Regional Climate Prediction and Risk Reduction in the Greater Horn of Africa

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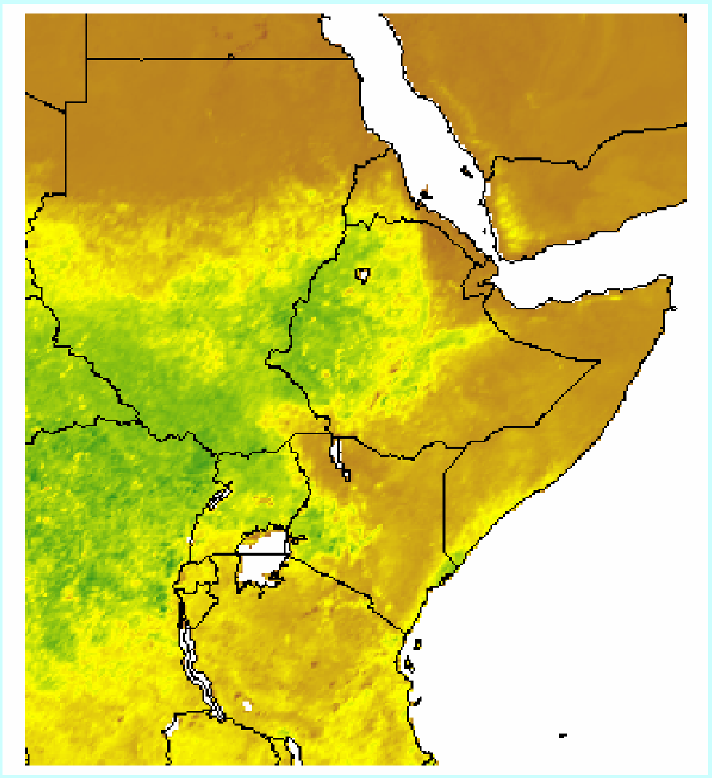

Final Report to the USAID Office of Foreign Disaster Assistance from the
International Research Institute for Climate Prediction (IRI), The Earth
Institute at Columbia University

June 15, 2005

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1) Introduction

1.1. Background

Sub-Saharan Africa (SSA) regularly experiences negative climate-related outcomes such as disasters, disease outbreaks, water shortages and food crises due to a combination of climate variability and vulnerability to climate-related hazards. SSA is also the least developed part of the world, with very low development indicators. The Greater Horn of Africa (GHA) is one of the least developed and most vulnerable regions to climate variability in Africa. Climate variability creates risks in many climate sensitive sectors including agriculture, livestock, water resources and health.

Extreme climate events such as droughts and floods are common in GHA countries. Historical disaster frequencies and the numbers of people killed and affected during disasters show Sudan, Ethiopia, Kenya, Somalia and Tanzania ranking among the most disaster-burdened countries in the world. The vast majority of natural disasters in the GHA have historically been triggered by climate shocks, exacerbated by civil conflicts.

El Niño-related floods in 1997/98 led to loss of life, destruction of infrastructure and large-scale economic losses. The floods were immediately followed by one of the longest and severest droughts in the history of the region, related to the 1998-2001 La Niña. The 1998-2001 drought had harsh negative impacts on agriculture, livestock, forest, wildlife, tourism, water resources and hydroelectric power generation. For example, about 100,000 hectares of Ethiopia's forests were hit by fire in the year 2000[1]. Electricity shortages due to low reservoir levels led to power rationing in Kenya and Ethiopia[2]. There was a shortage of water for industrial and domestic consumption due to the drought, with serious water shortages both in urban and the rural areas. Lack of water, pasture and food accompanied severe conflicts between pastoral communities in Kenya and even among wild animals in some areas[3].

The impacts of the 1997/98 El Niño-related floods and 1998-2001 La Niña-associated drought forced the governments in the GHA to declare emergencies and receive international relief. The World Bank loaned Ethiopia[4] and Kenya[5] $61.7 and $40 million dollars respectively for emergency recovery.

Climate variability and extremes affect the welfare and livelihoods of people. The GHA is particularly vulnerable because of the dominance of rain-fed agriculture for food supply and hydro-electric for power generation. African farmers lose their crops due to

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[1] IRIN (UNOCHA). News Coverage of Ethiopian Fires. March 30, 2000.

[2] USDA FAS Online, June 26, 2000. http://www.fas.usda.gov/pecad2/highlights/2000/06/eaf_drought.htm

[3] For examples see Lions See off Hyenas, BBC News, Africa. April 19, 1999. http://news.bbc.co.uk/1/hi/world/africa/323422.stm

[4] The World Bank Group. Ethiopia Emergency Drought Recovery Project. 2003.

[5] The World Bank Group. Kenya El Niño Emergency Project. 1998.

lack of information on the onset, distribution and cessation of rainfall. Droughts destroy crops, pasture and the availability of water both for humans and animals. The destruction of crops during droughts and floods reduces the economic status of most rural communities, especially women.

Drought constitutes the lower tail of the highly variable rainfall distribution. Impacts also occur in high-precipitation years due to flood and unseasonable rainfall distribution. Climate variability is highest in semi-arid areas. The semi-arid zones that are prone to drought and flood disasters are also hotspots for hunger and malnutrition (figures 1a and 1b).

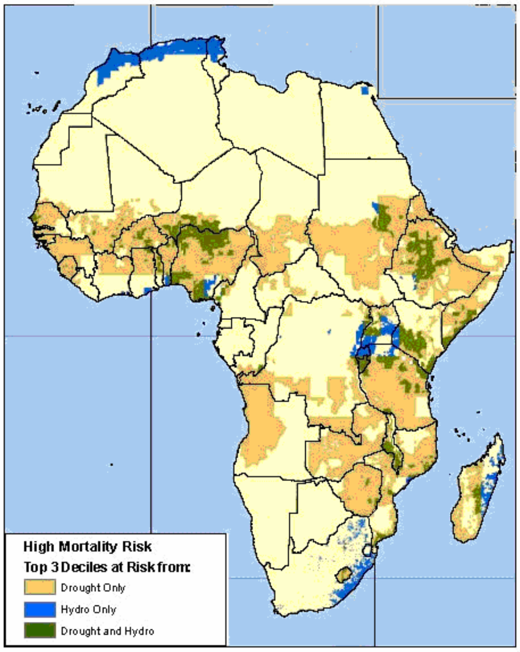


Figure 1a. Disaster mortality risk
(Source: Disaster Risk Hotspots project)

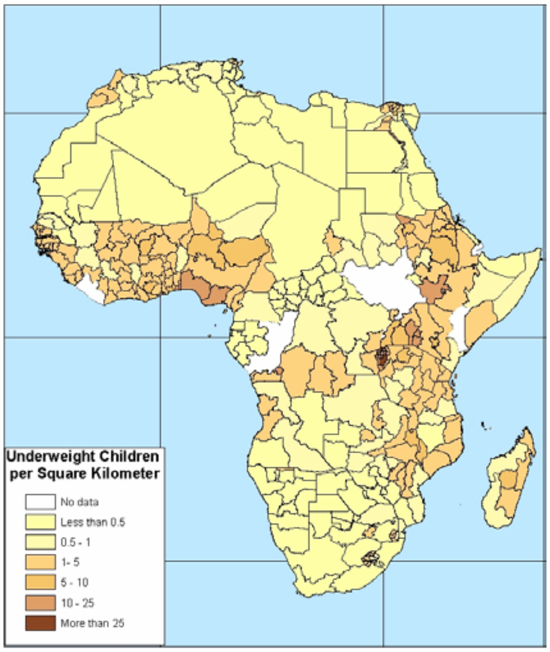


Figure 1b. Density of malnourished children
(Source: Millennium Development Project)

These same semi-arid areas are also areas prone malaria and meningitis epidemics (figures 2a and 2b). Malaria outbreaks are associated with precipitation, flooding and temperature variations. Wet conditions also create risks to animal health and livestock trade by creating higher probabilities of outbreaks of Rift Valley Fever. Meningitis, transmitted through a dust-borne virus, is also associated with dry conditions.

Figure 2a. Epidemic malaria distribution (Source: WHO and UNICEF)

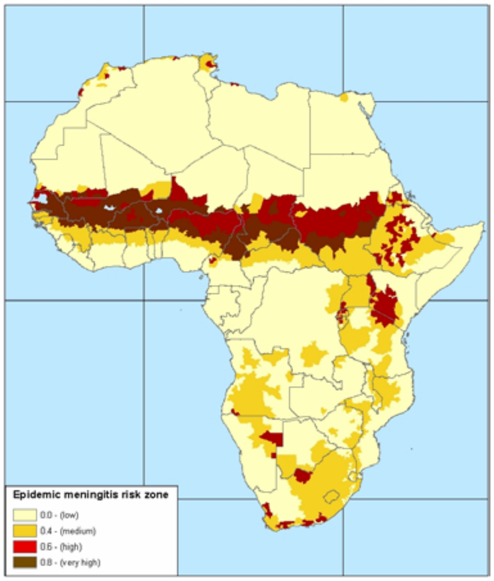


Figure 2b. Epidemic meningitis risk zone (Source: Molesworth et al. 2002)

1.2. The current project

The International Research Institute for Climate Prediction (IRI) has been active in the GHA since 1999 with funding from the United States Agency for International Development (USAID). The results presented in this report are from the current project -- Regional Climate Prediction and Risk Reduction in the Greater Horn of Africa -- which began in July 2002. The results described were achieved in partnership with many other organizations. Two that were crucial in every phase of the work are the IGAD Climate Prediction and Application Center (ICPAC) and the World Meteorological Organization (WMO). The U.S. Geological Survey (USGS), FEWSNet and the World Food Program (WFP) collaborated extensively on many of the activities.

The grant from the USAID Office of U.S. Foreign Disaster Assistance (OFDA) for the project whose results are described below was a counterpart to a second USAID/OFDA grant to the WMO. Additional funding was provided by REDSO. The IRI and WMO projects both supported the work of the Drought Monitoring Center in Nairobi (DMCN, now ICPAC) and collaborating partners concerned with disaster reduction and sustainable development in the GHA. The complementary projects contributed to the achievement of the overall results.

The project goal is improved monitoring, prediction and applications for early warning of climatic hazard events in support of disaster reduction and other regional sustainable development objectives. The objectives deal with 1) improving regional climate models and products; 2) increasing the availability and application of tailored products for reducing vulnerability to climate extremes and adapting to climate change; and 3) improving the application of climate products and services to reduce disaster losses and promote sustainable development.

One of the principal vehicles for coordinating the project and its many stakeholders has been the Greater Horn of Africa Climate Outlook Forum (GHACOF) and network. Participants and contributors include climate scientists, experts from national, regional and international institutions, donor representatives, NGOs and UN agencies involved in food security. The purpose of the COFs is to provide a consensus forecast for the region before each major rainy season and indicate possible societal implications.

The COFs have been organized jointly by the ICPAC, the WMO and the IRI in collaboration with national meteorological services and other stakeholders. One of the achievements of the COFs has been capacity building in climate forecast skills in the GHA through training workshops. These workshops are conducted prior to the COFs, attended by experts from the GHA National Meteorological Services (NMSs) as well as other specialists from climate-affected sectors.

All aspects of the project were implemented through an international partnership of stakeholders. Partners involved in specific activities are identified throughout.
They include the University of Nairobi, USAID Famine Early Warning System network (FEWSNET), University of Nairobi, FEWS/USGS, International Center for Research in Agro-forestry (ICRAF), International Crop Research Institute for the Semi Arid Tropics (ICRISAT), the Inter-African Bureau for Animal Resources (IBAR), Red Sea Livestock Trade Commission (RSLTC), International Animal Health Organization (OIE), Texas A&M University, the World Food Program (WFP), KenGen, and the Network of Climate Journalists in the Greater Horn of Africa (NECJOGHA).

We hope that the results demonstrate how climate impacts can be managed through improved understanding of climatic patterns in the GHA and throughout semi-arid Africa. We believe the project outcomes suggest that enhanced monitoring and seasonal predictions can lead to more effective and timely dissemination of early warnings as well as increased awareness of the usefulness of climate information for decision-making. Tools and techniques developed through the project address particular climate-related problems in specific decision-making contexts. The results of these demonstrations are explicitly intended to provide a basis for undertaking future work on increasingly wider scales.

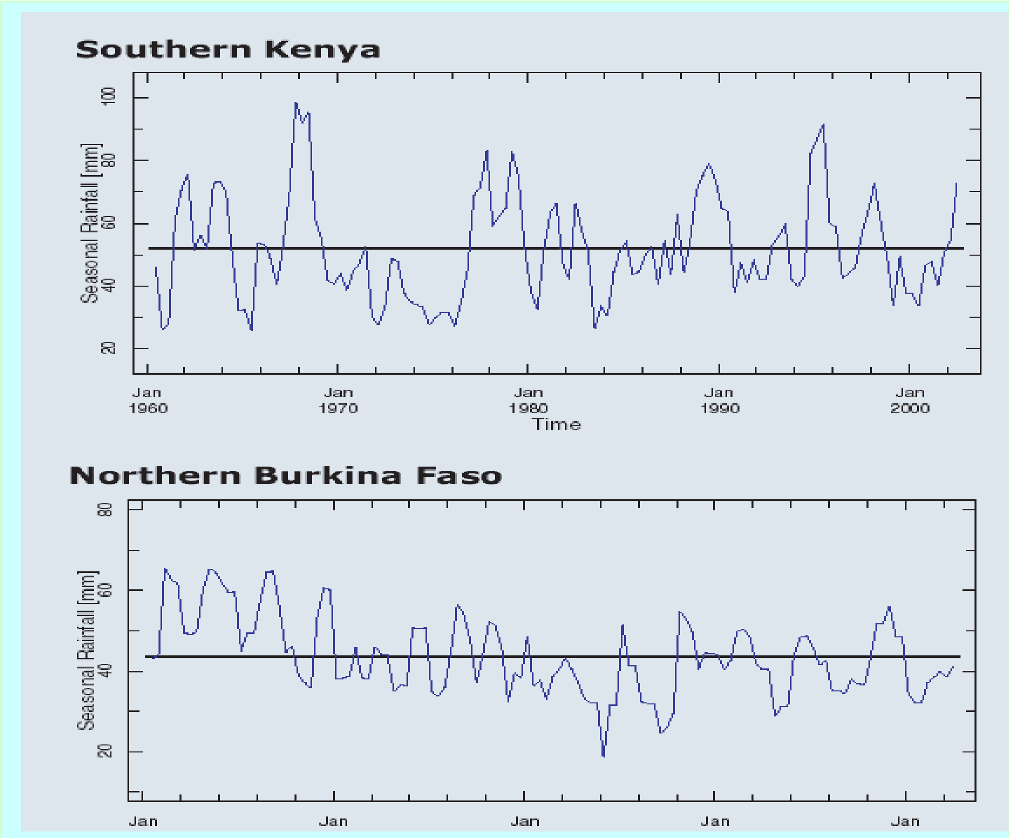
2) The problem: outcome risks in semi-arid Africa

Droughts and floods are the two extremes of the climate spectrum in the semi arid areas (figure 3). These semi-arid areas -- prone to hunger, disease, disaster and other negative, anti-developmental outcomes -- share two overriding characteristics. First, the countries in them tend to lack resources and in many cases have a high economic dependence on primary sector activities. This makes them vulnerable to climate variations. Second, they have highly variable rainfall. Rainfall one year may be exceptionally low, leading to agricultural failures, water and sanitation problems, high food prices and food insecurity, and the next year they can be very wet, accompanied by outbreaks of diseases such as malaria.

