Chapter 7

# Climate Applications and Agriculture: CGIAR Efforts, Capacities and Partner Opportunities

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## 7.1 Introduction

Climate variability creates risk in rainfed farming. Risk in turn discourages investment by farmers, governments and development agencies. For instance, in dry regions recurrent droughts debilitate and destabilize poor, agricultural-based societies, and contribute to land degradation by reducing vegetative cover and water supplies. Drought triggers the exploitation of diminishing resources in order to survive (Cooper 2004). Climate change caused by global warming is likely to increase the frequency of climatic extremes in the future and result in changes in cropping practices and patterns over time and space.

If climate variability could be predicted in advance, it would help societies prepare for and cope with the resultant shocks. As well, since drought is a trigger for desertification, better drought prediction and monitoring could help prevent land degradation. This chapter first identifies some key institutional mechanisms of the Consultative Group on International Agricultural Research (CGIAR) for carrying out research to use climatic information in improving agriculture. It then reviews efforts through these CGIAR institutional mechanisms and individual center efforts on climate prediction and adaptation to climate variability, indicating some research highlights and future directions. The CGIAR center's strengths and weaknesses in climate-related work and synergies for potential partnerships are identified, principally with the national agricultural research systems (NARS) and advanced research institutes (ARIs).

## 7.2 CGIAR Inter-Center Initiatives

The 'Oasis' partnership is the CGIAR's initiative to provide research support to the United Nations Convention to Combat Desertification. Oasis engages seven CGIAR centers, many NARS, UN agencies (UNEP, UNDP, FAO), civil society organizations (IUCN, WWF), NGOs, and ARIs.

Oasis catalyzes innovative research-for-development partnerships among agricultural and meteorological institutions, and with agricultural stakeholders in the public and private sectors. Oasis is currently studying local methods and indicators of drought and desertification, and coping methods, as well as science-generated indicators and new or improved adaptation strategies.

The Desert Margins Program (DMP) is a collaborative effort among nine African countries that include the margins of the deserts that encircle sub-Saharan Africa: Botswana, Burkina Faso, Kenya, Mali, Namibia, Niger, Senegal, South Africa and Zimbabwe. Rainfall is low and unreliable in these countries. The goal of the DMP is to help these countries arrest land degradation through more sustainable practices and systems that improve livelihoods. The DMP pursues this goal through partnership-based research-for-development activities, demonstration to farmers, and capacity building.

The DMP countries are assisted by five CGIAR centers: ICRAF, ICRISAT, IFDC, ILRI and TSBF-CIAT. In addition, three advanced research institutes from the developed world contribute their expertise in specific areas (CEH, CIRAD and IRD). Regional networks (ASARECA, CORAF, and SADC-FANR) and non-governmental organizations are also core participants.

The DMP is currently executing a major GEF/UNEP project to arrest land degradation, with particular emphasis on indigenous knowledge. This includes local methods and indicators of drought prediction, as well as indicators of drought, and coping methods.

The Virtual Academy for the Semi-Arid Tropics (VASAT) is positioned as a coalition of sources to promote knowledge-sharing in South Asia and sub-Saharan Africa. The coalition membership, which is non-formal, ranges from IARCs and NARS to community-based or rural NGOs. Activities presently take place in both West and Central Africa as well as in South Asia. Lead partners include the Desert Margins Program, along with the ICT/Knowledge Management program of the CGIAR. The Commonwealth of Learning, an inter-governmental organization that promotes non-formal learning, is a key advisor.

VASAT aims to develop climate literacy and drought preparedness among rural communities, development workers, service providers, policy makers, and other strategic sectors through the integrated use of information and communication technology (ICT), open distance learning, and other communication media. It will also communicate information on climatic trends like monsoon behavior and methods of drought management for community mobilization and disaster preparedness.

