several 4 to 6 weeks fieldwork periods during the dry season and during the rainy season. It encompassed a range of significant climate events, such as a major drought in the Central Plateau and equally devastating heavy rains in 1999 which washed out crops, houses, and roads in the Southwest. The time span enabled us to observe how these events impacted production strategies and outcomes, how local households coped with the resulting shortages, and how they shaped expectations and adaptations relative to the subsequent farming season.

At each site the following was done. Existing data-bases, project reports, government records, and secondary materials were reviewed and relevant information synthesized to provide a referential framework for the preliminary investigation in each site. Then core samples of 10-15 households were randomly selected for in-depth interviewing including household heads and groups based on age and gender outcomes of production decisions and/or livelihood requirements. We then conducted a socioeconomic survey using a larger, random sample (10% of households in each village) to classify households on the basis of access to resources and productive and livelihood strategies. The survey resulted in documenting and assessing the outcome of decisions that were made in response to climate forecasts by farm families. Our understanding of the use of forecasts was then tested by developing a set of culturally-appropriate hypothetical scenarios to elicit from local informants information on the effects of climate forecasts on decision-making. We also had in-depth interviews with on indigenous knowledge with experienced farmers and cultural specialists.

Task 4. In-Country Workshop. The third Regional Climate Outlook Forum was held in Ouagadougou on May 8th –12th, 2000 (PRESAO-3). The purpose of this Climate Outlook Forum was to discuss the scientific aspects of forecasts, to receive feedback from users, and to develop a consensus forecast for the region. As was the case with previous Fora, the consensus forecast was produced by combining forecasts developed by each national meteorological service on the basis of sea surface temperatures (SST) and by international meteorological centers like the Hadley Center and the U.S. National Oceanic and Atmospheric Administration (NOAA). The 2000 program also contained a workshop sponsored and organized by CFAR during which regional climate scientists interacted with a small group of farmers from the CFAR sites and elicited their information needs and their views regarding the potential uses of forecasts. Farmer participants were selected jointly with relevant community leaders and committees, but all of them were key project informants with whom the project had worked since the beginning of the project. They included individuals of different ethnicities and wealth levels, and a few women.

During this workshop period, CFAR also organized the experimental dissemination of forecasts to farmers in its three sites. At a meeting preceding the Forum the forecast was presented to the participating farmers by laying out differently colored slips of paper (40 green, 40 yellow, and 20 red), and then placing them in a bowl and randomly selecting one slip of paper. The selection was repeated several times to show that the low probability scenario can occur, though with lesser frequency. The presentation of tercile forecasts for the three climatic zones of Burkina Faso was repeated during the scientist-farmer workshop during PRESAO-3.

Task 5. Review of Forecast Use. CFAR received the rest of its original budget to conduct this extra task to review how the 2000 climate forecast, which was distributed to some CFAR farmers during PRESAO-3 in May 2000, was used in farmer decision-making**.** The seasonal rainfall forecast was updated by DMN at the end of June, with minor changes (35% higher, 45% middle, 20% lower tercile). In mid-July a team composed of collaborators from the Burkinabe Meteorological Service (DMN) and the National Agricultural Research Institute (INERA) traveled to the CFAR sites to present the updated forecast to the communities. The presentation was done during a village meeting, which had been convoked by the CFAR facilitators during previous visits and (in the Sahel site) by broadcasting the information over the local radio. The meeting also included those farmers from the community who had attended the Climate Outlook Forum. Between mid-January and the end of February 2001, the CFAR team returned to the research sites to assess the impact of forecast dissemination. The CFAR site facilitators assisted the CFAR researchers. DMN and INERA collaborators also joined the CFAR researchers during this time for a restitution meeting with the communities during which they presented data about the actual outcome of the 2000 rainy season in the zone in question, in different areas of Burkina Faso, and in neighboring countries, and clarified misunderstandings relative to the forecast disseminated in July.

The CFAR assessment team spent from one to two weeks in each site doing semi-structured interviews and focus groups to understand what rural producers had understood, how they had used the information in their production choices, and how it could be better explained and delivered to farmers. Interviews were also carried out in one different village in each site, which was selected on the basis of relative similarity to the CFAR villages, to assess the extent to which information had circulated to areas the DMN/INERA team had not reached. These 'control' villages were Dani in the Sahel, Bouala in the Central Plateau, and Bombi in the Southwest.

D. Description of any matching funds used for this project.
No matching funds were used for this project.

II. Interactions

A. **Description of interactions with decision-makers who were either impacted or consulted as part of the study; include a list of the decision makers and the nature of the interaction; be explicit about collaborating local institutions.**
CFAR had interactions with many decision-makers during the research. We define decision-makers as individuals who are responsible for making decisions that can implement or directly support climate forecasting use other than members of the climate forecasting scientific research community. The list is in Appendix A with organizations and names if known.

B. **Description of interactions with climate forecasting community (i.e., coordination with NOAA climate forecasting divisions, the International Research Institute for climate prediction (IRI), regional or local climate forecasting entities, etc.)**
See Appendix B.