Risks posed by climate variability are high in the GHA because of the lack of coping capacity among large sectors of society. These populations are unable to absorb the shocks of climate related hazards due to lack of information and resources.

When a shock occurs because of drought hazard, the vulnerable economies of Africa are affected in many ways: agricultural production, hydro-power generation, water use, and household-level water availability. These primary impacts increase the need for food aid, food imports, creating balance of payments problems, depletion in foreign exchange, inflation and so on. Climate shocks like drought can have macro-economic implications in these regions, affecting the livelihood and food security of people throughout the economy. Drought affects agricultural prices, export earnings and power generation. The contraction of the economy due to drought leads to unemployment. Drought depletes the asset of poor people and its impact lingers for many years. Managing climate-related risks across multiple sectors to avoid these types of negative outcomes is important. It is a key for achieving the Millennium Development Goals (MDGs) and other development objectives. Impacts of drought shocks are particularly widespread, and are transmitted throughout the entire economy (figure 4).

Several regions in Africa show potential predictability. This predictability is associated with El Niño and the Southern Oscillation (ENSO) as well as with sea-surface temperature variability in the Indian and Atlantic Oceans. Predictability in the GHA is exceptionally high in the October-December "short rains" season. According to preliminary findings, there is optimism for a good predictability for the June –September season. However, there is currently less predictability skill for the March-May season. Climate prediction, when combined with an understanding of climate impacts in sensitive sectors, offers the possibility to anticipate climate variations and extremes and manage the impacts to improve climate-related outcomes.



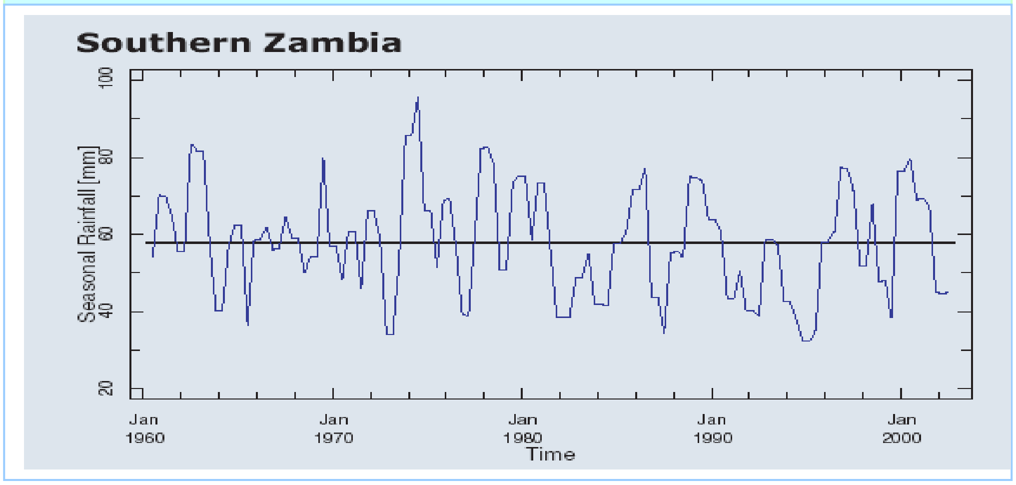


Figure 3. Large areas of Africa are challenged by a high degree of climate variability

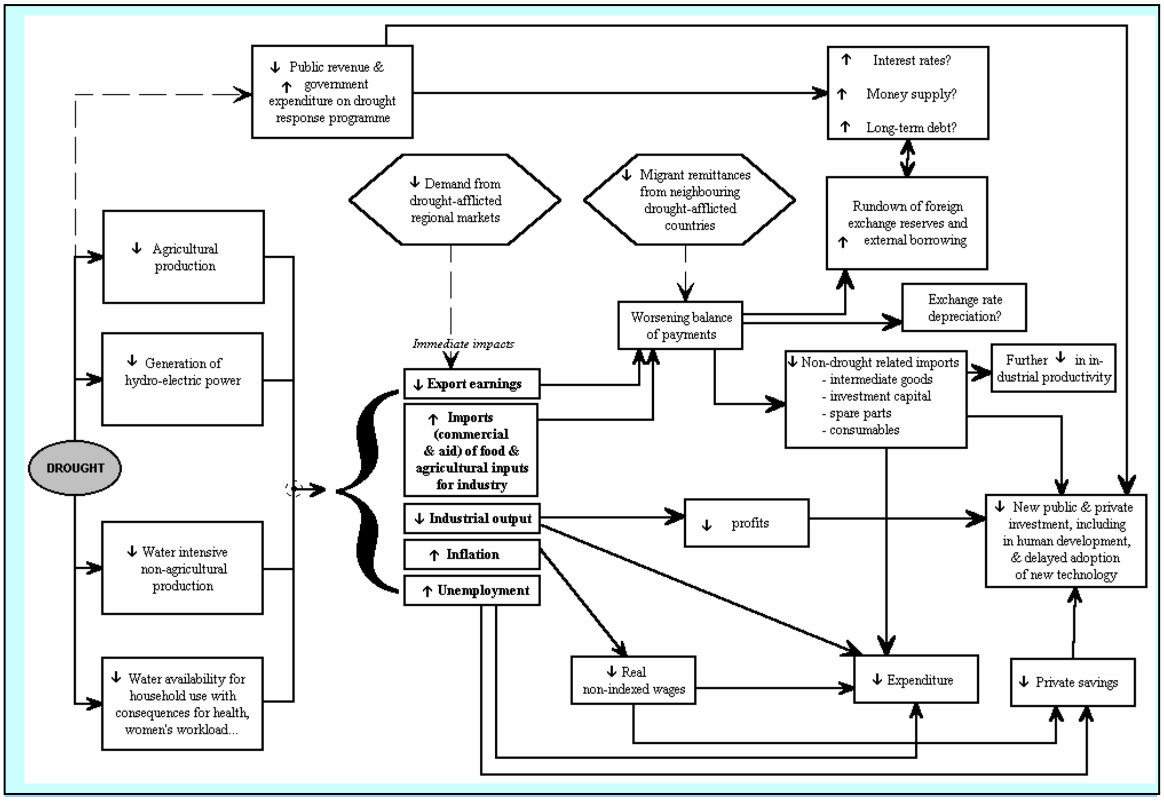


Figure 4. Transmission of a drought shock through an economy (Benson C. and E. J. Clay, 1998)

3) Climate-risk management for African development

The Millennium Development Goals (MDGs) underpin an international strategy to achieve targeted levels of poverty/hunger reduction, access to decent health, water and the protection of the environment.[6] The MDGs represent a converging mechanism, intended to lead to decreasing variation between donor objectives and national plans, and more agreement on priorities and best practices than has previously been the case.

Because of the potentially disruptive impact of climate variability on the effort to achieve African development objectives there is a need for comprehensive management of climate variability in sensitive sectors. The economy of the GHA is climate-sensitive. The livelihoods of many people depend on the onset, intensity and cessation of the rainfall. Livelihoods, food security, poverty and sustainable environmental management are intrinsically linked to climate variability and extremes. Almost all agricultural activities and livestock resources depend on rainfall. Rural roads that link various towns become inaccessible during the heavy rainfall season due to flooding. The countries' foreign exchange reserves that depend on the export of primary products such as coffee and live animals are periodically drastically reduced because of climatic fluctuations.

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[6] The MDGs are a United Nations strategy to cut many poverty indicators in the poorest parts of the world at least by half by 2015. http://www.un.org/millenniumgoals/

A major assumption tested by the project is that the economy and society of the GHA region would benefit from better use of climate information that has been unavailable until recently. Increasingly, African institutions are demonstrating the capability to convert "raw" predictive capability into decision-support products to improve climate-related development outcomes in areas related to disaster reduction, development and the MDGs. This process involves extensive engagement among varying mixes of local, national, regional and global stakeholders.

The MDGs are beyond the scope of any single project. Thus, this project developed a two-track approach. The first track consists of targeted demonstration projects, designed to address specific climate-related risks. The second track is to "upscale" the results of the demonstration projects by involving multiple stakeholders at the local, national and regional levels. The demonstration projects build the capacity of all partners to address climate-related risks using the acquired knowledge and skills. At the same time, the results and lessons learned provide a basis for undertaking the types of interventions that were tested through the demonstration projects on a wider scale.

3.1. Collaborative demonstration projects

A major thrust by the IRI and partners under the project has been demonstration projects designed to improve specific outcomes through managing risks associated with climate variability. The initial findings in the demonstration projects suggest that climate information can successfully be developed jointly with risk managers for addressing specific problems. Examples, described in more detail below, involve the use of climate information to manage risks related to farm-level agriculture, food insecurity, livestock trade and reservoir operation.

The demonstration projects seek to create tools so that stakeholders can replicate the results elsewhere under similar circumstances, both nationally and on a regional basis. The tools encapsulate methodologies for managing climate-related risks in specific sectors. They also promote a structured approach to improved knowledge generation, its transfer and management. The demonstration projects necessarily involve participation between different kinds of experts and stakeholders. Collaboration also leads to exchange of ideas and increases capacity through knowledge transfer.

The capacity of the GHA countries to tailor and apply climate forecasts has improved tremendously during the project. Post-project steps will include national and regional up-scaling of the demonstration projects the findings of the demonstration projects.

3.2. National and regional upscaling

One means of IRI involvement with regional partners in the GHA over the project period has been through the COFs. The GHACOFs have been important mechanism for capacity building and knowledge transfer in the region.

Prior to each COF, a regional workshop is held to develop national level forecasts using state of the art forecasting techniques and to enhance the skills of forecasters. These workshops are an opportunity to introduce new forecasting techniques, some of which can be run at national scales by the participating meteorological services.

GHACOFs are also typically preceded by capacity building workshops in the application of climate forecasts to sensitive sectors of the economy. Workshop participants from the agriculture, water resources and health sectors engage with the climate community to understand and apply climate information to their specific sectors. The interest of the users of seasonal climate information led to the creation of a series of demonstration projects designed to establish a framework for applying the seasonal forecast to various sectors, described below.

Another COF focus has been improvements in climate information dissemination through the media. The participation of journalists in the GHACOFs has led to the establishment of the Network of Climate Journalists in the Greater Horn of Africa (NECJOGHA). The network is involved in outreach programs to build the capacity of fellow journalists to be partners in communicating climate information more effectively to the public. The example of the NECJOGHA is being repeated in Southern Africa through another USAID/OFDA-funded project, with professional support from the NECJOGHA.

To date, many partnerships have been forged through the COFs that reinforce institutional capacity to apply climate information to mitigate impacts. Collaboration between the IRI, ICPAC and the WMO has strengthened the framework for building regional and national capacity in seasonal forecast operations, training, and applications activities.

Thus, as described below, many opportunities have been identified for governments and the private sector to incorporate information on seasonal climate variability into decision-making. The results suggest that this has the potential to reduce climate-related risks and improve climate-related outcomes. The climate information products for decision support described below are meant to make it easier for decision makers to use climate forecasts. Through the same partnerships through which the various decision-support tools have been developed, the findings of the demonstration projects will be upscaled to contribute to achieving the MDGs in this part of Africa.

4) Improved basic seasonal forecast prediction skill

Using climate information to manage climate-related risks involves supporting better decisions by risk managers. The various demonstration projects described below involve identifying who the decision-makers are in each context, the outcomes of concern, and the alternatives for using climate information to improve the outcomes. Decision support tools bridge the gap between forecast development and end-user application.

These tools share a reliance on basic seasonal climate predictability as part of their value-added. One of the project's objectives, therefore, has been to improve seasonal climate prediction skill. This predictability can be subsequently converted into information of different forms for supporting specific types of decisions. The process of improving the skill of predictive models at higher resolutions and tailoring it for supporting specific types of decisions is known as "downscaling."

4.1. Improved climate predictions

Downscaling resolves the lack of detail in forecasts from global General Circulation Models (GCMs).[7] This improves the ability to readily tailor these forecast products to societal applications. Decision-makers typically require information at finer scales than what the output of the GCMs provides. They also tend to request information about the characteristics of weather within the season, such as dry/wet spells, extreme rainfall events, and start/termination dates of rainy season. These requirements are being addressed through climate downscaling methodologies[8].

Downscaled seasonal forecasts can be generated through the use of both *dynamical* and *statistical* models. Statistical models use the past evolution of climate variability to project in the future. Dynamical climate models (including GCMs) integrate equations governing atmospheric behavior from initial conditions (usually provided by Sea Surface Temperatures (SST), soil moisture, and observed atmospheric variables) to project future states. Dynamical models require specialized manpower and high-end computer facilities. Statistical models are much easier to run but require many past years of data for confidence building and are not comprehensive enough to handle rapid changes in climate variability.

There is high forecast skill in the tropics, depending on the season and location. Forecast skill has been evaluated for the GHA for two seasons (March-May, MAM and October-December, OND) for various models. The ECHAM 4.5 GCM provides best skill for the OND season with 0.8 correlation coefficient. The global ECHAM 4.5 GCM has been adopted as the principal forecast model for the region, and it provides boundary forcing fields for both statistical and dynamical regional model runs and downscaling.

Examples of dynamical downscaling over the region show an improvement in the circulation and in the rainfall patterns. These dynamicl predictions also provide additional information on within-season weather-scale performance (wet and dry spells frequencies) that is important for application purposes.

Statistical downscaling is important for end user application to manage the various climate sensitive sectors such as agriculture, health and water resources management.

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[7] A GCM solves equations of energy and motion to simulate the global behavior of the oceans and atmosphere.

[8] Matayo Indeje, Status of Climate forecasting in the Greater Horn of Africa. Report of the Second Training Workshop on Dynamical Climate Modeling For the Greater Horn of Africa. ICPAC, Nairobi, February 1-28, 2004.

There is high correlation between statistically corrected ECHAM 4.5 output and observed climate for large areas of the GHA between October and December (OND). Skill is more modest for the March-May (MAM) season in the GHA.

While MAM and OND are the main seasons throughout most of the region, the June-September (JJAS) season is an important one in western Ethiopia (in the southern part of the country the rainfall typically falls during MAM and OND). There is some predictability related to ENSO in Ethiopia. El Niño JJAS summers tend to have below normal rainfall, and La Niña summers above normal rainfall. The relationship is stronger when rainfall is averaged over a large region (such as over all of the country except for the southern part) than when applied to individual stations or farms. Note that in Ethiopia, not all El Niño summers are drier than normal - it is a tendency, not an absolute rule[9]. According to Dadi "Large teleconnection impacts of ENSO on seasonal climate patterns over Ethiopia significantly enhance the predictability of JJAS rainfall with drier/wetter than normal associated to El Niño/La Niña episodes [respectively]."[10]

ICPAC has been providing training in the latest forecast skills in the GHA through workshops and training[11]. This has helped improve the capacity of national forecasters to use the latest forecasting techniques. The next important steps are to continue to improve the value of forecast-based decision-support tools for national development by applying them more comprehensively to manage impacts in various climate sensitive sectors.

