Chapter 18

Communicating Agroclimatological Information, including Forecasts, for Agricultural Decisions

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Introduction

The seasonal variability of weather is a major source of production risks (Fraisse, et al 2006). Significant benefits have arisen from the use of seasonal climate forecasts. *However, it is now widely accepted that the existence of predictable climate variability and impacts is necessary but not sufficient to achieve effective use of seasonal forecasts* (Podesta et al 2002,and others). The realization of such benefits has been shown to require deliberate efforts to design and implement effective mechanisms for using climate information in service of society. Several empirical studies have identified theoretical and practical obstacles to the use of climate information and forecasts (see, Mjelde et al 1998; Stern and Easterling, 1999; Roncoli et al., 2001; Agrawala et al., 2002; Patt and Gwata, 2002 among others). The obstacles are diverse, ranging from limitations in modeling the climate system's complexities (e.g. forecasts have coarse spatial and temporal resolution, not all relevant variables can be predicted, the skill of forecasts is not well characterized or understood, contradictory predictions may coexist), to procedural, institutional, and cognitive difficulties in receiving or understanding climatic information, and in the capacity and willingness of decision-makers to modify actions.

Communities of potential users exist on and off field sites, including farmers, agribusiness, transportation, those interested in reducing off-farm impacts of agriculture etc. Rijks et al (2000) note that different groups of potential clients may exist within the same community, such as those who are aware of information and have access but may need guidance on use; those that might know information exists but may need improved access; and those who may not be aware of existing information and potential benefits of use. Climate information is not yet widely used by farmers who make routine decisions about production in existing farming systems (Jones, 2003). This is partly due to the complexity of agricultural systems. In addition, there may insufficient consideration of the actual conditions of the livelihood of farmers and thus of local adaptive strategies (Stigter, 2003). In such cases, the result is usually development of inappropriate support systems (Murthy and Stigter, 2004).

Several place-based studies have highlighted communication as a key weakness in the ability of the climate information system to serve the agricultural sector. This weakness that has been well documented for some time in the forecast applications literature, yet remains of critical importance.

Farmers face many challenges, including uncertain prices, access to needed inputs, governmental policies, marketing, pests and diseases, soil degradation and extreme weather. A common strategy is to employ surveys among farmers in any crop or commodity, asking the respondents to list and prioritize problems that they face in production. Many pilots were developed during and after the 1997-1998 ENSO events in which stakeholders were and are being engaged in dialogues with researchers and extension personnel on climate variability and use of uncertain climate forecasts (Buizer et al 2000). Vehicles of communication of new information in agriculture include the media, agrometeorological bulletins and extension services etc. Significant work still remains before climate forecast information is routinely used throughout agriculture for making decisions aimed at reducing climate-related risks. This chapter reviews the challenges of effective communication and make recommendations for bridging identified gaps. This is not simply a problem of rural underdeveloped areas. As Fraissse et al (2006) note even in more technologically advanced areas there is still the need for face-to-face multi-way communication and training between the extension agents.

The chapter focuses primarily on the communication of climate information for on farm planning. However many of the concepts are applicable to supporting off-farm activities. Livestock planning and management are not discussed explicitly.

Use of climate information in agriculture: Framing the decision problem

It is widely accepted that researchers, information providers and practitioners (in this case farmers and agribusinesses) frame problems differently from each other (Schon and Rein, 1984). "Framing" refers to the way a particular problem is presented or viewed. Frames are shaped by knowledge of and underlying views of the world. It is related to the organization of knowledge that people have about their world in the light of their underlying attitudes toward key values, their notions of agency and responsibility, and their judgments about reliability, relevance, and weight of competing knowledge (Jasanoff and Wynne, 1997). Researchers, policy-makers and practitioners (public and private) operate on different time-lines, use different languages, and respond to different incentive systems. These frames lead to different definitions of what constitutes the critical components of a problem, different approaches to problem-solving, to decidedly different recommendations for action, and to differing criteria for appraisal. The most important learning involves the basic “framing” of issues in terms the relevance and importance of particular conditioning outcomes.

The degree of acceptability of information and trust in the providers, dictate the context of communicating climate information. The following questions frame effective communication (Jones et al, 2001; Pulwarty 2003):

- Is the information *relevant* for decisions in the particular agricultural system?
- Are the sources/providers of information *credible* to the intended user?
- Are farmers *receptive* to the information and to research?
- Is the research *accessible* to policy/decision maker?
- Is the information *compatible* with existing decision models and farming practice?
- Do decision makers have the *capacity* to use information?