## 7.3
## Getting a Grip on Variability

Early CGIAR center work by Virmani et al.(1982) documented climatic trends in different regions in India and analyzed their implications for agriculture. This was followed by Sivakumar's seminal work in West Africa (Sivakumar 1988) on predicting variability in the length of the growing season and in soil water content to support crop growth. More recently, this baseline information was used to simulate crop yields in response to different climatic scenarios, e.g. Matthew et al. (1995) and Virmani and Shurpali (1999). In addition, microclimatology work was undertaken to forecast disease and pest incidence such as in Anantapur region, India (Virmani and Shurpali 1999). A third step was to relate these models to economic consequences, and generate policy and technology recommendations (e.g. Harris and Robinson 2001; Shapiro et al. 1993).

## 7.4
## Improving Analytical Tools for Monitoring Drought and Desertification

A dearth of effective, practical tools for assessing and monitoring drought has constrained the fight against desertification. Oasis is fostering the use of quantitative and analytical methods for direct measurements of ecological processes such as evapotranspiration from inexpensive, frequently-sampled satellite data (Rosema 1993). These remote sensing analyses are combined with on-the-ground participatory assessments of community perceptions and valuations of drought and degradation. Combined with an understanding of ocean-atmosphere interactions, these tools will significantly strengthen the capacities of communities, nations and regions to develop drought and desertification predicting and coping strategies and tools.

## 7.5 Predicting Seasonal Rainfall

Historically, there has been a tendency in agricultural research to assume that drought is an unknowable risk. But new understanding of ocean-atmosphere interactions has led to increasingly powerful predictive models for seasonal climatic trends. Columbia University's International Research Institute for Climate Prediction is a leader in this area. They use predicted global sea surface temperatures (SSTs) to drive a suite of atmospheric general circulation models (GCMs). Statistical corrections and optimal combinations of GCMs improve these predictions. By downscaling with dynamic regional climate models (RCMs) and statistical methods, the resolution of these predictions is increased (Hansen and Indeje 2004; Indeje et al. 2000). They have been remarkably accurate, for example in the retrospective prediction of the July-to-September rainfall in the West African Sahel over recent decades, including prediction of the drought years of 1972, 1983, 1987, and 1997. ICRISAT and its partners have also found this method promising in tests in India.

## 7.6 Predicting Climate Change and Its Consequences

Addressing a much longer time frame, some CGIAR centers are attempting to apply climate modeling to estimate the future impacts of global warming. CIAT and ILRI used a model called MarkSim, which uses data sources from thousands of weather stations worldwide to predict that tropical maize production could decline by 10% by the year 2055 due to global warming (Jones and Thornton 2003). They point out that 10% is merely an average; some areas could suffer much larger losses, with the poorest people being hit the hardest because they are the most dependent on maize as their staple food.

## 7.7 Effects of Climate Variability on Agriculture

### 7.7.1 Effects on Crops

CGIAR centers have attempted to adapt crops to variable environments through plant breeding. The largest impacts have been achieved by shortening plant growth duration so that the crop can be harvested before rains cease, i.e. avoiding drought. A more difficult challenge has been to breed traits that enable crops to tolerate drought. Maize in Southern Africa (Bänzinger et al. 2000), pigeonpea in India (Bantilan and Parthasarathy 1998) and barley in the Middle East (Ceccarelli et al. 2004) are just three of many drought-related breeding successes that could be cited.

However, uniformly early-maturing varieties may cause farmers to miss the opportunity posed by the occasional longer, wetter season. Using the mathematical programming method known as 'Discrete Stochastic Sequential Programming' (DSSP), intra-seasonal adaptive decision-making by farmers was modeled at three sites in Niger to understand livelihood strategies that mitigate the impacts of drought and improve incomes (Shapiro et al.1993). The results lead INRAN, the NARS of Niger, and EARO, the NARS of Ethiopia, to change their breeding strategies to target a range of maturity periods, so that some varieties could always do well despite annual variability in length of the growing season.

### 7.7.2 Crop-Environment Interactions

The interaction of crop genetics with the environment is also critical in reducing vulnerability to drought. In the Sahel, experts have concluded that nutrient deficiencies are an even greater constraint than low rainfall (Bationo et al. 1998; Breman 1992). Breman (1992) notes that natural vegetation in the 450 mm annual rainfall zone of the Sahel utilizes only 15% of the incident precipitation. The remainder is either lost to evaporation, as runoff or remains in the root zone unutilized. When soil fertility is improved, water use by vegetation can increase to 50% and productivity can increase fivefold, greatly lifting the carrying capacity of the land.