4.2. Project accomplishments

Two basic techniques for improving climate prediction have been developed under the project. The first is a high resolution dynamical climate model -- the Regional Spectral Model (RSM) – that generates predictions by solving physical equations that simulate the interactions of the oceans and atmosphere. The RSM receives its input from the ECHAM 4.5 GCM, which it processes at a much higher resolution for the region of interest, in this case, the GHA. Currently the RSM is being validated for the region using computers at the IRI and ICPAC. A 30-year climatology (1970-1999) for the October-December season for the GHA has been completed, providing a long term simulation for validating model skill. The simulations are based on multiple (10-ensemble) model runs representing a range of climate outcomes that can be averaged to obtain a climate prediction for the season. The results to date are stored in IRI and ICPAC databases.

Although the validation runs are not yet completed, the initial results have demonstrated enough skill to warrant incorporating them into the GHACOF consensus regional forecasts for the past several seasons. The 10 regional model simulations were used in preparing experimental downscaled regional climate forecast for OND 2004 in support of GHACOF14, held in Nairobi in August 2004. In addition to their contribution to the

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[9] Tony Barnston, IRI, Predictability of Ethiopian rainfall. Email communication, June 7, 2005

[10] Diriba K. Dadi. Ethiopian National Meteorological Services Agency (NMSA)/Earth Institute (EI), Predictability of Ethiopian rainfall Email communication, June 8, 2005.

[11] ICPAC. Report of the Second Training Workshop on Dynamical Climate Modeling for the Greater Horn of Africa. Nairobi, Kenya, 1-28 February 2004.

climate forecasts, these achievements have important long term implications for the design of decision support tools as well.

The second technique is known as Model Output Statistics (MOS) and involves statistical correction of output from a GCM to downscale the forecast. This downscaling is done using the Climate Predictability Tool (CPT) that statistically combines ECHAM 4.5 GCM global model and station rainfall data. The statistical correction removes systematic biases from the GCM output and provides predictions at a finer spatial resolution than the GCM. The MOS technique is also very flexible. In addition to rainfall, MOS can be used to forecasts such climate-sensitive variables as the Normalized Difference Vegetation Index (NDVI), soil moisture and streamflow.

The MOS approach has significantly improved the forecast skill for the highly variable October-December "short rains" over much of the GHA region (figure 5). Figure 5 shows the statistically corrected ECHAM 4 GCM rainfall for the Marsabit station in Kenya.

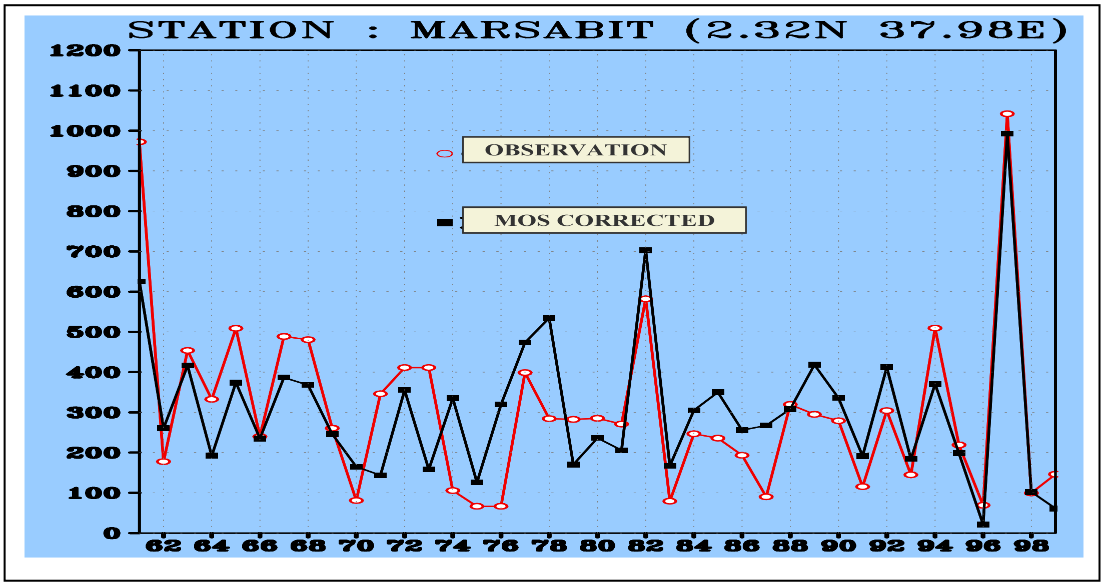

Figure 5. Statistically corrected ECHAM 4 GCM Oct-Dec precipitation to a station (Indeje, 2003)

Correlations of .8 shown in figure 6 represent skill similar to that shown in figure 5 over large areas of the GHA for the October-December season. This levels of skill is potentially highly valuable for many types of decisions.

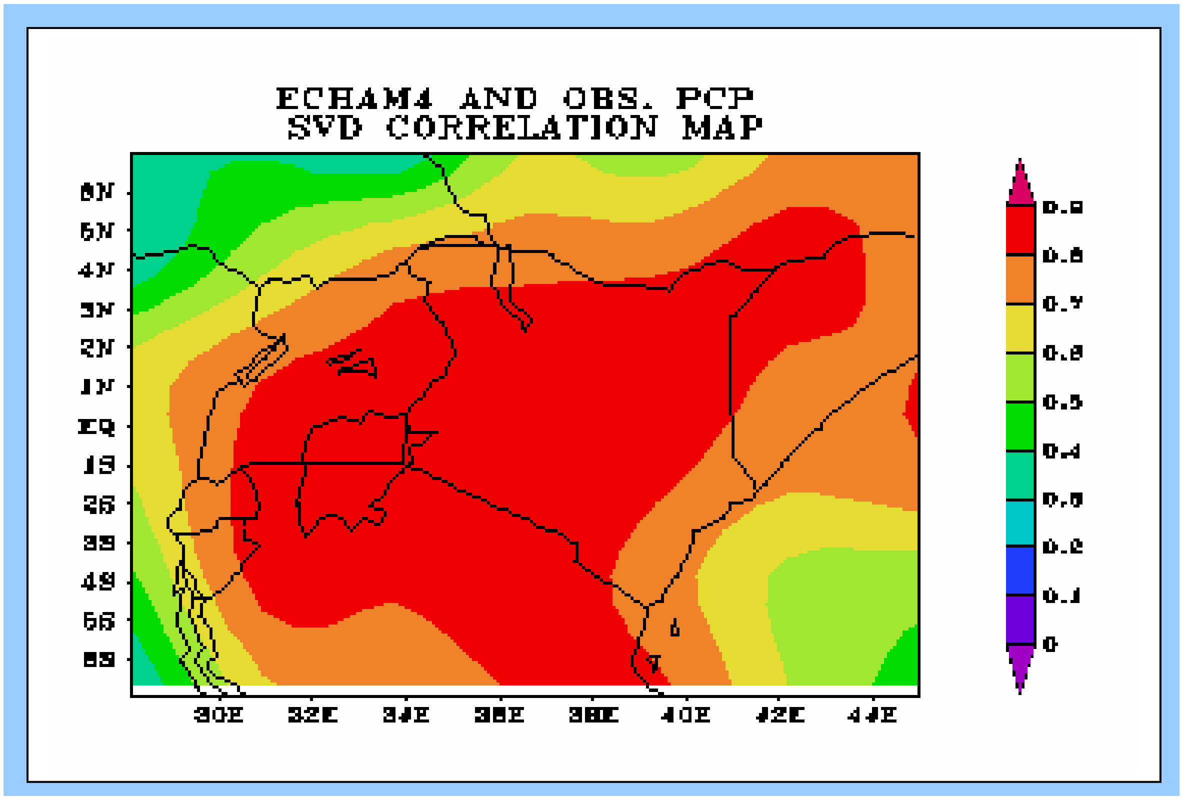

Figure 6. Correlation between statistically corrected climate model output and observed rainfall, Oct-Dec.

The CPT that the IRI developed makes it simple for a forecaster to develop a forecast using meteorological data from a local station. The CPT can also be used to forecast other variables besides rainfall, as described above. The CPT is a principal mechanism for transferring forecast capacity to meteorological services throughout the region. It is also useful for converting climate forecasts into forecasts of other variables related to specific types of decisions.

Finally, arrangements have been made for updating station data for the GHA. The station data will be gridded to form a database for the region to be used in regional climate model verification, operational climate forecasts in support of the regional COFs, and other application work.

5) Tailoring climate information for decision-support

Adoption of climate information for risk management relies on evidence that using climate information will result in more favorable outcomes than would occur otherwise. This requirement, of generating such evidence, makes the users and their goals central to the design of project activities. Demonstrating that climate information is cost-effective to use and improves user outcomes in specific contexts has several desirable results:

- it reduces vulnerability and risk in a specific setting or context
- if using the information is cost-effective and outcomes improve, the use of the information will be sustainable
- by involving local, national, regional and international partners -- tools and capacity realized through project-funded activities can be applied elsewhere, creating the potential to "upscale" the results in other areas.

The demonstration projects described in the next section below have two sub-objectives. The first sub-objective is to make a substantial contribution towards reducing disaster risks by addressing a specific-climate related problem in a particular context. The second sub-objective is to create the tools and capacity so that the stakeholders can replicate the results in similar circumstances elsewhere, both nationally and on a regional basis.

The demonstration projects below have been advanced by a wide range of project partners, to take advantage of their complementary expertise and degree of involvement in managing particular climate-related risks. Demonstration project designs address:

- what is the climate-related problem (or opportunity) that the demonstration project seeks to address?
- who are the decision-makers, what outcomes do they seek to achieve, how does climate variability affect that outcome, and what options to the decision-makers have for using climate information?
- what research is necessary to establish the feasibility of a tailored product that would inform the decisions identified by the decision-makers involved in the demonstration?
- which organizations would need to be involved, and in what capacity?
- what is the time line for each phase of the demonstration
- what resources are required to implement the project (human, technical and financial?
- how will the product be introduced and verified, working with the users?
- what will be different in the selected context if the demonstration project is successful?
- how will the results be up-scaled elsewhere in the region?

A general process for organizing activities to achieve these results consists of the following steps, all of which involve the intended users or client:

- identify a significant climate-related problem with broad implications for disaster risks across the region
- identify partners with the ability to influence the outcome and their decision-making options and calendar
- with these partners, design an operationally useful product to support the specific decisions they identify
- conduct research needed for development of the product
- produce a prototype decision-support product

- apply the decision-support product on an experimental basis, working with the intended users
- verify the results and make modifications as necessary.

Research to develop tailored product is demand-driven and requires both the support and participation of the beneficiaries. The various stakeholders come together, learn from each other, and brainstorm as to what climate information, in what form, would contribute to improved risk management decisions.

6) Risk management examples

The following are demonstrations of the use of climate information for risk management in the GHA developed by the IRI and partners through the project. They include:

- hydro-power stabilization and flood risk management (two related demonstrations)
- increased agricultural production and reduced losses through improved farm level decision making
- food security outlooks for contingency planning, and
- protecting pastoralist livelihoods by protecting livestock trade between the GHA and the Middle East through improved control of Rift Valley Fever.

Each of these demonstrations seeks to address a climate-related problem or opportunity in its own right, as well as to create a tool or knowledge that can be transferred and applied elsewhere. The degree of development achieved by the end of the project period varies from case to case. In some cases the work is fully completed, in other cases plans are in place to bring the demonstration project to full completion. In all cases additional work remains to be done to put the knowledge and tools to work on a widespread basis.

6. 1. Utility of climate information-based streamflow forecasts: Hydropower stabilization and flood risk management in the Tana River Basin, Kenya

6.1.1. Problem Context

In many parts of the GHA hydropower generation and irrigated agricultural are essential for national development. Energy requirements in the region are usually met through hydropower owing to its low maintenance and operating costs. However, the incentive to maximize water storage for hydropower generation can contribute to increased flood risk potential downstream. The objective of the demonstration project described below, and the one that follows (6.2), is the application of seasonal climate information to promote a predictable supply of water both for power supply and irrigation, at the same time reducing reservoir spillage and enabling contingency planning to prevent and manage flood events downstream.

Kenya depends on hydropower for much of its power supply. The 1999-2000 drought demonstrated the system's vulnerability to drought:

> ... the country suffered enormous losses in terms of lost revenue while several thousands of employees lost their livelihood as a result of massive lay-off. The economic losses to the government resulting from power rationing and power failures were estimated at US$ 2 million per day. The effects of power rationing left both Kenya Power and Lighting Company (KPLC) and Kenya Electricity Generating Company (KenGen) with an expenditure of US$ 141 million in additional fuel for electricity generation. Most industries and other manufacturing companies suffered monthly profit losses to the tune of between Ksh. 1.2 million and Ksh. 17 million and job layouts of between 10% and 60% while small companies had to close down (Oludhe et al. 2003, p. 28).

Seasonal forecasts can be used to develop climate scenarios for managing hydropower generation, delineate potential flood extent and to identify appropriate contingency measures. Potential power shortages, as well as periods of high flood risk, can also be anticipated.

6.1.2. Decision context

This particular demonstration focuses on the Tana River, which originates on Mount Kenya. The Tana River runs through a series of reservoirs known as 7-Forks Dam and supplies 50% of Kenya's energy requirements. The dams also modulates the risk of flooding in the lower Tana basin (figure 8).

The total installed capacity of the Tana River 7-Forks system is 545 MW. The uppermost reservoir is the Masinga dam, which serves as the primary storage system. Diversions for municipal, industrial and irrigation supply are very minimal along the Tana River system in comparison to the utilization for hydropower generation. There are conflicting objectives of increased hydropower generation and reduced flood risk for the lower Tana basin.

The reservoirs are operated by Kenya Electricity Generating Company Ltd (KenGen), a parastatal. According to KenGen, forecasts of the streamflow potential of the Tana River for the upcoming seasons would be very beneficial for resource management.