All studies to date show that rainfall distribution over a season is the key variable for all farmers throughout the tropics (Phillips et al 2001, and others. This information translates into the following key information needs depending on the particular crop being cultivate: (a) Adequacy of rainfall amounts both deficits and excesses depending, and (2) “Early warnings” of potentially poor seasons to inform key actions for general planning questions; When to start planting?; Knowing how much to diversify; Knowing which crops to plant; Likelihood of meeting or failing to meet quotas.

This calls for a much closer inter-institutional collaboration between national meteorological and hydrological services and agencies that directly intervene in rural areas, such as extension services, development projects, and community-based organizations and Non governmental organizations (NGOs.).

Farmers and information providers should be able to evaluate the outcomes of alternative actions ((Hammer, 2000; Meinke et al., 2001). Crop models and simulation approaches provide means to explore the consequences of a broad range of decisions. Simulation studies have shown associations between El Niño phases and yields of peanuts in Australia (Meinke et al., 1996); corn in Zimbabwe (Phillips et al.; 1998) and

Argentina (Ferreyra et al., 2001), as well as mix of crops (Messina et al.; 1999; Jones et al., 2000; Hansen et al., 2001; Fontana and Camargo, 2002). Crop models are the preferred choice of analysis because of their ability to simulate yield response to alternate management conditions, such as planting date, row spacing, plant population, irrigation and cultivar choice, over many years of historical weather records (Boote and Pickering, 1996; Boote et al., 1998; Meinke and Hammer, 1995). The traditional ENSO forecasts still lack the capability to characterize intra-seasonal rainfall variability, and without knowing the rainfall distribution, it will be difficult to correctly forecast crop yields (personal communication, Jagtap, 2006.). *Idealized estimates of economic value of information (including forecasts) form difficult benchmarks to achieve in practice.* It is important to complement the use of such models with an understanding of the impacts of previous climatic (e.g. different types of ENSOs) and other events on farming practice and favorable or poor outcomes depending on the crop being considered. To enable effective responses farmers should have the tools such as access to extension advice, inputs, markets, credits to allow them to make farm investments, and a functioning communication infrastructure (accessible roads, markets and extension advice).

Creating an enabling environment for the effective use of climate information requires asking the question, "What conditions must be in place before farmers can benefit from seasonal climate forecasts?" (Hansen, 2002.) The vulnerability and capacity assessment literature provides a useful typology for structuring capacity to respond to climatic risks (Pulwarty and Riebsame, 1997):

Physical/material resources: What physical climate risks, and social skills, productive resources exist?

Social/Organizational capacity: What are the relations and organizations among information providers and users?

Behavioral incentives: How does the community view its ability to create change?

There has been a growing emphasis on devolution of risk management to the community level and greater recognition of varying degrees of effectiveness of community-based management. This requires that the information management community develops and legitimizes innovative approaches for the application of emerging communication technologies in agricultural management. Differing goals, problem criticality, institutional barriers, basis for decisions, usability and capacity, appropriate entry points for information, and experience or tradition, shape the use of existing climate information including forecasts in the context of other issues affecting productivity.

Benefits arise when *prediction* of climate fluctuations leads to *decisions* that reduce *vulnerability* to impacts of climate variability. It is increasingly recognized that improved decisions depend on communication, and that the process depends on institutional support in an appropriate policy environment, Hansen (2002) proposed five preconditions to successful forecast application:

- *Decision maker vulnerability and motivation*. Forecast information is useful only when it addresses need that is real and perceived. Decision makers must be aware of climate risk and its impacts, and motivated to use forecasts to manage that risk.
- *Viable forecast-sensitive decision options*. Benefits are conditioned on existence and understanding of decision options that are sensitive to incremental information in forecasts, and compatible with goals and constraints.
- *Predictability of climate fluctuations*. Relevant components of climate variability must be predictable in relevant periods, at an appropriate scale, with sufficient skill and lead time for decisions.
- *Communication*. Use of climate forecasts requires that the right audience receives, understands, and correctly interprets the right information at the right time, in a form that can be applied to the decision problem(s).
- *Institutions and policy*. Sustained operational use of forecasts requires institutional commitment institutions to provide forecast information and other support, and policies that support provision and use of climate forecasts.