Phosphorus deficiency in the Sahel, for example, renders millet more susceptible to drought; research by ICRISAT and IFDC has found that the application of phosphorus increases plant vigor noticeably, resulting in higher yields and greater drought tolerance, as well as drought avoidance (by causing the plants to mature 1–2 weeks earlier).

### 7.7.3 Effects on Pests

As crops adapt to climatic change, so will pests. Climate change will favor invasive pests adapted to the new conditions that may devastate the native crops that were never bred to resist them. Periodic episodes of climate change due to the El Niño phenomenon provide a living example of what may happen. In Peru's Cañete Valley, the El Niño episode of 1997–1998 caused temperatures to increase by 3–5 °C and triggered torrential rainfall. This combination coincided with the first discovery of an aggressive new variant of the white fly pest, *Bemisia tabaci* and also the invasion of a species not found there before, *Bemisia afer* (CIP 2001). These species became established and remained even after the El Niño ended, plaguing the important sweet potato and other crops there. This example shows that reinvigorated efforts in integrated pest management and crop resistance breeding will be required to keep up with global climate change.

### 7.7.4 How Climate Variability Affects People

One particular climate applications gap to which the CGIAR and its partners have tried to respond in recent years has been in helping to find ways to improve sharing of climate information, technologies, and knowledge with farmers. These efforts have three aspects, first gaining a better understanding of how farmers perceive and respond to climatic risks; second, developing new policy instruments like appropriate drought insurance for poor farmers to help them cope; and third, using new information and communication technologies to share better climate information, recommendations, and policies with farmers.

## 7.8 Farmer Perceptions of Drought

A recent Oasis study in Burkina Faso (Slegers et al. 2004) found that farmers' perceptions of drought differ significantly from those of research institutions. Farmers are more focused on the agricultural and local-context effects of drought (crop stress, local variations in stress) whereas researchers tend to concentrate on the regional and meteorological aspects (regional rainfall and temperature patterns, soil erosion and impoverishment). To be more relevant, researchers need to translate their macro-level observations into micro-level recommendations that can help farmers reduce their vulnerability under the particular conditions of their own plots.

## 7.9 Livestock and Drought

ILRI and ASARECA, with USAID support, conducted a survey of 663 households investigating coping mechanisms of pure-pastoralists and agro-pastoralists, during the 1995–1997 drought and 1997–1998 El Niño rains (floods) in Ethiopia, Kenya, Tanzania and Uganda (Ndikumana et al. 2002). The DMP conducted a similar enquiry in Kenya (Anonymous 2004). The majority of respondents among four tribes in dry areas of Kenya were aware of traditional signs that they felt had predictive power for weather, vegetation and soil conditions. Systems analysis revealed a number of opportunities to help herders improve their preparation and coping strategies.

If droughts could be foreseen longer in advance, herdsmen could reduce herd size in an orderly way, avoiding panic sales. Cooperative action among herders could avoid them being exploited by middlemen e.g. in panic sales of livestock that depress markets and strip the herders of their capital assets. Coordinated downsizing and rebuilding of herds could reduce market squeezes and gluts. Better health care for animals during droughts could increase survival rates. Better range management and the creation of fodder banks could ease the dry-season feed constraint.

## 7.10 Drought Insurance to Help Land Users Manage Climatic Variability

Climatic variation is an age-old risk of farming. Its consequences are severe and can wipe out livelihoods. This risk may increase as global warming increases the frequency and intensity of climatic extremes.

A conventional way of mitigating risk is the use of insurance. However, conventional approaches to insurance bear high costs and may even create perverse incentives. For example, government relief aid tends to favor wealthier individuals who took greater risks (and therefore suffered greater losses) by cropping or grazing livestock herds in drought-prone areas, for example. This form of insurance is high-cost and encourages even riskier behavior in the future.