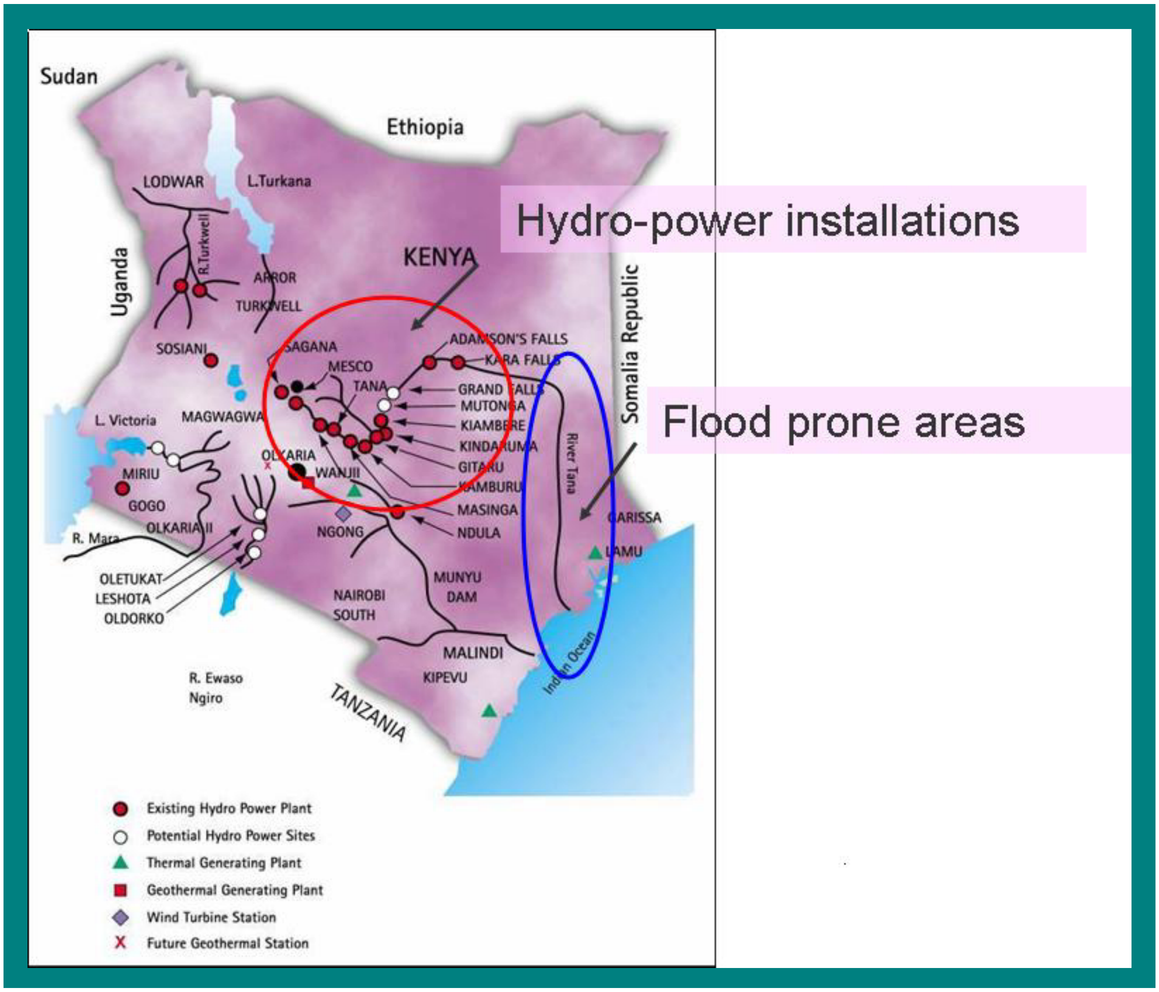

Figure 8. Tana River basin, Kenya (C. Oludhe)

Inflows into the Masinga Dam vary throughout the two rainy seasons, both of which are heavily influenced by large-scale climate systems (figure 9). Currently, the reservoir operational strategy pursued by KenGen is to identify three analogue years of streamflow based on Kenya Meteorological Department (KMD) forecasts. That information is used for deriving reservoir rule curves that maximize hydropower generation. This approach could be modified by adapting recent approaches to water allocation that recognize the importance of dynamic risk management contingent on seasonal climate information[12].

In this context, the 7-Forks Dam on the Tana River in Kenya can be considered a water resources management demonstration project for the GHA and Africa. The demonstration project utilizes climate information to aid decision-makers in resource allocation and management in response to seasonal fluctuations.

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[12] Arumugam et al., 2003

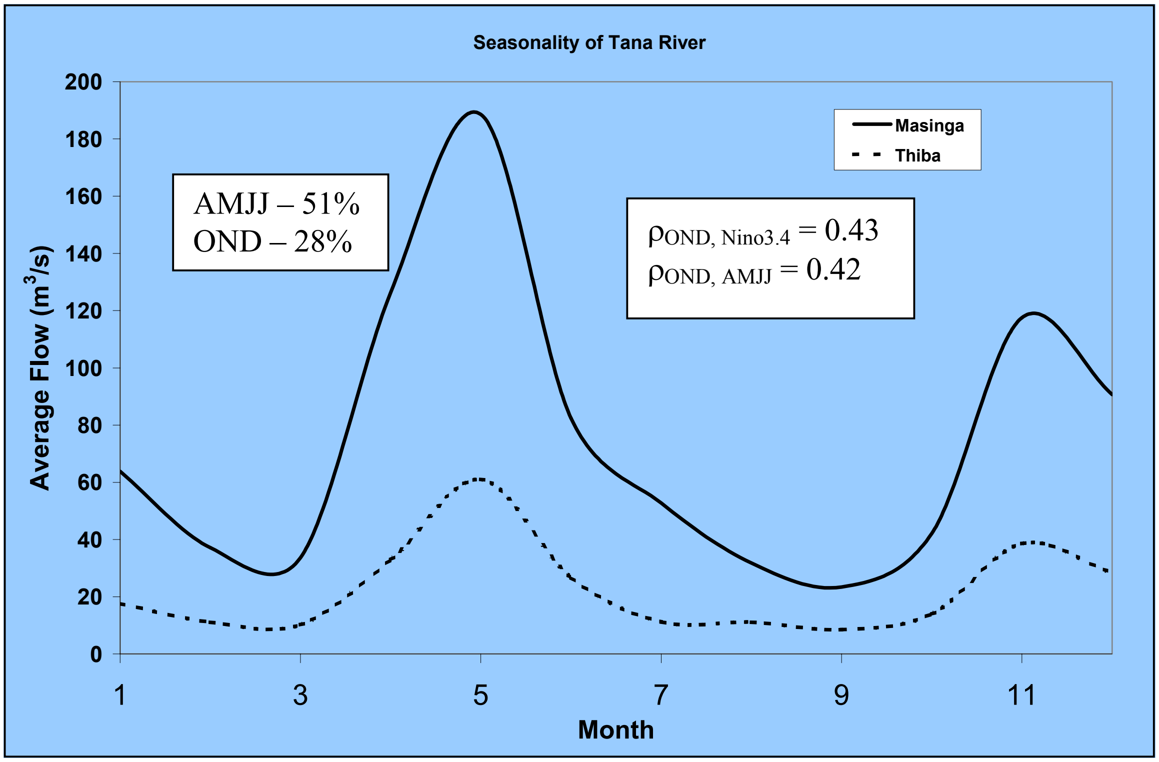

Figure 9. Seasonality of Tana River: Masinga and Thiba Inflows. Note the correlation between OND inflows of the current year with the AMJJ of the following year is 0.42, whereas the correlation between AMJJ and OND inflows of the same calendar year is zero.

6.1.3. Hydroclimatic Predictability

Figures 10a and 10b show the association between the large-scale climatic conditions and Masinga inflows for the period AMJJ and OND respectively. Tables 1 and 2 give the 3-months lag predictors for AMJJ inflows and OND inflows along with the correlation with the respective inflows. A simple regression model was developed using the climate predictors given in Tables 1 and 2 and the cross validated forecasts are given in figures 11a and 11b. The correlation between the observed and predicted AMJJ flows using the regression model is 0.87, whereas the correlation between the observed and predicted OND inflows is 0.60.

These results are preliminary, however. Diagnostic analyses of these predictors remain to be done to understand the physical significance of these predictors. Further, the length of the streamflow dataset is very small, spanning from 1983-2002.

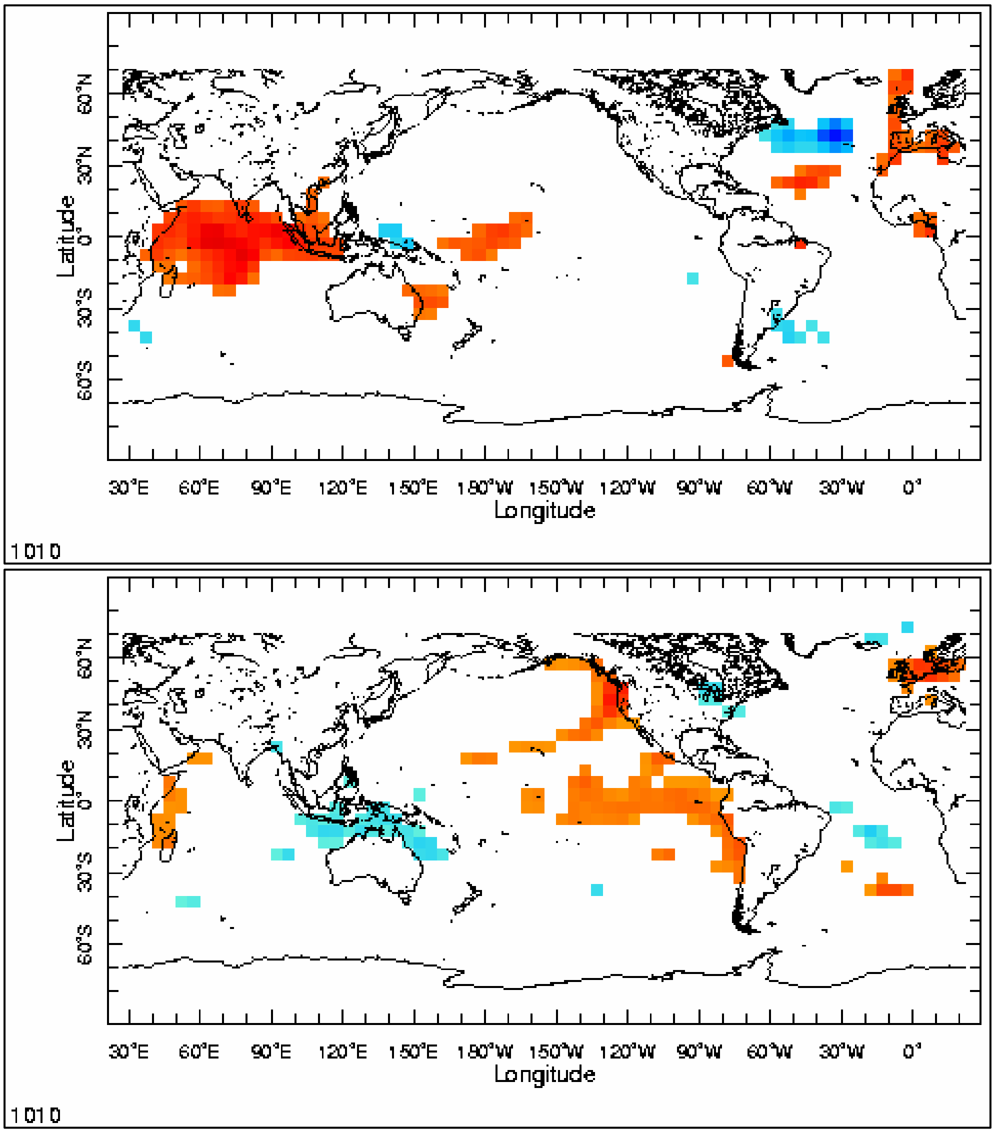

Figure 10a and b. Lag 3- Correlations between SST (4a) AMJJ inflows (4b) OND inflows. Correlations significant at 90% level (greater than 0.37) are only shown.

Table 1. Dominant climatic predictors influencing AMJJ inflows of Masinga Dam. The correlation given is the spatial average of SST over X and Y for the period JFM.

	Pred 1 (SST)	Pred 2 (SST)	Pred 3 (SST)	Pred 4 (MSLP[13])
X	40 E to 105 E	40 W to 25 W	50 W to 35 W	20 E to 40 E
Y	10 S to 10N	35 N to 50 N	20 N to 30 N	5N to 10S
Correlation	0.67	-0.55	0.47	0.52

Table 2. Dominant climatic predictors influencing OND inflows of Masinga Dam. The correlation given is the spatial average of SST over X and Y for the period JAS.

	Pred 1 (SST)	Pred 2 (SST)	Pred 3 (SST)	Pred 4 (MSLP)
X	110 E to 145 E	120 W to 170 W	40 E to 50 E	36 E to 44 E
Y	15 S to 5 S	5 N to 5S	20 S to 10N	8 N to 16 N
Correlation	-0.45	0.43	0.41	0.41

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[13] Mean Sea Level Pressure

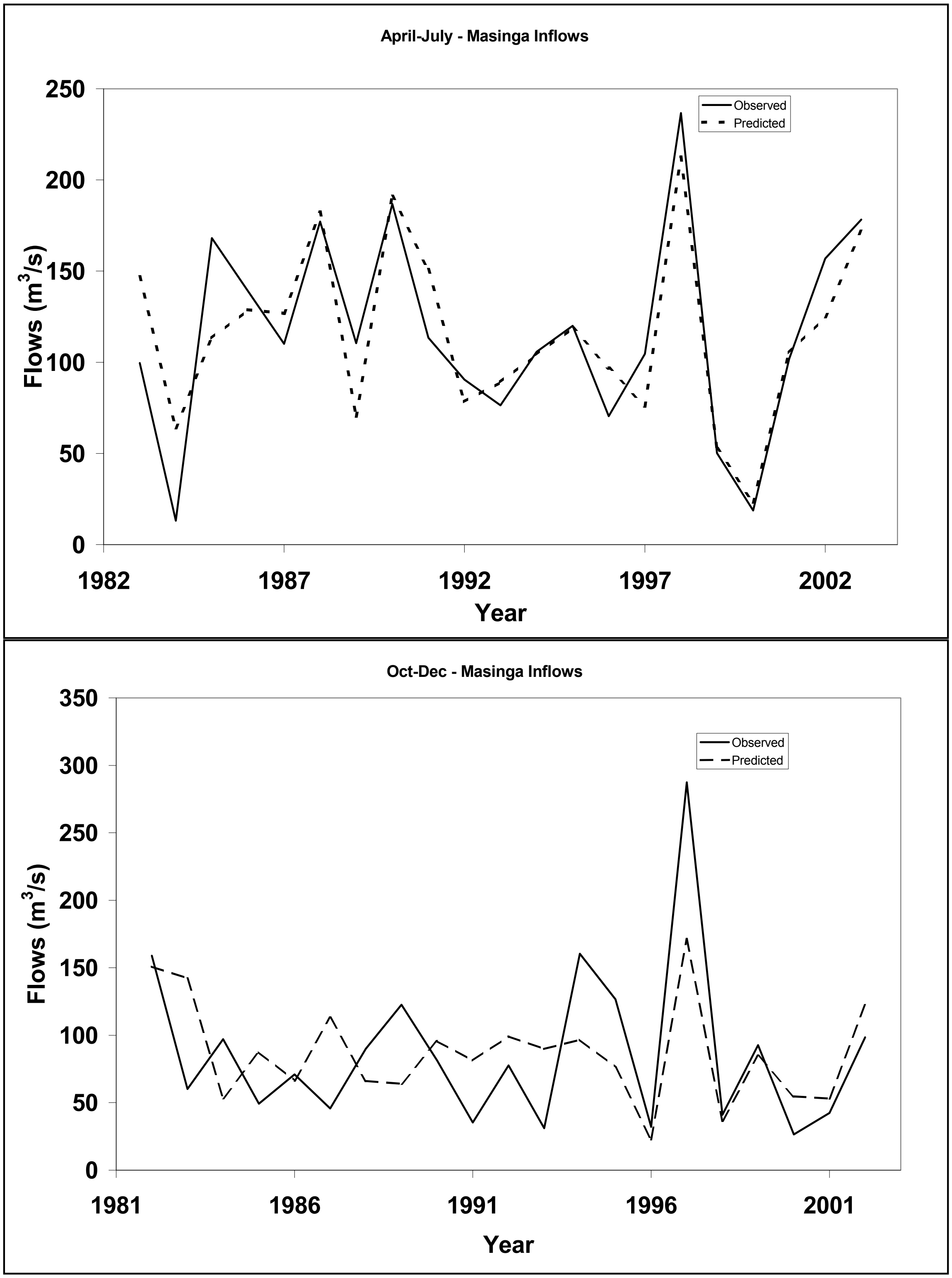

Figure 11. Cross-validated retrospective forecasts for (a) AMJJ inflows (b) OND inflows. The correlation between the observed and predicted AMJJ flows using the regression model is 0.87, whereas the correlation between the observed and predicted OND inflows using the principal components regression is 0.60.