C. **Coordination with other projects of the NOAA Climate and Societal Interactions Division (i.e., other HDGCR, Research Applications, or Regional Integrated Sciences and Assessments projects) .**
We participated in the OGP PI meeting in Arizona in 1999, several meetings at IRI, and the Climate Outlook Forum Review Meeting in South Africa in 2000. We have also participated in OGP's programs on adaptation to climate variability and change at Snowmass in 2000 and 2001.

CFAR has also been heavily involved in RANET. We provided resource persons and the facilitator for two start-up workshops which included between 20-30 representatives from 10-15 African countries. We contributed to production of training instruments and reports, as well as to an monotoring and evaluation framework for the project. We have continued to provide technical support to some of the trainees over the last two years: examples include Samuel Muchemi (Kenya), Milton Waiswa (Uganda), Mohamed Koite (Mali), Cherif Diop (Senegal), Pascal Yaka (Burkina Faso). In addition, Carla Roncoli helped Milton Waiswa (RANET UGANDA) write his proposal for and mobilize references for the IRI Fellowship for Advanced Training on Climate Variability and Food Security, which he received. In Mauritania we assisted Zones Arides – Mauritania, a national environmental NGO, to plan and organize a national stakeholder workshop for the development of a national strategy for communication of climate information (May 2001). This was an unprecedented event that triggered a process of institutional reform of meteorological services in the country, which up to that point had been scattered among various government agencies. We have assisted the same NGO to organize and conduct a training for representatives of agropastoral associations (June 2002). Carla Roncoli is currently helping them to plan and implement an evaluation of the impacts of the training. The Mauritanian contact is Mohamed El Mokhtar ould Mohamed Ahmed.

Carla Roncoli has also been providing support to graduate students in universities other than UGA (Colin West and others at the University of Arizona). For Colin West, Roncoli advised him on thesis, the write up for publication, and a proposal for a research fellowship, which he received, to work in Burkina Faso.

Christine Jost and Carla Roncoli also supported the UN Sahelian Office as they developed their eight African country program on Climate Information and Biodiversity Conservation. In particular, they helped them develop a much more feasible terms of reference for start up activities, institutional analysis, and regional-national workshops. UNSO contacts are Peter Gilruth and Lucy Mwangi.

Carla Roncoli also helped a women's association in northern Burkina Faso obtain funds from the Global Fund for Women to do literacy training in local language and (at their request) in French for two years. They also received some windup radios from ACMAD. While not strictly related to CFAR, literacy is a key factor in the ability of understanding and retaining climate information disseminated on the radio or otherwise. It is also an example of how CFAR seeks to address immediate felt needs as well as doing research in our sites. Another example of 'development' intervention is the briefing Carla Roncoli and two facilitators, Salifou Boena and Salam
Bahadio, gave to Plan International in July 1998 about the severe conditions of food insecurity in Bonam that followed the 1997 drought. It prompted Plan to mobilize subsidized food stocks to bring to Boulsa and distribute in Bonam and nearby villages.

III. Accomplishments

A. Brief discussion of research tasks accomplished. Include a discussion of data collected, models developed or augmented, fieldwork undertaken.

See Section I.C above.

B. Provide two or three overheads of key research results in bullet form. (Suggested Limit: 5 bullets per page).

See Appendix C.

C. **Elaboration of key findings (i.e., how this research advances our scientific understanding)**

Forecast information farmers request

Farmers have their own forecasting knowledge based on environmental and spiritual indicators. However, they perceive their own forecasting knowledge to have become less reliable due to increased climate variability. The influences of agricultural extension, formal education, and monotheistic religions have also weakened confidence in local forecasting knowledge, especially among young people. It is important that scientific forecast be presented in ways that respect and complement local knowledge.

Given that livelihoods of most rural households depend on rainfed farming, most farmers expressed strong interest in receiving seasonal precipitation forecasts. At the same time, farmers said that by itself a forecast of total seasonal forecast is of limited usefulness. Farmers in all sites stressed that forecasts on the quantity of rainfall must include estimates of duration and distribution of rainfall over time and space to be most valuable. In order of declining priority, the most salient rainfall parameters farmers want in a forecast are: i) timing of the onset and end of the rainy season; ii) likelihood of water deficits, that is, rainfall distribution; and iii) total amount of rainfall. The relative importance of these forecast products varies according to the different agricultural strategies and crop requirements in various zones and are also affected by recent experience. Farmers also prefer a combination of forecast parameters rather than a single parameter.

Lead-time required for greatest forecast value

Farmers of Burkina Faso agreed that a less accurate forecast with sufficient lead-time was more valuable than a highly accurate forecast that arrives after farmers have made irrevocable decisions. Most farmers in Burkina Faso make decisions about planting based on what happened during the previous season. They revise decisions based on short-term assessments of upcoming season. The planting period, which lasts 30 to 90 days according to climatic zone and date of onset, is the most critical part of the farming season. Farmers consider the timing and nature of onset and the performance of crop establishment, especially whether or how many times they must replant, to be the most reliable indicators for the rest of the rainy season. Farmers associate late onset of rains with drought and early onset with good rainfall, assumptions that can prove erroneous as they did in 1999.