An alternative being developed at IFPRI is private-sector insurance tied to objective, easily-monitored weather indicators such as rainfall levels (Skees et al. 1999). Farmers buy policies based on the size of their farm operation (or their judgment), so that larger risk-takers pay appropriately more to insure larger operations. If rainfall, for example falls below the pre-set minimum for a season, the insurance claim becomes valid. Insurance companies are able to accurately predict the risk and therefore calculate an appropriate premium, since there is a wealth of historical rainfall data available for most areas of the world. This approach would shift the insurance burden from the public to the private sector, and make it more efficient and equitable.

## 7.11 Information Technology for Knowledge-Sharing

VASAT uses the Internet, radio and other electronic means to prepare dryland farmers for drought and to help cope with it when it occurs. A hub-and-spokes model is followed (PANTLEG 1999). A central village with road access and electricity serves as an Internet or radio transmission point to reach surrounding hamlets. Receiving systems in the hamlets may be solar or battery-powered, or simply use personal radios. Village moderators in each hamlet consult with residents to gather their information needs and relay them to the hub, which collects the needed information and transmits it back to the hamlets, expressing it in the local language and displaying it through simple media such as bullhorns and chalkboards (and over the radio).

This telecenter/radio platform can also be used for conveying learning modules, gathering and relaying drought warning information, government assistance programs, market prices, and many other valuable types of information.

## 7.12 Conclusions: Future Climate Applications in CGIAR Centers and Partnership Opportunities

Since early efforts, little further work has been done by the CGIAR in modeling for climate prediction. The CGIAR has judged it does not have comparative advantage to pursue this type of work that is being done by ARIs like IRI. However, because of its location in developing countries, the CGIAR has a comparative advantage to continue to help partners in developing crop yield simulation models with ARI partners, making use of available weather and climate predictions. There are also continuing opportunities for the CGIAR to play a leading role in using these weather driven models to develop adaptive agronomic recommendations and do ground-truthing of these recommendations through field trials, both scientist and farmer managed, with NARS partners. CGIAR centers can also continue to make strong efforts in combining geographical information systems and climate simulation modeling with particular emphasis on the agricultural consequences of climatic variability, especially global warming.

The CGIAR, meanwhile, has made little progress in combining crop simulation and bio-economic optimization modeling to develop adaptive technology recommendations. Opportunities for partnerships in this area exist with North American and European universities such as Purdue University and Wageningen University, and with ARIs such as IRI.

The local consequences of global warming are difficult to predict; some areas may get drier and hotter, others wetter and cooler (Parry 2002). Therefore the centers are developing a range of scenarios so that countries can prepare for whatever they may encounter. As time goes on, these scenarios can be refined to match observed trends and narrow the response options to fewer, more likely alternatives. Partnership opportunities will exist in the linking of biological to economic criteria in these models, a major current challenge already starting to be tackled by some centers. Such bio-economic modeling is essential because decision-makers tend to rely most heavily on economic valuations. The agro-biodiversity costs of climate change, for example, could include higher food prices and less reliable food supplies (e.g. if major food-producing regions decline) (Rosegrant et al. 2002). Decreasing water supplies in some areas could raise the costs of irrigation (or make it unfeasible) while floods and droughts could create major costs in different sectors of the economy.

Since global warming appears inevitable, much CGIAR research will continue to be geared towards reducing vulnerability by adapting crops, land use systems and policies to likely scenarios. This involves work in plant breeding, integrated pest management, natural resource management, socio-economics and policy, and related topics that can be done with both NARS and ARIs.

The CGIAR can also lead (as currently exemplified by CIAT and ILRI) in the use of long-term climate prediction to analyze expected changes in cropping patterns over time, those due not only to climatic factors but also those due to changes in biotic stresses such as pests and disease.

Lastly, the CGIAR is looking for partners in its efforts to find ways to improve the sharing of climate information, technologies, and knowledge with farmers.

There is thus ample opportunity for the CGIAR to work with those who are developing better climate applications to improve agricultural productivity and reduce climatic risk.

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