6.1.4. Tana Reservoir System Management Model

Development of Tana River Reservoir Management Model was a collaborative activity between the IRI, the University of Nairobi and the ICPAC building on work by Oludhe et al 2003. The model (figure 12) utilizes probabilistic streamflow forecasts based on climate information to allocate water for multiple users that would reduce flood risk potential of the lower Tana River basin as well as develop scenarios of hydro-power generation.

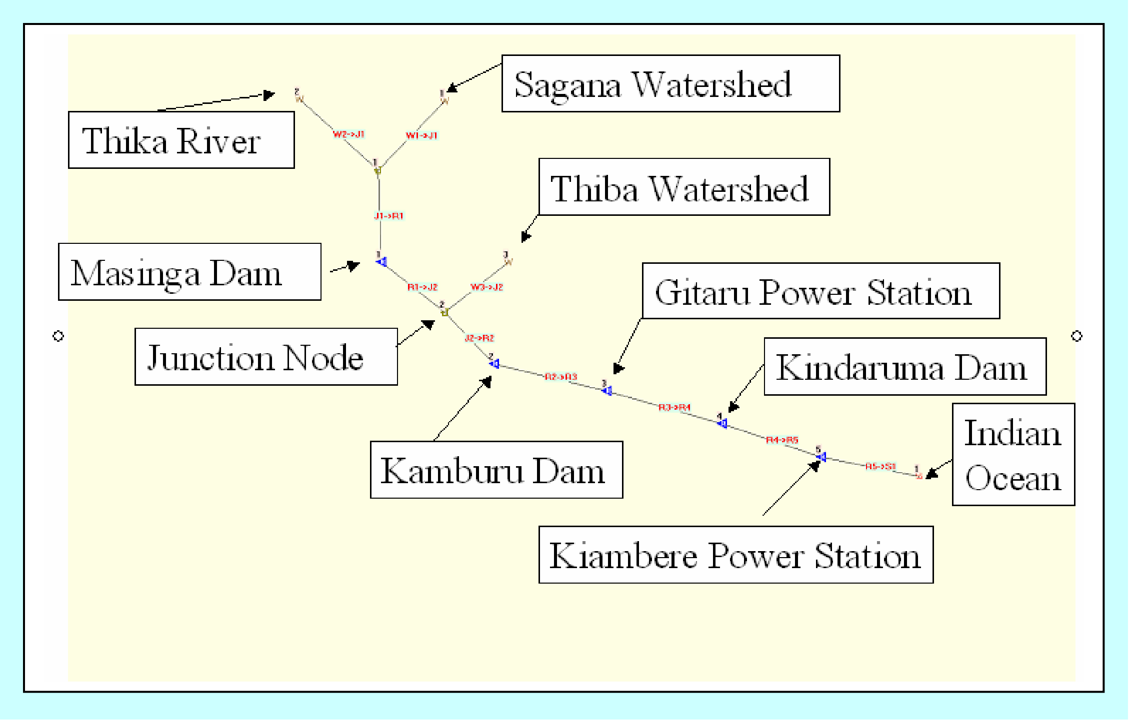

Figure 12. A snapshot of the Tana River 7-Forks Reservoir Management Model

The model was originally by the IRI for reservoir management applications in Ceara, Brazil and adapted for use in Kenya by the IRI and the University of Nairobi using project funds. The model interface allows users to build a complete description of a reservoir system. Inputs include reservoir characteristics, inflows and outflows, and descriptors of water use demand. When the entire system is completely characterized, decision-makers can use the model to simulate the effects of incorporating seasonal climate forecasts into reservoir operating decisions over extended periods of time, allowing the long-term benefits and costs of incorporating the forecast information to be evaluated. In operational mode, the model can be used to make real-time decisions regarding reservoir operation.

Work on the development of user-friendly interface software for the Tana Reservoir Management Model is completed. The software enables users and managers to use seasonal climate information in support of decision-making. Preliminary results suggest that use of the model would enable reservoir managers to reduce power shortages during drought and reduce flooding of the lower basin during heavy rainfall. Output from the model could also be used to protect the livelihood of the people who reside in the lower basin of the Tana River, allowing them to adapt their seasonal work activities according to a forecast with a longer lead-time.

6.1.5. Next steps

The partners who have developed the model – principally the University of Nairobi, IRI and ICPAC – will continue to develop and test the model and model interface in cooperation with KenGen. The inflow forecasts shown above based on correlations with global SSTs can be compared with results obtainable from downscaled streamflow forecasts based on MOS-corrected GCM precipitation as described in section 4, above. The MOS-based forecasts have the potential to improve inflow predictability beyond what has been obtained to date using solely SSTs.

Based on the results obtained, plans are also under development to upscale the techniques developed for the case of the Tana River elsewhere within the GHA and to other regions. Upscaling will be undertaken through a workshop to which reservoir managers from the GHA and southern Africa will bring the required data needed to develop a version of the model for application in their respective decision-making contexts. The workshop, to train reservoir operators in the use the model interface for reservoir-specific decision-support, offers a low-cost means of rapidly upscaling the techniques developed through the Tana demonstration project.

6.2. Flood livelihood impact assessment for contingency planning: the case of Lower Tana River Basin, Kenya[14]

6.2.1. Problem context

Emergency preparedness is a prerequisite for humanitarian response to be effective, coordinated, dependable, and timely. A critical factor that has hampered responding agencies in many countries is lack of information on who will be affected and what impacts are expected.

While drought adversely affects hydropower supply from the Tana River system, too much rainfall results in excess water needing to be spilled from the reservoirs, causing flooding in the lower part of the basin. In September 1997, heavy El Niño-related rains and flooding affected an estimated 900,000 people in the lower Tana Basin, killing 86, with an estimated $12 million in damages (www.cred.be). In June 2003, El Niño and related flooding returned, displacing an estimated 10,000 people.

6.2.2. Decision context

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[14] This section was taken almost verbatim from Maxx Dilley el al. Natural Disaster Hotspots: A Global Risk Analysis. Washington D.C. International Bank for Reconstruction and Development/The World Bank and Columbia University, 2005. Pages, 106-110.

Part of the solution, described in section 6.1, above, is to reduce spillage from the 7-Forks reservoir system through modification of reservoir operation depending on forecasted inflow into the system. Under El Niño conditions, when inflow is likely to be high, controlled releases throughout the season could reduce the need for uncontrolled spillage. Another part of the solution, described below, is to use forecasts to anticipate periods of increased flood risks and to have in place contingency plans for managing flood related impacts.

To implement the latter, the IRI and the World Food Program (WFP) signed a letter of agreement to conduct an analysis of flood impacts on livelihoods in the Tana River flood plain. The flood analysis has three purposes:

1. WFP, which provides relief to flood victims, would benefit by understanding how the flooding affects livelihoods, thus, improving flood assistance programming,
2. WFP could anticipate how flood-related yield losses affect people 2-3 months into the future, which could affect food aid needs.
3. The result served as a case study in an analysis of global disaster risk hotspots that was implemented by Columbia University, the World Bank, the Norwegian Geotechnical Institute, the United Nations Development Program (UNDP), the United Nations Environment Program (UNEP) and other partners[15].

In addition to WFP, a second major partner was the U.S. Geological Survey (USGS) Famine Early Warning System Network (FEWS Net). The USGS/FEWSNet Nairobi office operates a Stream Flow Model (SFM) that allows mapping of flood water levels, which can extend 20-30km from the river course. Once the water overflows the final dam in the Tana River reservoir series, the downstream area is flooded three days later. By monitoring the streamflow level upstream before water reaches the dam, the lead time can be increased by running the model and forecasting the inundated areas. WFP will undertake contingency planning based on analysis of the anticipated damages.

6.2.2. Results

The demonstration project uses a streamflow model and flood hazard mapping to generate flood scenarios for the lower Tana River Basin, a flood-prone area in Kenya where emergency assistance is frequently required (figure 13). Flood risks to the population and livelihoods are assessed using a livelihood zonation data set that includes populated places. Flood inundation maps associated with the river depths for the 1961 and El Niño-related floods in 1997–98 were generated, and impacts assessed for moderate and severe flood event scenarios. The results are interpreted for use in contingency planning and preparedness.

Garissa district is one of three districts that make up the North Eastern Province of Kenya. The total population of the district is 231,000 (1999 census population projections), about 40 percent of which resides within Garissa town. The district is predominately inhabited by Somali people who traditionally practice livestock keeping.

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[15] Dilley et al. 2005

The climate of Garissa is semiarid, and the long-term average rainfall is about 300 mm. Prior to the 1997–98 El Niño rains, the greatest rainfall occurred in 1961 and 1968, when an average of 920 millimeters was measured at many stations. Unusually heavy rains in 1997 totaled 1,027 millimeters, most of it between October and December 1997 -- a huge amount of rainfall for an area receiving an annual average of 300 millimeters. The resulting floods destroyed many houses, damaged infrastructure, swept away crops, and killed livestock[16].

The project assessed risks of worst-case flood impacts on livelihoods using the El Niño flooding event of 1997–98, with an estimated 35-year return period, as a scenario. The impact of floods on populations differs depending on their livelihoods and wealth group. Among the different livelihood groups in both districts, the ones most exposed to flooding are pastoralists, agro-pastoralists, and the dry riverine and Tana Delta livelihood systems (figure 13).

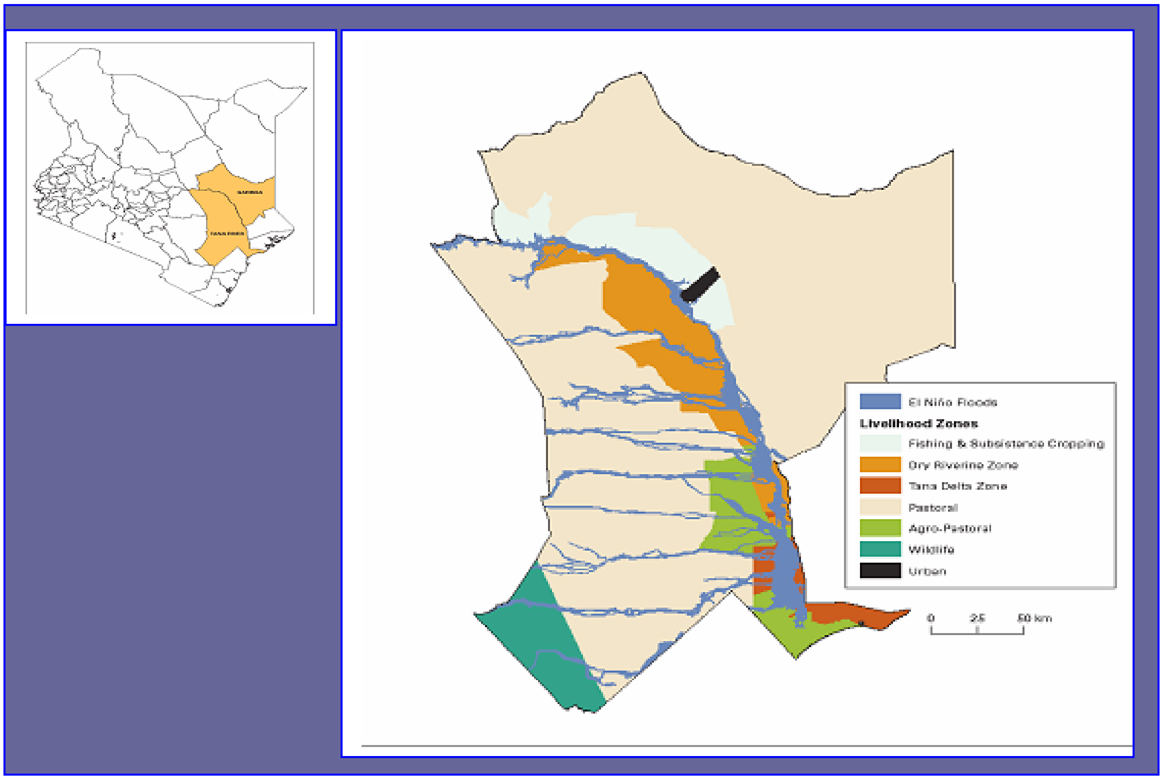

Figure 13. Livelihood zones overlaid on El Niño 1997–98 flood case (estimated return period 35 years)

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[16] Fredrick Karanja. Kenya Country Case Study: Impacts and Responses to the 1997-98 El Niño Event. In Reducing the Impact of Environmental Emergencies through Early Warning and Preparedness: The Case of the 1997-98 El Niño and Southern Oscillation. 2000.

The livelihood zones directly on the river (dry riverine zone, Tana Delta zone, pastoralist, and agro-pastoralist) are likely to be impacted by the direct destruction of their properties (such as houses, crop fields, and pumps). The agro-pastoralists are mostly located in the hinterland, except in the south part of the basin. The population in the urban area (especially at Garissa town) is likely to be affected through the indirect effect of the floods, such as an interruption of access to markets and associated loss of income. Some people might also lose property from flooding. However, people in urban areas are more likely to have resources to cope and therefore are less at risk of complete collapse of their livelihood. The population in fisheries and subsistence cropping may find benefits in the floods, thanks to the likely increase in fish production, but they are also likely to see their subsistence cropping resources affected.

Cash income for the pastoralist community is not diversified at all, as 68 percent of total cash income comes from livestock. This is also the case for agro-pastoralists who receive 40 percent of their income come from livestock. To a lesser extent, people in the dry riverine zone also derive most of their income from livestock (22 percent). During the El Niño floods of 1997–98, close to 90 percent of sheep and goats died in the Garissa and Tana River districts. These lose resulted to complete collapse of livestock as a source of income. For these three groups, sheep and goats represent close to 15 percent of their total income. In addition, for larger animals, which were less directly affected by floods, mortality and morbidity increased dramatically as a result of diseases such as foot rot and pneumonia. In addition to the direct loss of animals, the decrease in livestock marketability also reduced household income. Fear of Rift Valley Fever (see section 6.5, below) discouraged people from buying their animals from the market leading to the lose of value in the animals. The impact on livestock has hurt equally the "very poor," "poor and "middle" groups, who have seen their income from livestock reduced to zero. Most of the very poor and poor have moved to the destitute category, while only the middle group with large cattle herd size may have avoided destitution.