Most farmers in all sites requested that a forecast arrive one to two months before the expected onset of the rainy season, that is, by late April or early May. This lead-time would enable them to optimize labor and land allocation, to obtain seed of different varieties, and to prepare fields in different locations. Other strategic responses to a forecast, such as clearing new fields, applying more or less manure, ordering inputs, and implementing traditional soil and water conservation systems require the information to be delivered early in the dry season, by January or February. Though of less value, forecasts of total seasonal rainfall provided at the beginning of the rainy season could still contribute to revisions of farm decisions, in combination with farmers' own observations at the onset of the rainy season. A seasonal forecast could also assist SOFITEX to decide what varieties of cotton to distribute in different parts of the country. To ensure that seed is delivered to farmers in time for planting, they need forecast information by February at the latest.

Strategies for using forecasts to improve crop production and resource management

The main strategy whereby households attempt to reduce risk is by diversifying production and livelihood systems, especially in the Sahel and in the Central Plateau. Responses tend to be minor modifications to the highly diversified and risk-averse production system rather than drastic changes that seek to maximize yields. In the Southwest the dominance of producing cotton for export markets has decreasing diversification. In all areas, farmers diversify by becoming more involved in livestock production whereas agro-pastoralists expand the area they cultivate. Most households engage in various non-farm income-generating activities, such as making *dolo* (local beer), crafts, and trade. Emigration to seek cash income work outside the region is also common. Agricultural diversification requires farmers to carefully orchestrate what, where, when, and how to plant their crops in response to both current and expected conditions. Diversification results in a households managing a constellation of fields with different soil types and in different locations, planted in staggered sequences with various combinations of crops and crop varieties having different growth duration and water requirements.

In all sites, farmers interviewed strongly emphasized that their ability to respond adequately to forecasts is hindered by resource limitations, especially availability of labor and productive land. Most farmers also mentioned that they are constrained by lack of access to credit, capital, or agricultural technologies. Because rapid crop establishment is a key factor in coping with a shortened rainy season, farmers stated that access to tractors, plows, and other technologies that could expedite crop establishment are critical. Therefore, the household resource access profile largely defines which particular strategy is selected and, when and how it is enacted. Each response tactic entails compromises and trade-offs. Though a particular tactic may mitigate some risks, it may also expose farmers to other risks, both foreseen and unforeseen.

Among the three sites studied, forecasts would likely be of greatest value to farmers of the Central Plateau because they already use a large variety of traditional indicators to predict rains and adapt their resource management strategies accordingly. Ability to use forecasts is constrained in the Southwest by debt incurred in cotton production. Because herds are movable, agro-pastoral systems in the north are highly insulated from climate variation while farming systems in the North are constrained by competition with cattle herds.

Forecast dissemination

Literacy levels remain very low in all sites, particularly in the Sahel where families still resist sending children to school because they are needed to tend to livestock. In most sites farmers identified radio programs to be the best way to deliver forecasts, followed up by visits by and meetings with someone who can answer questions about the nature of the forecast and with whom they could discuss options for responding to a forecast. Radio broadcasting would ensure widespread and timely coverage, while follow-up visits would enable farmers to ask questions and get advice. This approach also reflects local learning styles, which are based on experience and interaction rather than verbal instructions. Popular gathering places, such as Friday mosques in the Sahel, markets in the Plateau, and beer drinking places in the Southwest, can also be points of information delivery and discussion.

Farmers stressed that radio programs should be aired when farmers are home from the fields and herders and not engaged with their animals. It should be clearly specified who is sponsoring the program and where the information comes from.

The ability of the government agricultural extension service is extremely limited, to the extent that agents do not have fuel to get to the field except when a foreign-funded project provides funds for specific areas and purposes. SOFITEX has deployed its own network of village-based agents, but most are young, poorly trained, and accountable to the company, hence farmers do not trust them deeply.

In order for forecasts to be understood by and useful to farmers, they need not only to provide relevant information, at the optimal time, and in the most appropriate form and language, but also by credible sources. This calls for a much closer inter-institutional collaboration between meteorological experts and all the players that intervene in rural areas, such as technical services, development projects, and local level institutions. For instance, extension and/or development agents or intermediaries could be trained in the interpretation of forecasts to farmers and they could advise meteorologists about the information needs of rural producers.

Forecast interpretation

In May of 2000, the C FAR team conducted a workshop to present the seasonal forecast to a group of three farmers from each of the three sites. We first explained in simple terms how the forecast is developed from based on sea surface temperatures and how the forecast may change unpredictably in the next few months. The forecast for Burkina Faso, predicting probabilities of 40% higher than average rainfall, 40% average rainfall, and 20% lower than average rainfall, had been issued at a regional forum the night before, so that these farmers were the first audience that received it. This scenario confirmed some farmers' indigenous forecasts, which also predicted a relatively wet season, given that temperatures during the early dry season, a common traditional indicator, had been colder than normal.