Communication channels

The research community has identified several impacts aspects of forecast communication, such as, communication channels, stakeholder awareness, key relationships and language and terminology, in addition to the nature forecasts themselves, There is a significant disparity in communication infrastructure across countries and across different kinds of agricultural user groups. While among the scientific and technical community there is a lot of enthusiasm to make use of emerging communications technologies to share real-time information as well as local knowledge and experiences, extension agents most responsible for managing farmer linkages, have to rely on rather conventional means of communication. Low bandwidth and poor computing infrastructure pose serious constraints. On a national and regional level this calls for conscious integration of emerging and conventional communication technologies. While disparities in communication infrastructure do exist, there are significant local innovations that need to be harnessed and integrated with new technologies. The use local cable television for Internet access and use of phone booths for Internet kiosks in India, wireless internet access in Lao are some of the examples of local innovation that can be exploited for communications in disasters. In some areas, farmers have identified local language radio programs as credible and accessible mechanisms to deliver forecasts if they occur *with* follow up meetings with extension agents or other intermediaries (Konneh, 2007). Radio broadcasting could ensure widespread and timely coverage, while follow up meetings would enable farmers to ask questions and receive technical advice. This latter point of following-up is non-trivial and merits special attention below.

In one illustrative assessment of follow-up needs (see Ziervogel, 2004) and several representatives from southern Africa outlined limitations within present modes of climate information communication and dissemination. Examples of country-identified limitations include:

Zambia: Weak dissemination of climate information to outlying farming areas.

Namibia: Communication strategies of their climate information system do not serve the communal farming sector.

Lesotho: Poor informational flow from meteorological service through extension to the farmers.

Swaziland: Too much reliance on radio as a tool of dissemination, such a ‘one-way’ devices for communication were felt to be inadequate for agricultural applications (for example, farmers are not able to ask further questions regarding the information provided).

Mauritius: Restriction on forecast provision. More intensive use of the Mauritian media such that climate information could reach the entire population
Mozambique: At present the forecast is provided too late for planting decisions in parts of southern Mozambique

Several countries (Lesotho, Mozambique and Swaziland) found that timely issuance remains a key weakness in climate information systems especially for communication passed on the National Early Warning Units (NEWUs).

Channels of communication typically take the form of (Perarneaud et al 2004):

- Workshops and meetings (shared scenario construction; shared model building?)
- Presentations and briefings (incl. locally organized events, e.g. hearings)
- One-on-one technical assistance
- Coordination with other ongoing projects
- Work with the local media
- Web site development and maintenance
- Courses on climate impacts & adaptation (see below)
- Media (mass media and information telenovelas etc.)

Successful interactions rely on open decision-making processes recognizing multiple interests, community-based initiatives, and integrative science in addition to traditional science. Weaknesses and gaps identified by earlier and concurrent diagnoses of forecasts, early warning and/or climate information systems still persist. All of the above issues point toward the need for increased training and use of extension staff as tools for communication and dissemination and the need to improve relations with the print media. Such stakeholder interactions should concentrate on the incorporation of new knowledge or experience into existing models, decision processes and in media representation.

Capacity development for effective communication

Several countries (e.g., South Africa, Zimbabwe, Ethiopia, Argentina, Peru, Brazil) have ongoing programs within either their meteorological institutions or agricultural research systems that support use of forecasts by agricultural decision makers. Other programs have targeted particular countries, as well as multiple countries in a manner that allows comparison across countries. A sampling of some of the programs and projects that have a strong research to applications to use focus is given below (Hansen et al and others):

(a) In Australia, there is a strong network of institutions support agricultural application of seasonal forecasts. APSRU and the Queensland Center for Climate Applications (QCCA) are the best known.

(b) *The Florida Consortium now called the Southeast Climate Consortium* (University of Florida, Florida State University and University of Miami) first worked in Argentina, then in the Southeast USA, leading to the development of a statewide program on climate applications cooperatively implemented through Florida's agricultural extension service.

(c) *CLIMAG-West Africa* is a consortium of institutions in West African and Europe that are exploring seasonal forecasts for both farm-level and food insecurity early warning applications in Mali through a project entitled "Climate Prediction for Mitigation of Global Change Impact on Agroecosystems in Sudano-Sahelian West Africa" .

(d) *Climate Forecasting for Agricultural Resources (CFAR)* is a joint project of the University of Georgia and Tufts University, both in the US, targeting smallholder farmers in Burkina Faso.

(e) *CLIMAG-Asia.* The initial project, "Management Responses to Seasonal Climate Forecasts in Cropping Systems of South Asia's Semi-arid Tropics," in India and Pakistan, with participants from Australia and the US. The next phase, "Applying Climate Information to Enhance the Resilience of Farming System Exposed to Climatic Risk in South and Southeast Asia," adds Indonesia.

(f) *The Advanced Training Institute on Climate Variability and Food Security*, implemented by the IRI and co-sponsored by START, was designed to equip young agricultural and food security professionals in developing countries to apply advances in seasonal climate forecasting to their home institutions ongoing efforts. Participants in fourteen countries are now managing projects that involve exploration or application of seasonal forecasting.