The loss of livestock also had an important impact on food consumption. Food intake was reduced because of the loss of animals that had provided meat and milk. The loss of income also translated into a loss of purchasing power, which together with higher commodity prices put the commodities out of reach for these communities. As a result, their access to food was drastically reduced.

6.2.3. Conclusion

Under the worst case scenario, pastoralists and dry riverine communities are expected to experience the worst losses. Therefore, a response directed toward these groups, particularly the pastoralists, would be advisable. Assistance should take the form of free food distribution and income-generating activities, as the analysis has shown that for all of the groups, income, daily food consumption, and nutrition are tied to livestock and crop production, both of which may completely collapse in any flood scenario. Furthermore, assessments during the 1997–98 El Niño floods showed that relief food enabled pastoralists to save their remaining livestock and to start rebuilding herds and livelihoods. For planning purposes, we know from our hazard maps that food assistance in the short term and income regenerating activities in the long term would be required for up to 70,000 persons. In a moderate-case scenario, the population in need would be 47,000. This finding provides core data for calculating the volume of food commodities required and costs.

6.2.4. Next steps

The combined results from the reservoir operation model development and flood risk assessment demonstration projects for the Tana River Basin make it realistic to envision a comprehensive risk management system. At one end of the system, use of the Reservoir Management Model can assist with stabilizing hydropower generation and minimizing flooding. At the lower end, forecasts can be used to warn affected populations of high flood risk periods and improve responses through contingency planning.

To realize this vision, however, additional work will be needed to enhance coordination and communication between relevant authorities. These include KenGen, the Tana Area Regional Development Authority, local authorities and international institutions.

6.3. Improving agricultural production through farm-level decision-making: the case of Eastern Province, Kenya

6.3.1. Problem context

Agriculture remains the backbone of national economies, and a major source of livelihood for more than 80% of the GHA population. With very limited land under irrigation, the livelihoods of these people will remain strongly linked to rainfall. Vast areas of this region are semi-arid, characterized by low and unreliable rainfall (500-900 mm/yr), which comes in two distinct seasons – the “short rains” (October-December) and “long rains” (March-May). The GHA experiences episodic food insecurity associated with rainfall variability. Livelihood impacts of climatic shocks can persist for years after the event. The uncertainty associated with climate variability also leads to conservative risk management strategies that reduce negative impacts in poor years, but at the expense of reduced average productivity and profitability. This conservative risk management uses resources inefficiently, and sometimes accelerates natural resource degradation due, for example, to under-investment in soil fertility inputs. The traditional low-input farming systems that evolved partially in response to climatic risk cannot meet the growing demand for staple foods. Although promising technologies that could contribute to increased productivity in the region are available, their adoption by farmers is low due to reasons that include the livelihood risk that results from rainfall variability and the high cost of inputs.

There is an urgent need to develop appropriate and affordable strategies that reduce risk and maximize the benefits of favorable rainfall. Household surveys in Machakos District, Kenya in 2001 revealed a surprisingly high degree of awareness of seasonal climate forecasts, and a strong predisposition to apply the information in farming decisions. However, lack of widespread forecast use to improve farm management suggests that farmers have difficulty translating the information into tangible economic farm outputs. Apparent difficulties include (a) mismatch between farmers' needs and the scale, format, timing and accessibility of current operational forecasts, (b) lack of trust or comprehension of the forecasts; (c) the uncertainty and time associated with learning a new, management-intensive technology, and (d) poor access to production inputs and credit that would allow farmers to take advantage of the forecasts.

However, there is good reason to expect that these constraints can be overcome, however. Farmers are generally quite innovative and willing to test a new technology once they see evidence of its benefits.

Demonstration activities in the Machakos and Makuene districts, Eastern Province, Kenya, have sought to:

- Monitor farm-level responses to seasonal forecasts and elicit farmers' subjective evaluation of their outcomes
- Evaluate the potential to enhance the utility of seasonal forecast information to farmers
- Assess the potential value of decision responses to a seasonal forecast system, and
- Identify constraints to desired decision responses to forecasts, and explore the potential to work with suppliers of production inputs and credit to reduce resource constraints.
- The results are suitable for use to design strategies for providing useful information to farmers on a larger scale.

6.3.1. Relevant forecast information

A set of two-day farmer workshops in Machakos and Makindu, Kenya in July 2004, provided an opportunity to test a protocol for presenting forecasts in probabilistic terms and evaluate farmers' comprehension. The approach is based on the assumptions that rainfed farmers (a) understand rainfall variability and uncertainty in terms of their memory of past fluctuations, (b) can relate memory to time-series graphs with just a bit of help, and (c) can learn to understand a more formal probability representation by relating it to historic rainfall quantities.

First, consensus statements about rainfall quality during the past five years were elicited. Participants were asked to take turns drawing the amount of October-December rainfall on a paper, then shade and label it as a bar graph (figure 14). At Makindu, filling cylinders with past reported rainfall depths, as an intermediate step, made the exercise more interesting, but did not seem necessary for understanding. The farmers took turns sorting the years from driest to wettest based on OND rainfall and marking on a blank graph the number of years (out of 10 for simplicity) vs. rainfall amount. The numbers of years out of 10 were reinterpreted as probabilities, yielding a probability of exceedance graph.

Shifted probability of exceedance graphs for La Niña years served as a way to introduce the idea of a forecast as a shifted probability distribution. On the second workshop day, farmers demonstrated varying degrees of understanding of hypothetical forecasts as shifted probability graphs (relative to the observed local climatology) and as sets of analog years. In breakout groups, they identified a range of management responses to the hypothetical forecasts. Based on experience in the Machakos workshop, more extensive discussion of hypothetical shifts in probability curves at the Makindu workshop appeared to enhance farmers' understanding.

6.3.2. Farmers' responses to forecast information

Farmers in breakout groups at the two training workshops consistently identified inadequate or unreliable rainfall as the most serious problem that they face in farming. Although they often identified lack of knowledge as the second most serious constraint, they collectively demonstrated sophisticated understanding of the implications of seasonal rainfall forecasts, and identified a range of viable management responses related to:

- Timing and method of land preparation
- Crop and cultivar selection
- Planting strategy
- Weeding
- Soil fertility management
- Pest management
- Area cultivated
- Terrace maintenance
- Labor procurement and allocation
- Fencing and cover for livestock
- Forage management
- Grain and fodder storage

Questionnaires were administered before and after a forecast was issued as a means of identifying changes in management attributed to forecast information. The pre-forecast questionnaire included characterization data, resource endowment, and management plans in the absence of the forecast. Farmers who participated in the two-day training workshops in July then attended forecast presentation workshops in September 2004, where they received a downscaled GCM-based, probabilistic forecast, and had opportunity to discuss its implications. The post-forecast questionnaire identified any departures from farmer' management plans, and whether the adjustments were attributed to the forecast information. Questionnaires were completed for about 80 farmers, split evenly between the two locations, and between those who participated in the training and forecast presentation workshops, and those who had access only through the existing media channels. Analyses of the resulting data are not yet complete.

6.3.3. Livelihood benefits of forecasts

Measuring the actual benefits of a technological innovation is generally not possible until years after it has matured in its development and until adopting farmers have mastered the skills associated with it. Economic modeling must therefore be used to estimate the potential benefits of the innovation during its early development. To estimate the potential livelihood benefits of GCM-based seasonal forecasts, we use the standard economic definition of information value as the expected value of the outcome of optimal decisions using the new information minus the expected value of outcome of optimal decisions in the absence of the new information. This framework directly addresses the match between a decision system and what we can predict at a seasonal lead-time, and is useful for providing evidence, targeting farmers and farm decisions with the greatest potential benefit, and providing insights about interventions such as improved access to credit and improvements in the forecast system. We consider two levels of decisions: maize crop management at a field scale, and livelihood portfolio decisions at the farm level.

To assess the potential value of seasonal forecasts for field-scale crop management, we simulated maize yields for the short rains, for a range of nitrogen fertilizer levels and planting densities, using both daily weather (1969-2003) recorded at the Katumani Dryland Research Center and weather consistent with forecasts for the same period. A nonlinear production function was used to find the best fertilizer rates, or the discrete fertilizer rate that gave the best net income was selected when simulated crop response did not fit the function well. Under the assumptions of our analysis and using 1999 price data, the forecast system appears to potentially increase net income by about 2500 KSH/ha/year, or about 6% of the gross value of grain produced. Analyses are not yet complete. Although, on average, farmers benefit from basing fertilizer use and planting density on forecasts, they have a chance of doing worse in about one year in three (Fig. 14). The estimated value of the forecasts is sensitive to prices, and likely to increase as we use more current price data, incorporating other management responses, and accounting for aversion to risk.

The pre-forecast household survey included information about household characteristics, resource endowment and livelihood activities designed to support analysis of the benefits and risks of adjusting a broader range of livelihood decisions in response to seasonal forecasts. Planned economic modeling is still pending. We hypothesize that intensification decisions (e.g., fertilizer use, planting density, cultivar, pest management, irrigation, multiple cropping) are likely to be important for farmers that grow primarily for market, whereas portfolio decisions (i.e., allocation of land and labor among competing farm and non-farm enterprises) are likely to be more important for those who produce primarily for subsistence. The constrained nonlinear optimization framework that we will use provides considerable flexibility for representing responses to information under a range of objectives and constraints, explicitly accounting for forecast uncertainty and attitudes toward risk.

Preliminary analysis of maize management response to seasonal forecasts focused on nitrogen (N) fertilizer use and planting density during the short rains. We simulated grain yields (y) for 6 fertilizer levels (0-120 kg/ha), and 3 planting densities, using observed daily weather data from the Katumani Dryland Research Center (1969-2003), and stochastically generated daily rainfall that matched monthly hindcasts from the ECHAM (v.4) GCM simulated with observed sea surface temperatures. For each year and each planting density, we fit the simulated yield response to N to a Mitscherlich function (y=a+b(1-exp(-c N)), subtracted costs associated with N fertilizer and seed, and differentiated to find the N level that maximizes profit. In those years that showed a near linear or convex response to N, we selected the N level with the highest gross margin. Management optimized to climate-based yield forecasts varies considerably from year to year, and is often far from the best fixed management strategy in the absence of the forecast (Fig 14a, b). Under the assumptions of our analysis, the forecast system appears to have the potential to increase net income by up to about 2,5200 KSH/ha/year on average, or about 6% of the average gross value of maize produced in the absence of the forecast.

Consistent with overall project results, the short, OND, rains show useful predictability (figure 15). Since simulated maize yields show greater apparent predictability than seasonal rainfall, prediction well before planting supports proactive management responses by farmers.

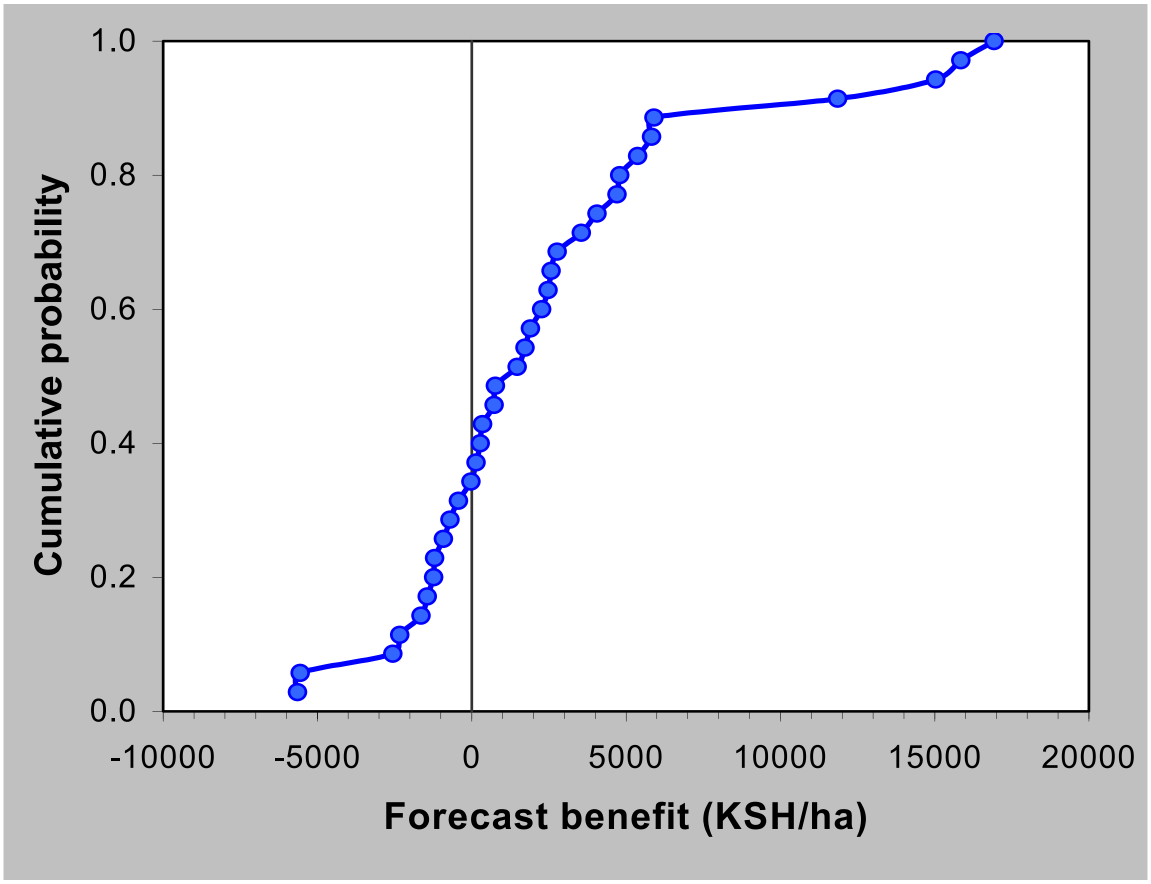


Figure 14. Modeled increase in net income from adjusting nitrogen fertilizer rates and planting for maize, based on ECHAM rainfall forecasts. Optimal forecast-based management increased income by an average of KSH 9,200/ha/year, or 24% of the gross value of the maize produced.

As Figure 15 indicates, short rains show useful predictability. Since simulated maize yields show greater apparent predictability than seasonal rainfall, prediction well before planting supports proactive management responses.