A practical demonstration emphasized the probabilistic nature of the forecast. We cut 5 cm × 5 cm squares from colored paper, with blue representing higher than normal rainfall, green representing normal, and red lower than normal. We arranged 20 squares each of blue and green and 10 squares of red to represent the probabilities forecast of each possible outcome. We emphasized that all outcomes were possible, only that there was a strong likelihood that total rainfall would be higher than normal or normal. We then placed all squares in a box, mixed them, and allowed farmers to draw squares randomly from the box to exemplify the relationship between forecasted probability and actual occurrence of seasonal rainfall. This demonstration was similar to a lottery draw, with which farmers were already familiar. They appeared to understand both the probabilistic nature of the forecast and the fact that all outcomes were possible.

Meteorology based forecasts are not farmers sole source of information and they will not rely heavily on these forecasts until the forecasts have proven themselves reliable. Finally, we believe it is imperative that forecast dissemination emphasizes that all outcomes are possible and that meteorologists issue regular forecast updates.

Additional Findings from Analysis of Use of 2000 Forecast

The supplemental research conducted in 2000 and 2001 on reviewing the use of the Year 2000 seasonal forecast in three CFAR sites and controls reinforced the findings from our previous research and provided these additional insights from the farmers we interviewed.

Forecasts that are presented prior to the onset of the rainy season are not used by farmers in making decisions: rather they use these forecasts to develop expectations that are then verified by the timing of the onset and the rainfall patterns during the weeks that follow. This reliance upon the onset rains significant impacted how the farmers applied the Year 2000 scientific seasonal forecast previously given to them. In the Sahel, the early rains, which were plentiful, reinforced the forecast that there was a high probability that the seasonal rainfall would be good. Thus many Sahelian farmers in the CFAR sites planted as if there would be above normal rainfall that season. When the season actually resulted in significantly less rainfall than normal, the farmers had large losses due to overplanting. In the Central Plateau and the Southwest the early rains were poor and the farmers planted as if the seasonal rains would be poor, which occurred. It is possible in these regions that farmers totally disregarded the forecast because it was contradicted by the poor onset rains or they weighted the uncertain nature of the seasonal forecast with the fact that the early rains were poor and decided that the low probability event (poor rains) might occur.

Many farmers interpreted the forecast pertaining only to the months of July, August, and September to mean that the rainy season duration would be only three months, a key determinant of crop performance and a top priority among farmers information needs. Given that three months is a relatively short season in the Central Plateau but a normal season in the Sahel, the belief that the forecast had predicted a season of three months might have shaped expectations for a poor season in the Central Plateau and for a good season in the Sahel. In the Southwest this information seemed to be less important than predictions concerning the possibility of floods or dry spells.

Another problem with forecast interpretation related to the regional nature of the forecast. The DMN/INERA team had presented the idea of 'climatic zone' as a way of explaining some of the limitations of the seasonal rainfall forecast, in particular, that forecasts relate to a regional rather than a local scale. The team mentioned some of the towns and provinces in each zone, which were known to farmers, and informed them which zone their village belonged to. Only one farmer in Bonam, who had been among the participants in the Climate Outlook Forum, understood the notion correctly. A few farmers retained the general idea of 'zone' without specifically remembering what had been said. Others mistook information relative to other zones (i.e. analog year) as applying to their own. Two farmers in the Southwest misunderstood the regional nature of the forecast to be a prediction that rains would actually be spatially localized, which is another key aspect of climate variability in the region that farmers mentioned in their evaluations of the 2000 season.

The information relative to analog years proved to be of low importance. Few farmers retained the years, and those that mentioned any years were mostly incorrect. The failure in retaining this information was partly due to the fact that the years in questions were either very long ago or relatively unremarkable, and partly to the fact analog years mentioned by the DMN/INERA team based on the updated forecast were different from those announced at the Climate Outlook Forum, which had reported that 2000 would be similar to 1970 in the Central Plateau and 1989 in the South. Moreover farmers and meteorologists assess seasons by very different criteria. Farmers assess seasons by production outcome, whereas meteorologists assess seasons based on 'cumulative seasonal rainfall.'

Being accustomed to functioning within a multiplicity of knowledge frameworks, farmers did not report being troubled by the introduction of externally produced scientific information, but stated that the knowledge complemented their own. In some cases the fact that the scientific forecast confirmed their own predictions, increased farmers' confidence to act upon them.

Local systems of thought stress that human knowledge is incomplete and provisional. Thus farmers accept the low probability forecast event occurring at times.

The probabilistic nature of the forecast lends itself to possibly conflicting interpretations by various institutions, which can create confusion and undermine its credibility. National level policies, processes, and mechanisms should be developed to harmonize forecast communications by various stakeholders.

Farmers' definitions of onset and end of the rains differ from those of meteorologists. Rather than measurements of precipitation *per se*, farmers stress climate-crop interactions, which are a function of soil conditions, field types, and crop traits as well as of rainfall patterns.

Farmers are interested in receiving climate forecasts for their agro-climatic zone, but especially for their own village area. They also want to know about rainfall in zones other than their own, because it affects crop prices and grass and water availability. If extension or research provides such additional information, care should be taken to avoid confusion among forecast products.