(g) *Agrometeorological Information Center (CIIAGRO)-Brazil*. In 1998 CIIAGRO was created in the State of Sao Paulo, Brazil jointly by the Office of Agriculture and Supply and the Office for Science and Technology. A key activity is the operational use of agrometeorological models for estimation of water needs of main crops and related productivity, as well as to estimate the potential frequency of pests and crop diseases (Fontana and Camargo, 2002).

(h) Regional Climate Outlook Fora (COFs.). COFs are international frameworks in which climate analysis, assessment and data are synthesized by various regional forecasting groups to arrive at a consensus regional forecasts for a particular upcoming rainfall season Policy/decision makers are active participants of this process. The process was initiated by NOAA's Office of Global Programs (Buizer et al, 2000).

Many countries highlight the need for extensions training (using, for example, rural training centers) to include the use of tailored forecasts. For example, Lesotho instituted awareness-raising campaigns aimed at farmers (and the larger community) regarding the importance of climate information and its distribution, and user education programs to increase the demand for the forecast in communal areas, as well as an annual workshop to train extension training in various agricultural risk management directorates. In South Africa, this training included recommendations for the interpretation of the South African Weather Service's training manual specifically for the agricultural sector. Lessons from these and other projects funded by NOAA and other agencies are summarized in Table 1.

Table 1. Key lessons from international experience with agricultural application of seasonal forecasts (Konneh, 2006)

- Climate information is likely to have value, if communicated through extension agents/contacts who farmers already know and trust. Seasonal forecast communication, therefore, needs to go through existing trusted institutions (Hansen, 2003; Jones et al., 2003; Walker et al, 2003).

- Communicating the right information to farmers at the right time is one of the greatest challenges in the application of seasonal climate information in farmer decision-making. This study suggests that the current information needs to include additional details, such as applicable technological options given the forecast. For instance, if the forecast changes during the season how can users respond?

- The availability of the right type of seasonal climate information does not guarantee its use. The method of presenting the information, understanding the decision contexts of different user groups, such as the seed growers, livestock managers, and seed suppliers, are equally critical to effectively communicating seasonal climate forecast to benefit the users (Kirshen et al, 2001)
- Future resource allocations and policy priorities should focus on both technology transfer and programs, such as micro credit financing, that would create an enabling environment to apply technology, especially in developing regions, such as Africa, Latin America and Southeast Asia.
- Decision makers continue to resort to crisis management in climate-related disasters largely due to the low confidence they have in the current seasonal climate forecasts (Baethgen et al., 2003). The low level of use of current seasonal forecasts is especially due to their minimal ability to accurately inform decision makers about upcoming climatic conditions.
- User perception of climate vulnerability (e.g. exposure to recent extreme events) and understanding user decision contexts are critical factors that can influence forecast use (Yarnal et al., 2003).
- The value of ENSO forecast depends to a great extent on the identification of flexible mitigation options and the desire and ability of agricultural stakeholders to adopt alternative farm management practices.

Experience from extension services: Key Lessons

Quantitative, computer-based analytical tools can be combined effectively with participatory approaches to facilitate farmer discussion and foster mutual learning. Climate information is likely to have greatest value if communicated through advisors who farmer already know and trust. Any initiative must either work through existing institutions and advisory networks, or invest considerable time and effort to establish trust and credibility.

Different factors determine farmers' ability to change decisions in response to forecasts. Many apparent barriers can be overcome by taking a holistic approach and engaging all relevant stakeholders in the process. As has been shown, such activities entail considerable personnel (and personal) effort and resources applied over long time periods. As agricultural applications of seasonal climate prediction move increasingly beyond exploratory efforts of the climate community into mainstream agricultural research, credible demonstration of farmer use and benefit becomes increasingly important (Ziervogel, 2004).

Three key areas of concern related to communication can be distilled from these efforts (Ziervogel and Downing, 2004 and others):

(1) *Language / terminology*

Challenges of language and terminology were specifically highlighted by ten of the responding country teams. A range of responding countries called for translation of forecast terms into language understandable to the agricultural user. Zambia, for example, specifically states that the language is too technical.

(2) Provider/User / stakeholder awareness / training

User/stakeholder training and awareness are critical Weaknesses. In addition, providers need to be educated about the needs and decision-making processes that the farmers employ. Strategies to improve user and stakeholder awareness of climate information and its potential applications are described below.

(3) Characteristics of climate and climatic forecasts

The spatial distribution of forecasts is of particular concern for several countries and locations. Agro-ecologically specific forecasts are of key importance (e.g. statements from Lesotho, southern Mozambique, and Mauritius). Several country teams analyzed forecasts currently provided on different time-scales and critique them as follows:

- Seasonal: provides probability of rainfall amounts BUT does not address distribution;
- Monthly: provides probability of rainfall amounts BUT too general & probabilistic;
- Decadal: addresses rainfall distribution BUT in general, there are no daily rainfall amounts or relative humidity projections;
- Daily: addresses rainfall distribution BUT generally deficient of rainfall amount and relative humidity parameters.