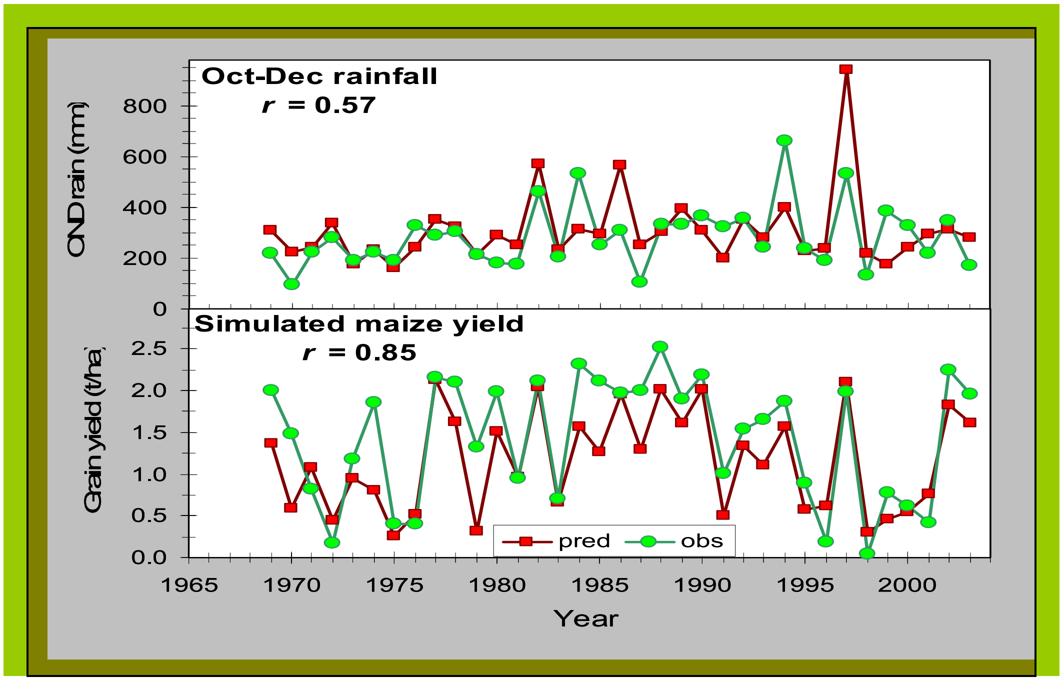
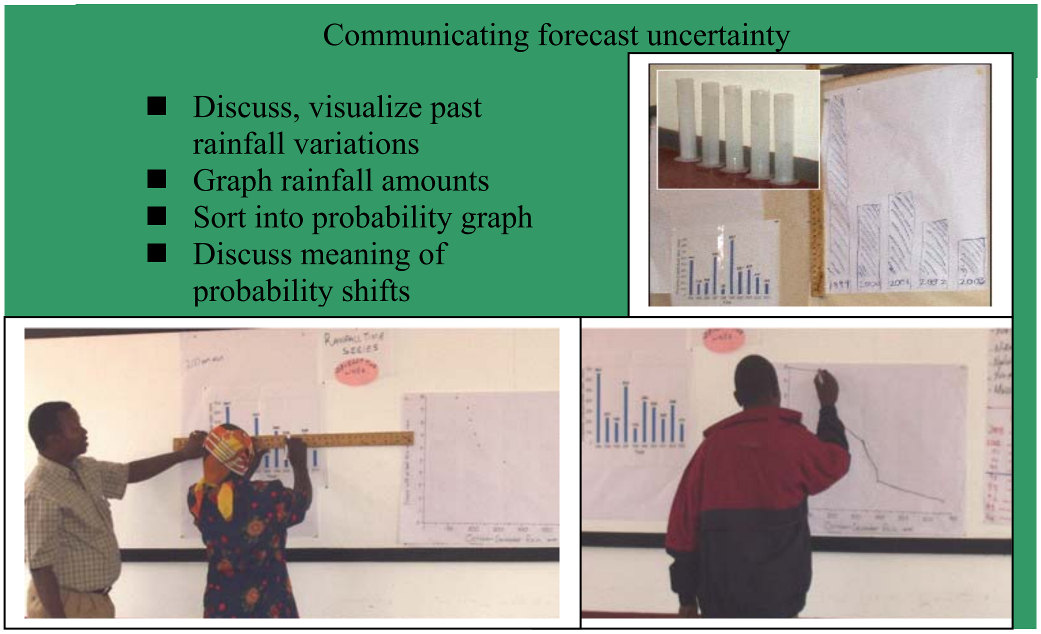


Figure 15. Predictability of rainfall yields at Katumani (September 2004).


Communicating forecast uncertainty

- Discuss, visualize past rainfall variations
- Graph rainfall amounts
- Sort into probability graph
- Discuss meaning of probability shifts

Figure 16. The visual techniques used to demonstrate forecasts to farmers.

6.3.4. Next steps

For farmers in the districts of Machakos and Makueni, the research to date has shown that:

- Farmers see rainfall as their greatest challenge.
- Seasonal forecasts that are skillful at a regional scale can be downscaled and translated into forecasts of local crop yields, although accuracy of the crop model simulations has not yet been evaluated with farm production data.
- With some interaction and an appropriate presentation, farmers can understand forecasts in probabilistic terms, and understand their significance.
- Farmers perceive a range of opportunities to change their management to take advantage of advance climate information.
- Using forecasts to adjust crop management show potential livelihood benefits. A broad range of promising management and livelihood responses still needs to be evaluated.

Some analyses from the current project remain to be completed. Maize management valuation results are still preliminary, and need to be completed for Makindu as well. The farm-level economic modeling will give a richer picture of how a range of livelihood decisions and constraints interact with the predictable components of rainfall variability, and should yield insights about promising interventions (e.g., reducing credit constraints). Analysis of the pre- and post-forecast questionnaires will yield insights into how farmers are currently responding to forecast information, and the immediate added value of tailored information coupled with training.

The preliminary evidence from the Machakos and Makueni agricultural work suggests that forecasts coupled with an appropriate suite of interventions may contribute to improved prosperity among rainfed farmers in semi-arid Kenya. This will require attention to equitable and timely distribution of relevant climate information; education and technical support for farmers as they learn to use the information, and hence strong research support and training for extension personnel and other intermediaries; and involvement of suppliers of production inputs and financial services to reduce constraints. Next steps are likely to include dialogue with the Ministry of Agriculture and the Kenya Meteorological Department, the development of training curricula for intermediaries, analysis of the influence of various institutional actors on availability of resources and flow of information. The way forward with this demonstration project when completed would be the expansion of the network of demonstration research sites.

Work has already begun to extend the work in Machakos to Sauri, Kenya and to Southern Province, Zambia. The Nairobi-based Millennium Development Center of the Earth Institute at Columbia University has recently begun a series of demonstrations projects to ascertain what combination of interventions is needed to lift African villages out of the poverty trap, and the cost. Plans are under development for the IRI and partners to provide climate information for agricultural risk management in multiple other locations throughout Africa as part of this larger Millennium Development effort.

6.4. Food Security Outlooks for contingency planning in the Greater Horn of Africa

6.4.1. Problem context

Of the many factors that affect food security throughout Africa, climate variability is particularly important. Food security is influenced by interactions between climate and livelihood strategies.

Experience in the GHA has shown that when vulnerable populations are exposed to extreme climate events such as a drought or floods the impacts are serious. External emergency assistance is often required to save lives from famine. Currently, East Africa alone receives one half of the global assistance provided by the World Food Program.

The prevalence of climate-sensitive livelihood systems, chronically high levels of vulnerability, and a highly variable climate make episodic food insecurity a regular occurrence in the GHA. Severe droughts during the last three decades have led to a widespread food insecurity causing loss of livestock, depletion of productive assets, rural to urban migration and famine. The problem of drought is compounded by insecurity and weak national or local governance further complicating the food security situation.

6.4.2. Decision context

The first three-four months of a food emergency is a critical period in which to intervene. Consequently, governments and international donors have devoted considerable attention to monitoring techniques for food insecurity early warning. Recent advances in climate monitoring and prediction, in combination with food security analysis, can dramatically increase early warning lead times. The seasonal climate is highly predictable in the GHA for at least one major rainfall season. This creates the possibility that climate conditions associated with food crises can be anticipated even prior to season onset. Earlier warning of potential problems increases the range of available response options for decision makers.

Drought is a slow onset hazard. As drought-induced food insecurity and famine begins to develop, it is difficult to reach consensus among governments and humanitarian agencies as when and how to respond. Experiences show that responses and interventions to food insecurity are often delayed, affecting the effectiveness of humanitarian response.

Climate forecasts on possible droughts and food shortages should help governments and humanitarian agencies plan ahead for a timely humanitarian assistance. The GHA Climate Outlook Forum that is organized by the ICPAC brings participants from the 10 GHA countries and issues a consensus seasonal climate outlook. More can be done, however, to link climate information into food security models. This could help to reach an expert consensus on the food security outlook associated with the expected seasonal climate conditions. To date seasonal forecast information typically has been provided in terms of rainfall probabilities (figure 17). Such seasonal forecasts, however, are not immediately interpretable into probable food security outcomes. It is a challenge to convert information on cumulative or predicted rainfall or temperature into more proximate variables affecting food access such as crop production, herd size, livestock marketing, labor opportunities or market prices.

6.4.3. Towards Food Security Outlooks for contingency planning

From January through March 2004, a series of consultations took place among experts in the GHA on climate and food security led by the IRI, USGS/FEWSNet, ICPAC and WFP. The focus of the consultation was on the possibility of using climate information and forecasts to generate food and livelihood scenarios. This would require translating the climate forecast into impacts on crops, livestock, health, pests and other factors affecting livelihoods and therefore food security.

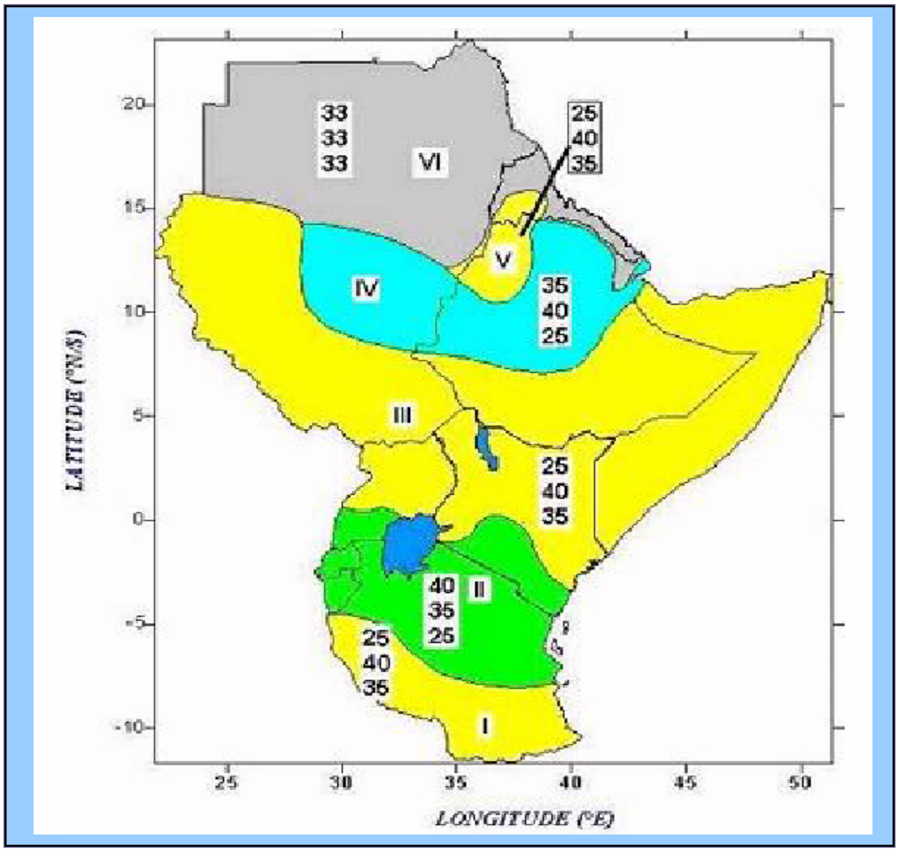


Figure 17. GHA Consensus Outlook for March-May 2005

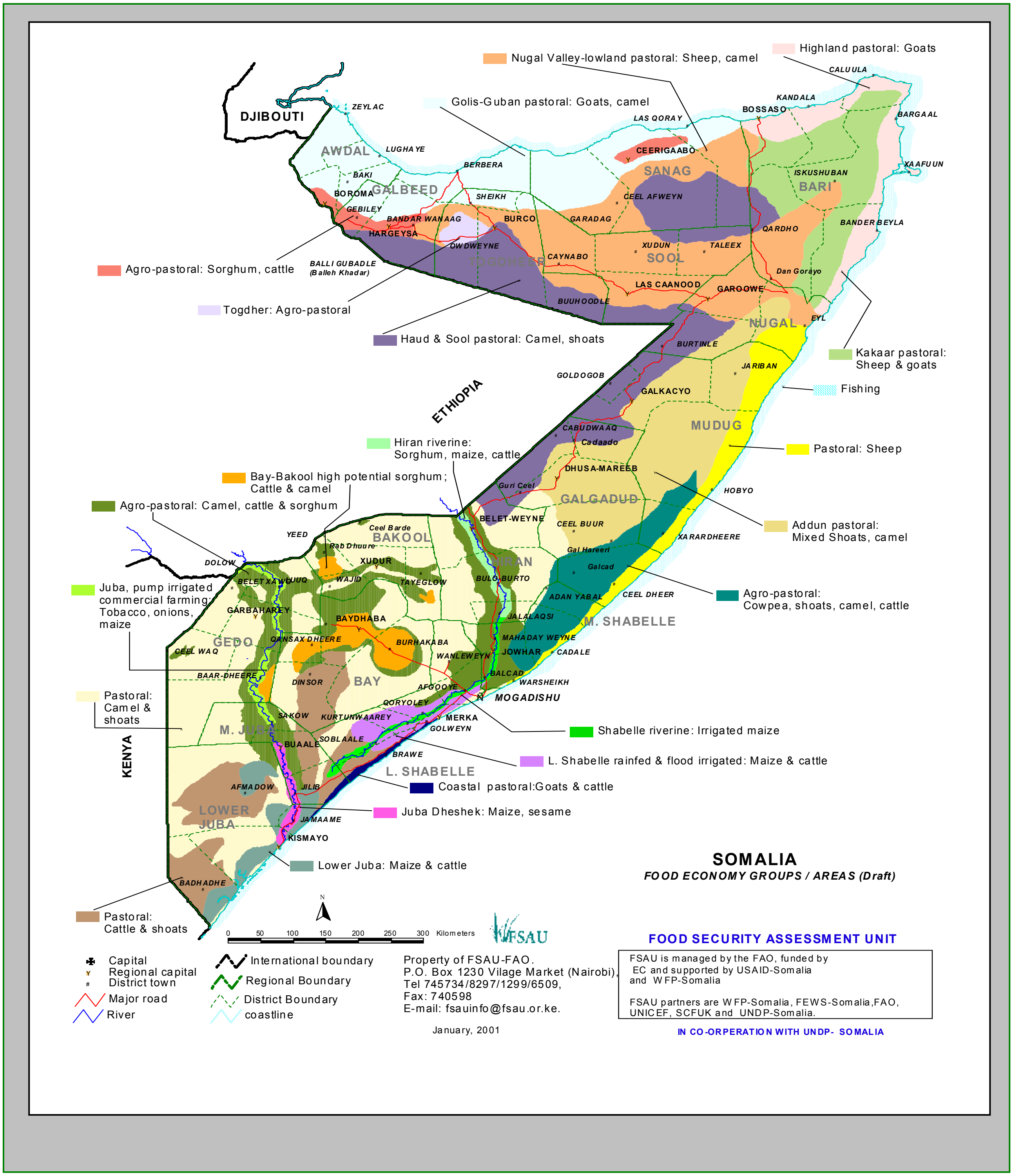
The methodology used for creating food security outlooks involves several steps. The first is to have an assessment of current food security conditions. Food economy/likelihood zone maps are available for some areas within the GHA region (figure 18). Each zone is made up predominately of households sharing a particular portfolio of economic options through which they pursue food security. In Somalia, for example, these typically involve some combination of livestock – camels, sheep and goats – sometimes supplemented with different kinds of crops.