Farmers wish to have forecast updates, especially if rainfall unfolds in ways that are different from what had been predicted. However, it is important that updates be presented in ways that uphold rather than undermine the credibility of intermediaries involved in its dissemination.

It is important to note that the lack of information dissemination may also be taken as a forecast. For instance, because customary leaders tend to be silent in the case of ominous predictions, farmers may interpret the lack of forecasts as an indication that a serious drought may be expected.

Certain social groups, such as pastoralists, women, and immigrants, may be marginalized by forecast dissemination efforts because: a) they lack resources (i.e. radios, batteries, transport, etc.): b) their work schedule conflicts with scheduled broadcasts or meetings: c) community leaders may not consider them to be integral parts of the community; d) they do not speak the dominant language; or e) cultural rules prohibit the mixing of men and women in public.

Farmers understand climate information in terms of what they are most interested in knowing and what they expect on the basis of their own experience. In some cases, their ability to interpret a forecast in the context of their own predictions helped mitigate the negative impacts of a forecast that failed to predict seasonal rainfall.

Pastoralists did not use forecasts to support livestock management decisions because those decisions tend to follow rather than anticipate the rains. Because most pastoralists also cultivate some lands, they might be able to use forecasts in making decisions on whether to emphasize livestock or crop production, as well as in seeking more favorable terms of trade between livestock sales and grain purchases.

Because of the complex and iterative ways that farmers make decisions it is difficult to identify direct causal links between forecasts and yields, or other outcomes. Forecast information is only one piece in a wide suite of information that farmers consider when making crop and resource management decisions. Farmers' decisions are influenced by multiple factors, so that what they actually do may or may not be consistent with what the scientific forecast predicted.

Major Unanswered Questions

Our CFAR research identified three major unanswered questions regarding the application of climate forecasts for improved livelihood and production systems in the Sahel-Sudan region: 1) How can we best explain scientific information, particularly the probabilistic nature of the forecast, to farmers? 2) What additional information or resources must accompany a forecast, and how should such information and resources be made available to farmers? 3) What is the optimum role of intermediaries in forecast dissemination, and who are the best intermediaries for forecast dissemination. Such intermediaries may include extension agents, development workers, local leaders, community animal health workers, or communications specialists.

D. List of publications and presentations arising from this project (some reprints to be sent separately).

Publications

Roncoli, C., Ingram, K., P. Kirshen, and C. Jost, "Meteorological Meanings: Understandings of Seasonal Rainfall Forecasts by farmers of Burkina Faso." In Sarah Strauss and Benjamin Orlove eds. Climate and Culture, Berg, in press.

Ingram, K., C. Roncoli, and P. Kirshen. 2002. "Opportunities and constraints for farmers of West Africa to use seasonal precipitation forecasts, with Burkina Faso as a case study." *Agricultural Systems,* in press.

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E**. Deviations from Proposed Work plan**. None.

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IV. Relevance to the field of human-environment interactions

A. Describe how the results of your project have furthered the field of understanding and analyzing the use of climate information in decision-making. As described in more detail in our research results, we have determined how farmers use traditional forecasting methods to make crop and livestock management decisions and what response actions they take. We have also determined the incentives and constraints to implementing the use of scientific seasonal forecasting in the three agro-ecological zones of Burkina Faso.

B. **Where appropriate, describe how this research builds on any previously funded HDGEC research (i.e., through NSF, EPA, NASA, DOE, NGOs, etc.)**
There are two past research efforts we have built upon. The first was the recent research by Barnston et al. (1996) that found a negative correlation of minus 0.54 between ENSO SST patterns and the total rainfall during the main months of rain (July, August, and September) in the Sahel-Sudan. The second was the SANREM CRSP project, which was a diagnostic and planning exercise to develop and launch a participatory research agenda in sustainable agriculture and natural resource management in Burkina Faso. It developed an institutional analysis, a description of the socio-economic and biophysical characteristics of the area and the current natural resource management practices, and an analysis of the constraints to sustainable agriculture and improved natural resource management (SANREM CRSP Research Report, 1995).

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C. How has your project explicitly contributed to the following areas of study?

1. Adaptation to long-term climate change. We have determined the sensitivity of the livelihoods of farmers to present climate variability, including impacts and adaptation measures. Their major strategy to adapt to the present variability is diversification of non-farm and farm activities. This research could be expanded to include possible impacts of long-term climate change on the region.
2. Natural hazards mitigation. We have termed how scientific forecasting might be used to help mitigate the negative impacts of droughts and floods by providing advance information to farmers.
3. Institutional dimensions of global change. Our institutional analysis of the use of climate information in Burkina Faso showed that institutions at all levels are interested in the possible uses of climate forecast information to improve farmer livelihoods.
4. Economic value of climate forecasts. We did not explicitly examine the possible economic value of the forecasts. This, however, could be done as part of another project. We did learn, however, that farmers value scientific forecasts as one of several, often complementary, means to improve their livelihoods.
5. Developing tools for decision makers and end-users. One of the major challenges is explaining forecasts to farmers. Important concepts to convey are the probabilistic nature, the regional nature, moderate skill level, and the period covered. We have experimented with some methods to accomplish these to make forecasts useful tools, but more research is needed on this.