The fact that forecasts can be too general (spatially and other aspects) to be of use to the agricultural sector echoes findings of other assessments. Farmers and extension agents also point to the limited utility of the High, Normal, and Low categories, regularly presented in Outlook Fora for decision-making. Thus, determining the level of acceptability of risk for particular negative outcomes is key.

Given the limited familiarity with concepts of climate across timescales (from extremes to change) efforts simply to provide awareness of the role of climate in lives of farmers and agribusiness need to be developed and understood by information providers including extension agents themselves (see Training the Trainers, below). One such effort is the "Climate Field School". While the lessons from the field school are slowly emerging it is worth outlining the approach for the purpose of supporting effective communication channels.

The Climate Field School concept: Setting the context for effective communication

The concept of Climate Field School is adopted from the Farmer Field School designed for Integrated Pest Management (see Gallagher, 1999; Birkhaueser, 1991). The Climate Field School (CFS) is intended for (i) increasing farmers knowledge on climate and ability to anticipate extreme climate events for particular farming activities; (ii) assisting farmers in observing climatic parameters and their use for supporting farming activities, and (iii) assisting farmers in translating the climate (forecast) information for supporting farming activities, in particular planting decision and cropping strategy (see Appendix 1 for an illustrative case). The process for the dissemination of climate information to farmers should follow the process of introducing new technology. Farmers should be convinced from their own experiences that the use of climate forecast information would increase their benefit and the resilience of their system to the extreme climate events. The forms of CFS activities are simulation process and interactive discussion between field facilitator and farmers regarding climate, and group dynamic.

Training materials in field schools should cover the following aspects:

• Basic concepts of climate prediction (probability concept, terminology used in climate prediction etc.), climate forecast products and explaining seasonal forecasts on shifting probabilities on crop yields, marketing trends, likely pest outbreaks etc..

• The use of historical agriculture data (drought/flood data, planting data, frost, harvesting data, agriculture production data etc.) to assess the impact of climate variability/extreme events on agriculture, and simple water balance analysis, technology for rain harvesting, etc.

• The use of climate forecast information for setting up cropping strategy (cropping patterns, crop rotation, intercropping etc.).

As discussed by Feder et al (2003) there is merit in continually reviewing the curriculum, and focusing training on the highest priority topics, while simplifying the presentation of the information. The simplification of the program's content will make more effective with respect to improving the performance of graduates, and also increase the likelihood and speed of diffusion of new knowledge among other farmers. Diffusion can also be enhanced (and made more cost-effective) by employing mass media and other dissemination approaches for key aspects of the knowledge (e.g., safety rules regarding the use of pesticides). This would require additional efforts to ensure that the media (print, television) is familiar with concepts such as ENSO and the associated forecast uncertainties. They may themselves be seen as recipients of extension services. The narrowing and prioritizing of the curriculum will also shorten the length of the training, and will reduce programme costs. Increasing the extent of simple decision rules in the training will make the program less dependent on trainer quality and more amenable for scaling up.

The necessity of "training the trainers"

Information providers should themselves be clear as to the nature and limitations of the information being provided. Extension agents can themselves benefit from Climate Field Schools, which would build additional trust among users. The key emphases in addition to developing a critical acceptance, should be identifying appropriate entry points and application of jointly produced information at those points of decision making (Pulwarty et al. 2003). This necessitates a technically strong facilitator. A major problem is that the providers of climate information are communicating probability information in deterministic ways. Seasonal forecasts must be communicated and understood in probabilistic terms. It is however difficult to communicate that the climate forecasts are a spread of possible outcomes (with some probability of an outcome of "dry" conditions in a wetter than normal forecast) and not a single prediction. The expectation of a deterministic forecast that will turn out to be either "correct" or "false" is especially damaging in situations where the decision maker will experience post-decisional regret after believing that s/he acted on a "false" forecast.

Overconfidence due to miscommunication or distortion of uncertainty can negate the value of forecast use, leading farmers to make decisions that are inconsistent with their risk tolerance. Better understandings of the outcome variables that matter to farmers provide guidelines on whether and how best to "translate" climate forecasts. If, for example, crop yields or the costs of production input needs particular attention, it becomes necessary to "translate" a climate forecast into the agronomic yield, income, and/or cost implications that it holds.

Various researchers have found that communicating the nature of seasonal forecasts is critical for changing user behavior with regard to utilizing seasonal forecasts. The researchers agree that agricultural extension agents are one of the best vehicles to communicate forecast information to users in the agricultural sector. Many extension agents, however, lack basic climate education to enable them package the probabilistic climate information into flexible and operational formats for users (Hansen, 2002; Jones et al., 2003; Walker et al., 2003.) As discussed, workshops, participatory discussions, which actively engage decision makers, are effective for communicating seasonal forecast information (Hu et al., 2003; Kirshen et al., 2003; Patt and Gwata, 2002; Orlove and Tosteson 1999.) This conclusion is especially true, for rural communities in developing regions of Africa, Latin American and the Caribbean, and South East Asia, where opportunities for internet access are low and the use of print media is minimal due to low literacy levels. However as noted above, even in more technologically advanced areas, there is still the need for face- face multi-way communication and training.

There are many other issues that undermine the effectiveness of the agricultural extension agents, especially in the developing regions such as Africa. a) Extension services in many countries (e.g. Burkina) are being severely impaired by cuts in government spending, so that agents do not even have the means of transport to reach farmers; low pay and poor work conditions results poor motivation and absenteeism. In other cases (e.g. Uganda), 'modernization' policies support the hiring of university graduates as agricultural extension agents, but the latter have no experience with farming, and can often show too little respect for farmers, and rarely visit the areas they are supposed to cover (Roncoli, 2006). Against this backdrop, WMO should collaborate with RANET, NOAA climate Education Program, the IRI, NOAA's Regional Integrated

Sciences and Assessments (RISA) through the South Eastern Climate Consortium (SECC) and regional institutions in Africa, Latin America and the Caribbean, the South East Asia and the South Pacific, to develop training and reporting scheme that would enable the extension agents, regional journalists and users to understand the basics of seasonal forecasting, and how climate affects the agricultural sector. The instruction should focus of how the trainees use the knowledge to optimize production and minimize climate related losses in the agricultural sector (Konneh, 2006).

Off-farm Planning and Decision-making

Climate variability is also associated with other sources of production risks such as pest and disease incidence and market plans require analyses of supply and demand projections throughout the cropping season and post-season storage and transportation. In addition to on-farm users (farmers), a broader typology of "users" or stakeholders" would include:

Information Providers
Owners and suppliers of inputs (seeds, fertilizers)
Buyers and Market intermediaries
Sources and developers of technology
Financiers of technology transfer
Local, regional, and national governments

While studies have identified barriers related to resource availability, few have attempted to involve relevant actors, such as suppliers of agricultural inputs or credit, sufficiently to address barriers (Hansen, 2002.) Few attempts at forecast interventions have allowed sufficient time for farmer learning, often due to the constraints of project funding cycles. There are not very many clear, well-documented examples of forecast use particularly by resource-poor farmers in less-developed countries (see Archer, 2003). Marketers now examine seasonal forecasts in developing marketing and shipping plans and harvest operators and farmers have identified different harvesting strategies that can be employed for different climate outlooks. In addition, they have identified how seasonal climatic forecasts can be used to assist with herbicide and fertilizer management. The ex post analysis of forecast use and utility should help to facilitate an ongoing process of social learning.

Linking the decision making calendar to the agro-climatic calendar: Seasonality of climate, practices and decision-making inputs

Decision makers in numerous domains, including research, have been shown to have limited insight into their own decision processes and goals and objectives. Employing simple elicitations such as “What do you need and when do you need it?” might be in fact misleading since a high degree of prior knowledge is presumed. Successful information development and use is a learning process. Many researchers and mediators have argued for consensus in judgmental forecasts e.g. combining regional scale dynamic forecasts with local insight. Without consensus validity, scientific consistency, and generalizability may be lost (Arkes, 2001). In such processes can also lead to “groupthink” with domination by particular individuals. A more careful structuring of feedback within partnerships developed between providers and users (or representatives of user) needs to be established.

The concept of the decision calendar was introduced in Pulwarty and Melis (2001) as a means of obtaining and cooperatively mapping decision making characteristics, perceptions, and information inputs as they co-evolve with the hydro-climate, or in the present context, the agro-climate calendar. This simple tool, employed as a joint product between farmers, resource providers (e.g. seeds, fertilizer etc.) and information providers, is a means of co-producing knowledge about the key timing of inputs to generate particular outcomes. In addition to the benefits of the “annual round” it can also indicate potential off-farm (e.g. ENSO, market, globalization of farm inputs) interactions as they affect in-farm activities. Table 2 (Walker et al 2003) shows one example of an agro-climate decision calendar. Added to this could be information on how ENSO affects the seasonality of precipitation during key activity periods, and what climate information would be needed at which critical points in time to be included in decision-making (Table 3; Pulwarty et al 2001). It helps an information provider structure his or her interaction while allowing for stakeholder inputs for planning, resource gathering, implementation, harvest, storage, processing and transportation as forecasts change or verify. It also offers a means of facilitating knowledge development between providers at different scales (e.g. on farm, regional forecast providers) and farmers (or managers).