6. Sustainability of vulnerable areas and/or people. We have learned a great deal about how Burkinabe farmers survive in their difficult climate. Perhaps their best survival mechanism is diversification of their production and livelihood systems, especially in the Sahel and in the Plateau. Responses to information tend to be minor modifications to the highly diversified and risk-averse production system rather than drastic changes that seek to maximize yields.
7. Matching new scientific information with local/indigenous knowledge. We have chartered the many local forecasting methods of Burkinabe farmers. We have not attempted to explore the validity of them.
8. The role of public policy in the use of climate information. We have shown that climate information is potentially very important to Burkinabe farmers as it may improve their livelihoods and help mitigate natural disasters. The farmers can not make the forecasts themselves; therefore it is good public policy to continue the support climate forecasters and researchers.
9. Socioeconomic impacts of decadal climate variability. We have not investigated this.
10. Other (e.g., gender issues, ways of communicating uncertain information). See details in Section III.C above.

D. **Suggestions for Future Research: How could this research be applied/tested in other sectors or geographic areas? What are possible future collaborations with other government agencies or NGOs?**

The project has uncovered many further research topics in both the physical and social sciences. The major physical social science topic is how to improve the skill and spatial and numerical detail of the current seasonal forecast of total rainfall and how to forecast the start of the rains and the distribution throughout the entire farming season (May through October). The most relevant social science topics to improve the value of the forecasts for farmers are: how to best explain scientific information, particularly the probabilistic nature of the forecast, to farmers; what additional information or resources must accompany a forecast and how should such information and resources be made available to farmers; and what is the optimum role of intermediaries in forecast dissemination, and who are the best intermediaries for forecast dissemination.

The approach, which was based upon institutional and field research with collaborators, could be applied in other regions of Africa as well as other developing countries. In Burkina Faso, further collaboration could be carried out with the Extension Service, Farmers Unions, and more commercial operations.

V. Graphics.

A. Graphic depicting the overall project framework/approach.
See Appendix D.

B. **Graphic(s) depicting key research results.**
See Appendix C.

C. Map of region covered by study.
See Appendix E.

D. Photographs from fieldwork to depict study environment.
To be sent separately.

Appendix A. CFAR Interactions with Decision Makers

Organization	Function	Individual	Nature of Interaction
Regional Organizations			
African Center for Meteorological Applications and Development (ACMAD)	ACMAD provides meteorological training, development, and applications in Africa and builds the capacity of the national meteorological services.	M.S. Boulahya, O. Baddour	In the initial phases of the project, CFAR discussed project design with ACMAD and in the later phases actively worked with ACMAD to foster forecast use. This also included co-hosting PRESAO-3 with them, DMN, and others, and participating with them in RANET.
AGRHYMET	This regional organization's goal is to contribute to food security in the Sahel region by the use of agrometeorological, hydrological, remote sensing, and pest control information. It carries out its mandate through training and information dissemination.	A.A. Diallo	CFAR met with them during early phases of project and cooperated with them in joint research programs.
USAID Famine Early Warning System (FEWS)	FEWS provides early warning of food shortages in subSaharan Africa so that relief efforts may be initiated to avert food crises. FEWS is headquartered in Washington DC with offices in most countries in sub-Saharan Africa.	F. Gilbert (USA)	We spoke to both Washington, DC and Burkina Faso offices of FEWS about cooperating in disseminating the seasonal forecast.
USA Organizations			
US Embassy, Burkina Faso		J. Kolker, C. G. Palmer	The Embassy is an enthusiastic supporter of CFAR and we often meet with the Ambassador during field trips.
National Organizations			

National Meteorological Service (DMN or NMS, Direction de la Meteorolgie Nationale)	The Burkinabe NMS is in charge of collecting, archiving and publishing national climate data. There is an agrometeorological division within the NMS whose major objective is to support agriculture.	A. Outtara	NMS is a major CFAR research partner. We receive the forecast from them and they have participated in our research in forecast use and dissemination.
Coordination of Information for Food Security Group (Comite de Coordination de l'Information pour la Securite Alimentaire, CCI)	This group has been set up from representatives of several ministries to coordinate information during the wet season to follow agriculture production. One of its major purposes is to provide early warning of food insecurity to the national government. It cooperates freely with FEWS.		We met with CCI to discuss the possibility of their disseminating forecasts. They are interested once the NMS has tested them and provides clear interpretations.
Office of Hydraulics (Direction General de L'Hydraulique)	Responsible for operation of dams and water supplies.	I. Ouedraogo, J.L. Frerotte	CFAR discussed use of forecasting for reservoirs.
Office of Vegetable Production, Ministry of Agriculture (Direction des Productions Vegetales, DPV)	DPV is responsible for the implementation of agricultural technology and for the diffusion of pest and disease management. It provides a link between agricultural research and the agricultural extension services.	C.A. Ouedraogo	CFAR met with DPV to discuss forecasting. At the appropriate time, DPV is willing to conduct some farmer trials using seasonal precipitation forecasting.
Extension Service, Ministry of Agriculture (Direction de la Vulgarisation et Transferts Technolo-giques)	This organization administers the national farm extension service.		CFAR met with them to discuss forecast dissemination by them.