Table 2. Various decision taken by farmers in the low and adequate rainfall agro-climatic regions of the central Rift Valley of Ethiopia (Walker et al 2003)

Agroclimate Zone	**Dominant**	**Crops Secondary**	**Cash Order choice**	**Date of Sowing**	**Variety Preference**	**Land Labor Preparation**	**Harvest Date**
S3 Single Growing Period low Rainfall areas :Melkassa &Miesso	Maize Beans	 Sorghum Teff	Maize 3 Beans 1 4 Teff 2 Teff	Early April – May Late June to early July Late July	Medium duration Short duration No choice	3 times med 2X least 3X med 4X greatest 4X	Starts in early October Late Oct. to November
D3 Double growing period, adequate rainfall :Awassa& Arsi Negelle	Wheat Maize Barley	 Teff Sorghum	Wheat Barley Teff Potatoes Onion tomatoes	Early to late April June,July, August	Nochoice long duration Medium Replant if failure	med 3X med 4X high high high	November & December for long duration

Table 3 provides a sequential list of questions that may be cooperatively answered between providers and stakeholders over the period of interest (e.g. planting through harvesting), linking the key inputs (e.g. how an ENSO event modifies the climatological averages and exceedance probabilities and this in turn affects practice).

Table 3. Key issues in linking the decision-making calendar to the agro-climatic calendar for assessing and responding to potential ENSO impacts (Pulwarty et al, 2001).

- What are the sources of climate variability and controls on yields and operations?
- What are the critical months that influence the crop quality in the following harvest?
- How does rainfall and temperature (solar radiation etc.) impact these critical

months? seasonal precipitation, temperature, solar radiation).

- What is the critical period for ENSO impacts (which seasons) on yield predictability?
- How do different "warm" (El Niño) and "cold" (La Niña) events and their evolution phase affect yield?
- What is the present degree and evolving use of climate information?
- Where are the entry points for climate information into the annual cycle of operation decisions and into longer term planning
- What types of information (forecast characteristics) are identified as important and when where and how should this information be provided?
- What other factors condition vulnerability? What practices and policies give rise to failures and to successes in the use of scientific information? What changes in the physical and management environments have impacted sugar production on an annual basis (pest outbreaks, worker strikes, and factory breakdowns)?
- What management actions can be taken with given probabilities and lead times? What capacity building measures are needed within the industry?

Conclusions:

Few studies that have taken a holistic approach have been designed explicitly to evaluate information adoption, impact and refinement. Podesta et al (2002) and others outline key supporting activities in the effective communication of climate information for agricultural decisions:

- *There is need to develop procedures to convert raw climate information and forecasts into likely outcomes of alternative decisions in climate-sensitive sectors of society. Mapping practical pathways to different outcomes can be carried out as a co-production strategy between, research, extension and farmer communities.*
- *Efforts to foster effective use of climate information and forecasts must be grounded in a firm understanding of the goals, objectives, and constraints of farmers and agribusinesses in the target system.*
- *Existing stakeholders' networks and organizations may provide effective ways to*

disseminate and assess climate information and forecasts.

- *Research, teaching, and outreach on the environmental and societal implications of climate variability and change require a broad spectrum of talents and participants. Yet, our understanding of factors leading to the development and sustained operation of successful interdisciplinary research and outreach teams still is quite limited.*

Wherever resources allow, a holistic approach that attempts to put the necessary conditions in place, and concerted efforts to demonstrate and quantify use and benefits, will benefit the cause of seasonal forecast applications and the farmers. We conclude with the following framework for researchers and practitioners cooperatively engaging in the use of climate information, including forecasts, in the agricultural sector:

(a) Integrate an understanding of local contexts and contending perspectives with an understanding of how new information becomes framed and socialized into farming practice;

(b) Assess impediments and opportunities to the flow of information including issues of credibility, legitimacy, compatibility (appropriate scale, content, match with existing practice) and acceptability

Baseline work with farmers and other agricultural stakeholders:

(1) Describe the agro-climatic decision calendar/annual cycle of decisions of different processes (planning, information gathering, forecasting, decision-making, implementation evaluation, etc.) to identify entry points for relevant climatic information and competing pressures at different stages

(2) Clearly document single past events of significance and evaluate the contexts within which decision-making occurred, including lessons learned and incorporated.

(3) Refine Climate Field School material in the context of other field schools. Key emphasis should be on analyses of the role of antecedent events and decisions on constraining or enabling alternatives recommended during rapidly developing events

(4) Evaluate decisions and outcome scenarios within the context of longer-term climate variations such as decadal-scale wetter and drier periods. This includes evaluating the

cumulative impacts of shorter multi- year variations (e.g. extended dry periods) and antecedent physical conditions (e.g. high precipitation during key germination periods or hhigh temperatures during flowering) .

From the perspective of forecasting these tasks involve actions to clarify both acceptability of information and context in which such information is going to be used (Fischoff, 2001; Pulwarty and Melis, 2001),:

Before making forecasts:

Meet with recipients or representatives to determine which measures they would find most useful.

Independently analyze the problems that stakeholders face in order to obtain a complementary perspective.

Empirically test formats for communication in order to ensure that stakeholders understand the information as intended.

Seek users explicit agreement on appropriate formats.

Develop decision calendars cooperatively with stakeholders to determine key entry points for different kinds of information.

While making forecasts:

Make the nature of links to decision calendars and the forecast as explicit as possible, including alternate possible outcomes.

Document the assumptions underlying forecasts including how changes seasonal development would change the forecast (how is the forecast verifying?)

When evaluating use:

Do post-season farmer workshops (during if possible)

Review what was predicted and what assumptions were made

Construct explanations not only for what actually happened but what could have happened as a way of retrieving uncertainties at the time of predictions

Evaluate what new was learned about the process producing the event predicted as well as the vent itself.

For climate information and forecasts to be used to their considerable potential, four general requirements are identified: 1) Stakeholders (or intermediaries) must be able to obtain information (from forecasts or existing information) on factors or variables of direct interest to them and at lead times allowing for planning; 2) Paths to decisions, using this information, must be clear and practical; (3) Stakeholders must be able to critically question the provided information to assess appropriateness; (4) Stakeholders must be convinced that such information when used effectively will indeed make them better off than before.

Through mechanisms such as the Climate Field School (even an abbreviated version) and the co-production of agro-climate decision calendars information providers should treat the development, communication, and use of climate (and other scientific) information as a process where symmetrical learning takes place between providers of scientific information and farmers and agricultural stakeholders over time. Researchers, through ongoing dialog and joint studies, should engage practitioners as full partners in uncovering issues of mutual significance, explicitly address uncertainties, and known barriers to information. The goals are to have better matches among what is needed, what is provided and, what actions may be undertaken that increase flexibility in decision making. The recommendations above are made from years of empirical studies that show what has worked based on experience. The approaches require considerable transactions costs in terms of human resources and time. To realize the potential of climate information including forecasts requires support for personnel to maintain sustained communication pathways as outlined above.

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Appendix 1. Key Modules being developed in the First Phase of Climate Field School program (adapted from Boer et al, 2003)

1. Knowledge about Elements of Weather and Climate	Introduce element of weather and climate Build ability to differentiate between weather and climate
2. Process of Rain Formation	Study the process of rainfall formation Develop better understanding on the importance of forest in retaining water.
3. Developing Understanding on Terminologies and Indices Used in Seasonal Climate Forecast	Develop capacity to understand the meaning of averages and deviations from average. Develop capacity to translate the seasonal climate forecast used by the BMG to local condition (in their farm) considering the trend in rainfall data measured by the farmers.
4. Developing Understanding on Probability Concept (Forecast Error history) Types of seasonal variability: ENSO and non-ENSO related: Effects of ENSO –precipitation relationship on critical periods	Develop better understanding of probability concept and skill of forecast in climate forecasting and its relation to decision making Impacts on previous years and seasonality Also for non –ENSO related precipitation impacts
5. Introduction To Measuring Tools for Weather/Climate Weather Measurement Equipment and Ways of Calibrating Data •	Introduce instruments used for measuring weather/climate elements Learn factors affecting the accuracy of data measured by non-standard instrument Learn how to calibrate data which is not measured using standard method
6. Learning about Water Balance Concept and Its Use To Assess Irrigation Water Requirement, and Flood Risk	Develop better understanding the meaning of rainfall deficit from evapotranspiration Develop better capacity on how to estimate irrigation water requirement from based on simple water balance Assess risk of flood from water balance analysis
7. Using Climate Forecast Information for Setting Up Field Management and Planting Strategies	Develop better understanding on how climate extreme events will affect the crop (e.g. relationship between cropping rotation and planting time on level of damaged) • Site selection • Pest control and fertilizer applications Develop better capacity in using seasonal climate forecast in setting up cropping strategies (to avoid or minimize effect of floods and drought) Vegetation conditions for livestock
8. Assessing the Economic Value of Climate Forecast Information	Develop better capacity to quantify the economic benefit of using climate forecast information Market impacts