Office of Pasture Management and Tenure, Ministry of Animal Resources (Direction des Amenagements Pastoraux et du Foncier)	This sub-division of the Ministry of Animal Resources is in charge of managing pasture land and associated land tenure. Its extension agents provide the information on the state of pastures and water sources in their regions to the CCI.		CFAR met with them to discuss forecast dissemination by them.
Agriculture Production Organizations			
SOFITEX	A cotton parastatal headquartered in Bobo-Dioulasso.		CFAR met with them several times and they were an active participant in PRESAO-3. Through their own extension agents, they disseminated the forecast in Bwahoun in 1999 and 2000.
Several Commercial Cooperatives, and Irrigation Areas with the Acronyms of UCOBAM, SOFIVAR, AMVS, MOB	Most of these organizations produce and market many crops during the wet season and the dry season using irrigation. Most also provide extension services.	O.P. Guissou (AMVS)	CFAR met with them to discuss forecast use by them. All expressed interest in using forecasts.
NGOs			
Plan International	Plan is an international charity working to improve the welfare of children through agriculture, education, and health. They provide practical assistance to over 300 villages in two regions of Burkina Faso.	E. Kragholm, J.F. Sanchez, E. Mamboue	PLAN is one of CFAR's major research partners in Burkina Faso. They generally have made arrangements for us to work in their villages, provided logistical support, and enriched our research results with their experience. They see their programs benefiting from climate forecasting.
National Organization of Farmers (FENOP)	FENOP is one of three national farmer organizations.		CFAR met with them to discuss forecast dissemination by them.

Appendix B. CFAR I interactions with Climate Forecasting Community

Organization Name	Individual	Nature of Interaction
Non Burkinabe National and International Organizations		
Climate Prediction Center, NOAA	W. Thiao	CFAR discussed scientific forecasting with him.
UK Hadley Center		Several meetings to discuss scientific forecasting.
International Research Institute	N. Ward, A. Barnston, K. Broad, R. Basher, M. Dilley, J. Hansen, J. Phillips	CFAR has shared knowledge with them many times on use of forecasts by subsistence farmers.
Regional Applications Programs, OGP	K. Konneh, M. Stewart	CFAR has supported and been supported by several RAPS activities in West Africa
National Organizations		
National Meteorological Service (DMN or NMS, Direction de la Meteorologie Nationale)	A. Outtara	NMS is a major CFAR research partner. We receive the forecast from them and they have participated in our research in forecast use and dissemination

Appendix C. Overhead/Graphic Key Findings

- **Farmers want and value scientific information, including climate forecasts, to complement their own local knowledge and improve their quality of life. The most salient rainfall parameters that farmers want are: i) timing of the onset and end of the rainy season; ii) likelihood of water deficits, that is, rainfall distribution; and iii) total amount of rainfall.**

- **Farmers indicated that they need seasonal rainfall forecasts to arrive several weeks before the expected onset of the rainy season for them to be able to optimize their integration in planting decisions. However, since farmers stagger planting during the first half of the rainy season, forecasts provided after the onset may still be useful.**

- **The main strategy whereby households attempt to reduce risk is by diversifying production and livelihood systems, especially in the Sahel and in the Plateau. Responses tend to be minor modifications to the highly diversified and risk-averse production system rather than drastic changes that seek to maximize yields.**

- **Farmers have a range of response options available to them, such crop types, planting location, and water conservation techniques. They emphasized, however, that their ability to respond adequately to forecasts is hindered by resource limitations. Examples include shortages of labor and land suitable for different rainfall scenarios, and lack of access to credit, viable seed, farm inputs and plowing equipment**

- **In order for forecasts to be accepted by farmers, they need to be delivered by credible sources. This calls for a much closer inter-institutional collaboration between meteorological services and agencies that directly intervene in rural areas, such as extension services, development projects, and community-based organizations.**

- **Farmers identified local language radio programs as a good way to deliver forecasts with follow up meetings with extension agents or other intermediaries. Radio broadcasting would ensure widespread and timely coverage, while follow up meetings would enable farmers to ask questions and receive technical advice.**

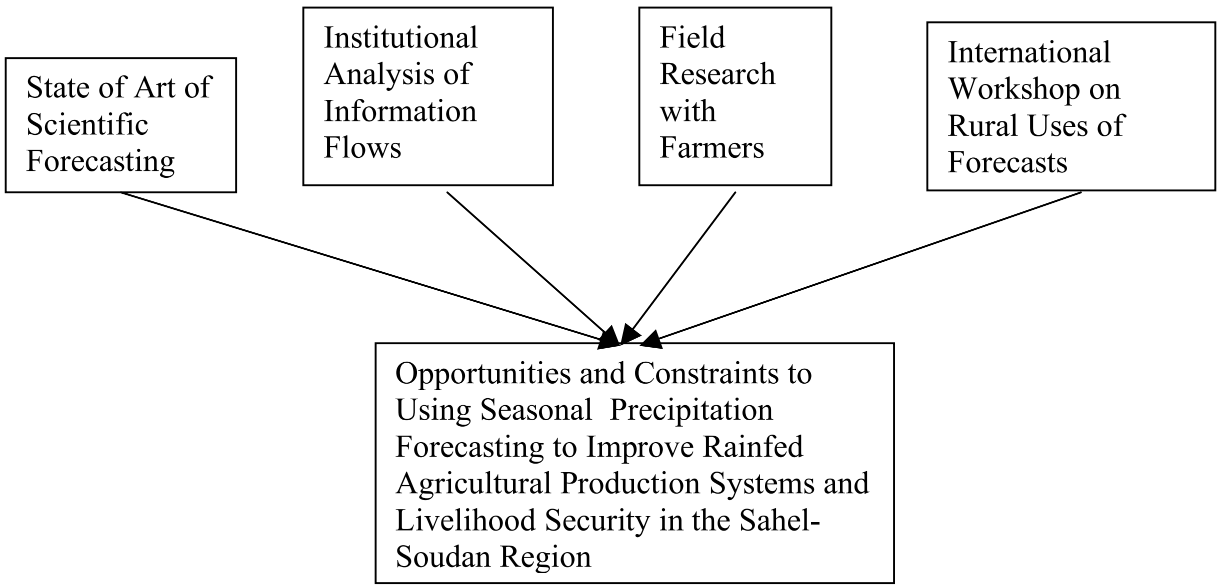
- **The analysis of responses to and impact of the 2000 forecast indicated that, although farmers grasped the notion of probability, they did not fully appreciate the probabilistic nature of the forecast. Because the probability aspect may lend itself to manipulation by certain groups, who may magnify or minimize uncertainty according to what serves their interests, it is imperative to continue efforts to develop objective approaches and systematic tools for communication of probabilities and risks inherent in forecasts. Many farmers also misunderstood the forecast only covering the three months of July, August and September, its regional extent, and the use of analog years.**

- **In the three CFAR research sites, farmers blended the 2000 year scientific forecast with their own forecasts and local knowledge, which in some cases mitigated the negative impacts of the low probability forecast occurring.**

- **Even though the low probability forecasted rainfall event occurred in 2000, overall farmers remain very interested in receiving and experimenting with forecasts.**

- **CFAR research identified three major unanswered questions regarding the application of climate forecasts for improved livelihood and production systems in the Sahel-Sudan region: 1) How can we best explain scientific information, particularly the probabilistic nature of the forecast, to farmers? 2) What additional information or resources must accompany a forecast, and how should such information and resources be made available to farmers? 3) What is the optimum role of intermediaries in forecast dissemination, and who are the best intermediaries for forecast dissemination ?**

Appendix D. Overall Project Framework/Approach.



Appendix E. Map of Study Region

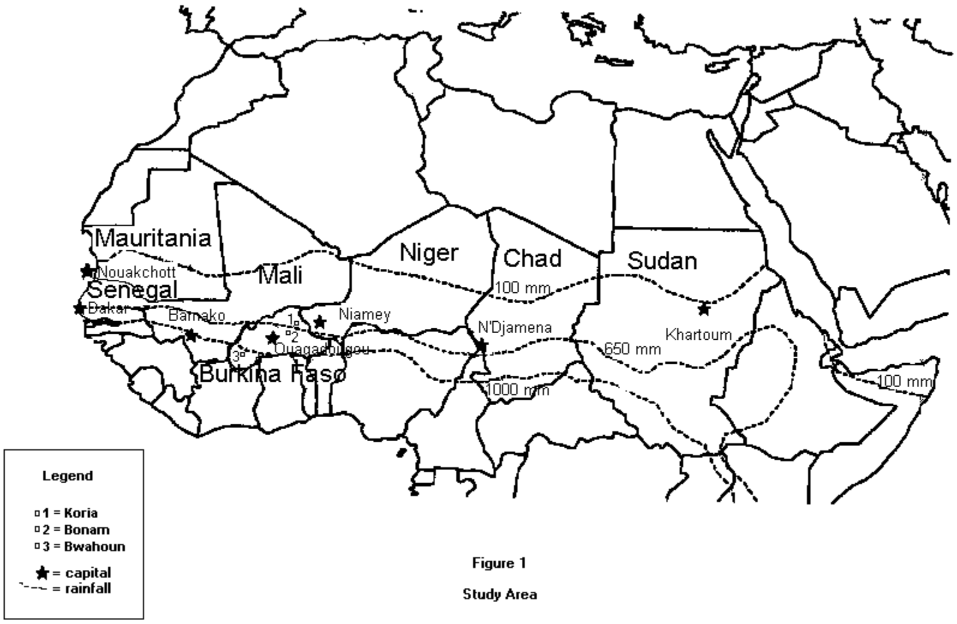


Figure 1

Study Area