Drought or other shocks affect households in these zones differently, due to differing configurations of livelihood activities and their response to climate. Using seasonal forecasts, in principle, projected climate-related changes in crop yields, livestock conditions and other climate-sensitive variables can be superimposed onto the livelihood zones. The likely impacts on food security of the expected climatic conditions over the course of the coming season can then be anticipated.

In some cases, the conversion of the seasonal climate outlook into crop, livestock and other food security-relevant variables can be done using models. USGS, for example, uses a Forecast Interpretation Tool to convert climate forecasts into rainfall amounts, which can then be used to generate probable effects on crops. The University of Texas A&M has a livestock forage model which can be used to anticipate changes in forage conditions. Where models are not available, it may be possible to qualitatively estimate the impact of forecasted seasonal climate on health, pests, prices and other climate sensitive variables based on expert judgment. To generate Food Security Outlooks, these analyses were applied to the current food security situation to assess whether household in the various food economy zones are likely to be better or worse off at the end of the season.

The theory behind the use of climate forecasts to assess probable food security conditions is based on the Food Economy Approach (FEA), developed by Save the Children UK and the Food Economy Group, and employed by FEWSNet. The FEA involves monitoring the food security situation of communities in different food economy zones. The FEA quantifies household access to food in normal years (baseline information) and the risks faced by the household to external shocks during bad years. The households in a food economy zone are divided into rich, poor and medium households and their coping strategies to the hazard identified. Then the results of the impact on normal food supply and the shortfalls are calculated.

Figure 19 illustrates the effects of a hazard and how a hypothetical household copes with it. When an exogenous shock such as a drought strikes these areas, some of these livelihood options, most of which are in some way tied to the primary sector, will be greatly affected. For example, an affected household could experience a reduction in crop production. A combination of the shock and the households' vulnerability to it will determine the households' food security outcomes. If a hazard, for example, destroys 50% of the crop, the household readjusts its budget to fill the food gap. The success of that response would depend on the assets, networks or supplementary employment of the household. The household might be forced to sell its goats or get help or a loan from other better off relatives. The gap might also be filled through seasonal employment or relief aid.



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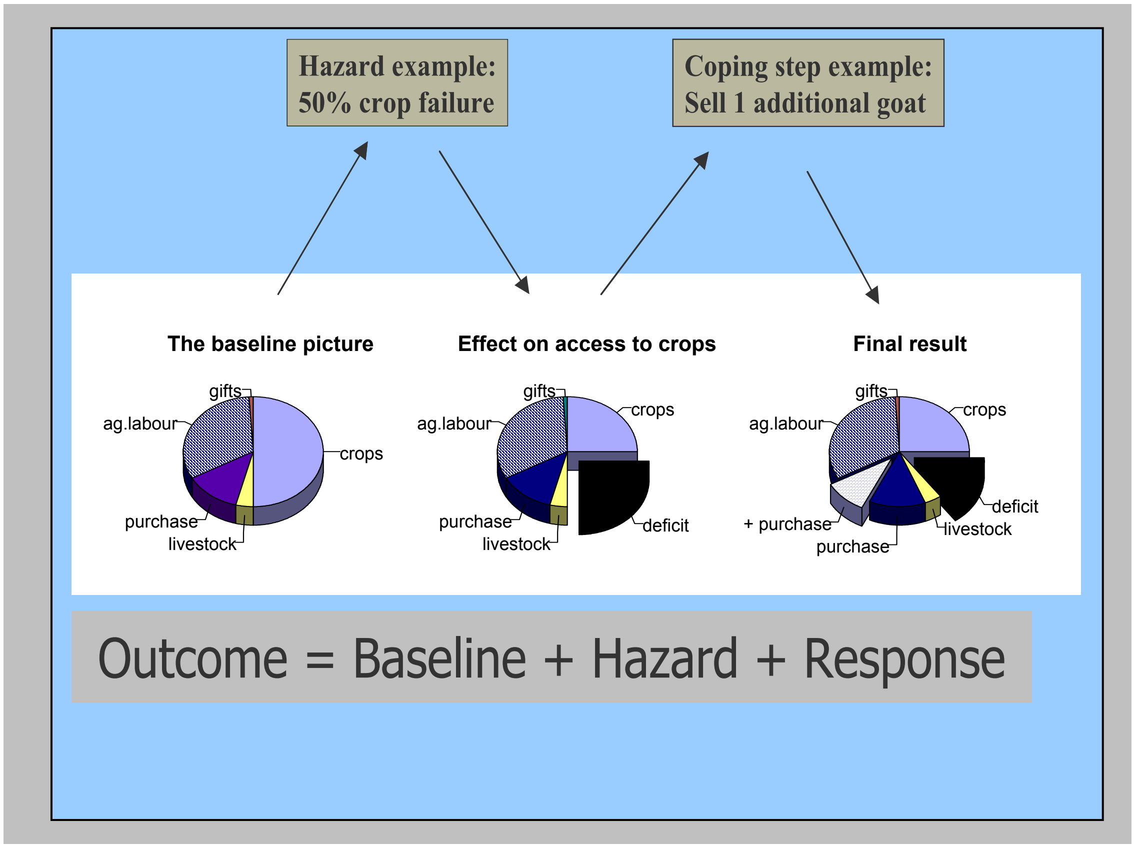
FSAU partners are WFP-Somalia, FEWS-Somalia,FAO, UNICEF, SCFUK and UNDP-Somalia.

IN CO-ORPERATION WITH UNDP- SOMALIA

Figure 18. Somalia food Economy Zones (FSAU, 2002)



Hazard example: 50% crop failure

Coping step example: Sell 1 additional goat

Outcome = Baseline + Hazard + Response

Figure 19. Information on response strategies allows an analysis of how households will cope with the effects of a hazard (Food Economy Group/FEWSNet)

Households become food insecure when they are unable to meet their annual food requirements because of the external shocks (figure 20). If the household is still able to meet 100% of its minimum annual food requirements it is still food secure. However, if the impacts are severe enough and prolonged enough, large numbers of households can slip into food insecurity, precipitating a food crisis.

The FEA identifies the food gap by estimating the impact of the hazard on the baseline information for a normal year. Although it is not yet comprehensively in use for the entire GHA region, the Food Economy Group and FEWSNet have developed a quantitative model through which food income deficits and surpluses in different livelihood zones can be calculated. Save the Children UK employs a similar model.

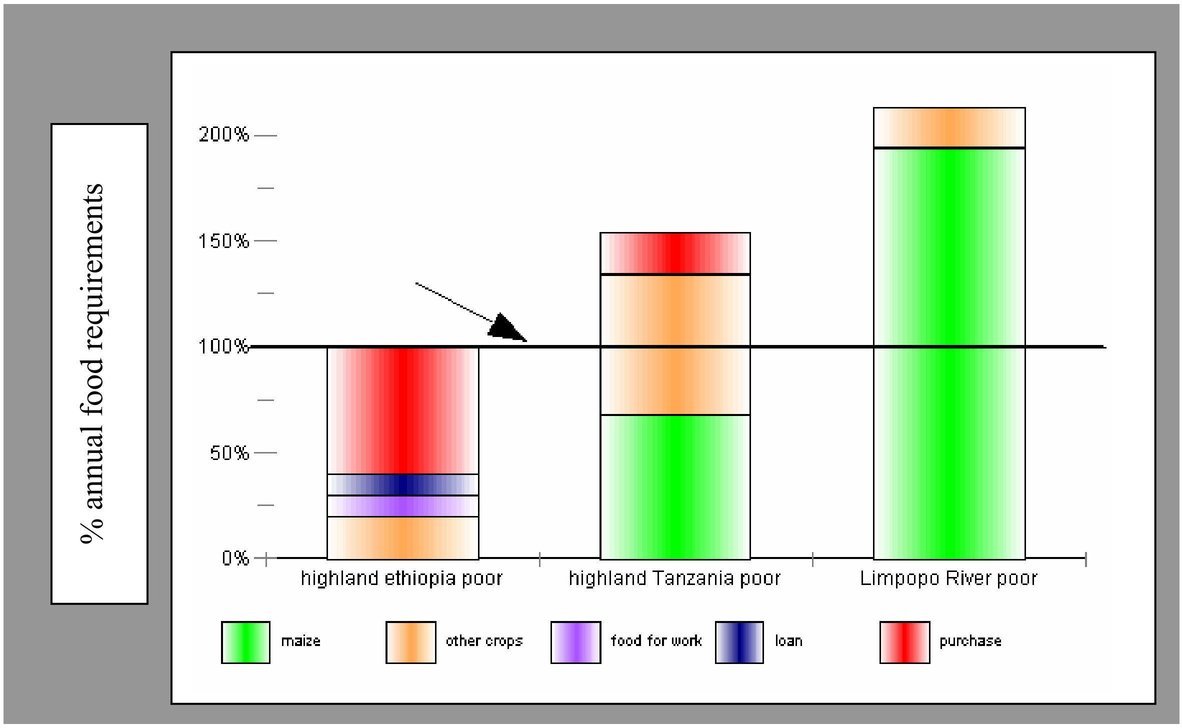


Figure 20. Households become food insecure when they cannot meet 100% of food requirements (Food Economy Group/FEWSNet)

6.4.5. The first Food Security Outlook Forum

In August 2004, food security and climate experts and others concerned with food security early warning and response convened in Nairobi for the first GHA regional food security outlook forum[17]. The August 2004 Food Security Outlook Forum, associated with the GHACOF, was the first experimental attempt to systematically incorporate climate forecast information into a regional food security analysis. The crop and livestock forecasts were overlaid on the livelihood zones to assess the likely trajectory of food security over the subsequent three months from September through December. The experts examined the current food security situation within the region; the climate outlook for September through December 2004; and likely climate effects on crops, livestock, diseases, and pests over the season. The effects of the projected behavior of these variables – based on the climate outlook – were interpreted as food security impacts for the various livelihood zones within the region. This allowed the forum participants (specifically FEWSNet and food security experts) to make informed judgments about the potential trajectory of current food insecure hotspots through the coming season.

Compared with the August outlook, the actual end-of-season conditions reported in the FEWS bulletin in January, 2005 indicated that while in some areas the situation stayed the same or worsened, in other areas it improved, sometimes in contrast to the outlook.

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[17] FSOF Report, 2004 (http://iri.columbia.edu/africa/whatisnew/FSOFreportv3.pdf)

To verify the outlook, the food security situation as it was assessed in August 2004, the outlook for food security in December 2004, and the assessed food security conditions in January 2005 as published in the FEWS bulletin were compared. The comparison of the outlook to the various livelihood zones in January revealed some areas where the agreement with the forecast was quite good, others areas were not so good and there were a few where the outlook was quite different from what was subsequently reported.

In the process of verifying the August 2004 outlook, all the factors were reviewed that could have affected the food security outcome in December 2004 both climate-related and otherwise. This allowed an analysis of why the outlook might have disagreed with the assessed end-of-season food security conditions in some areas. For example, the rainfall forecast that was used could have been off in places, or errors introduced when translating rainfall into its effects on crops, forage and other climate-sensitive variables. The interpretation of the impacts of the behavior of these variables on different livelihood zones was subjective, so that could have affected the outlook. There is also the well-understood fact that food security is not just a direct consequence of climate and that there are many non-climatic and unpredictable factors that affect the outcome. Also, it is possible that the reason some extremely food insecure areas improved over what was expected in the outlook may have been because some assistance was actually provided, so that factor also could not be ruled out.

6.4.6. Second Food Security Outlook Forum

A second GHA FSOF was organized in Nairobi in February 2005. The participants were able to identify some of the factors that should be taken into consideration based on lessons learned from the first. Some of the inputs to the outlook were considered not so deterministically, but rather in terms of best-case, worst-case and most-likely scenarios. A larger range of variables was explicitly considered. There was more effort to explain which factors were responsible for the food security situation, and the outlook, and to differentiate those related to climate from those that are not.

As was the case with the first FSOF, the first step in the process of generating the outlook was to identify current food security conditions as of February 2005. This time, the underlying causes were also identified (figure 21). Best case, worst case and probable crop and livestock forage scenarios were generated using the GHACOF seasonal climate outlook and overlaid on livelihood zones by USGS/FEWSNet. The result was a Food Security Outlook for June, 2005 (figure 22). As of this writing the observed actual food security situation in the GHA is yet to be assessed.

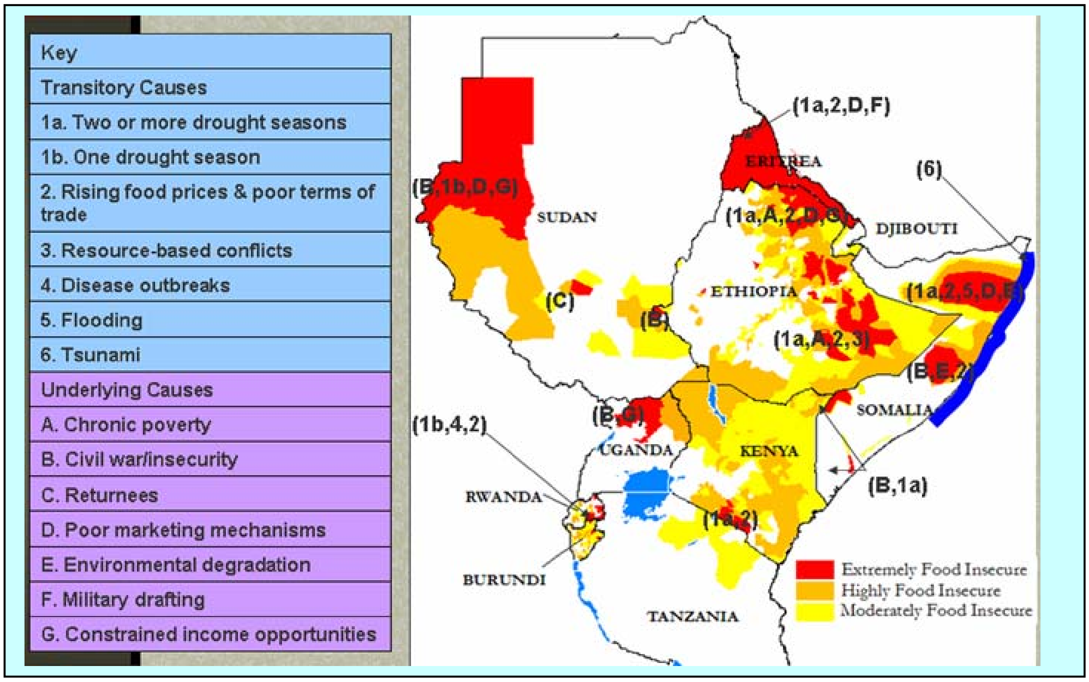

Figure 21. Current food security situation, February 2005

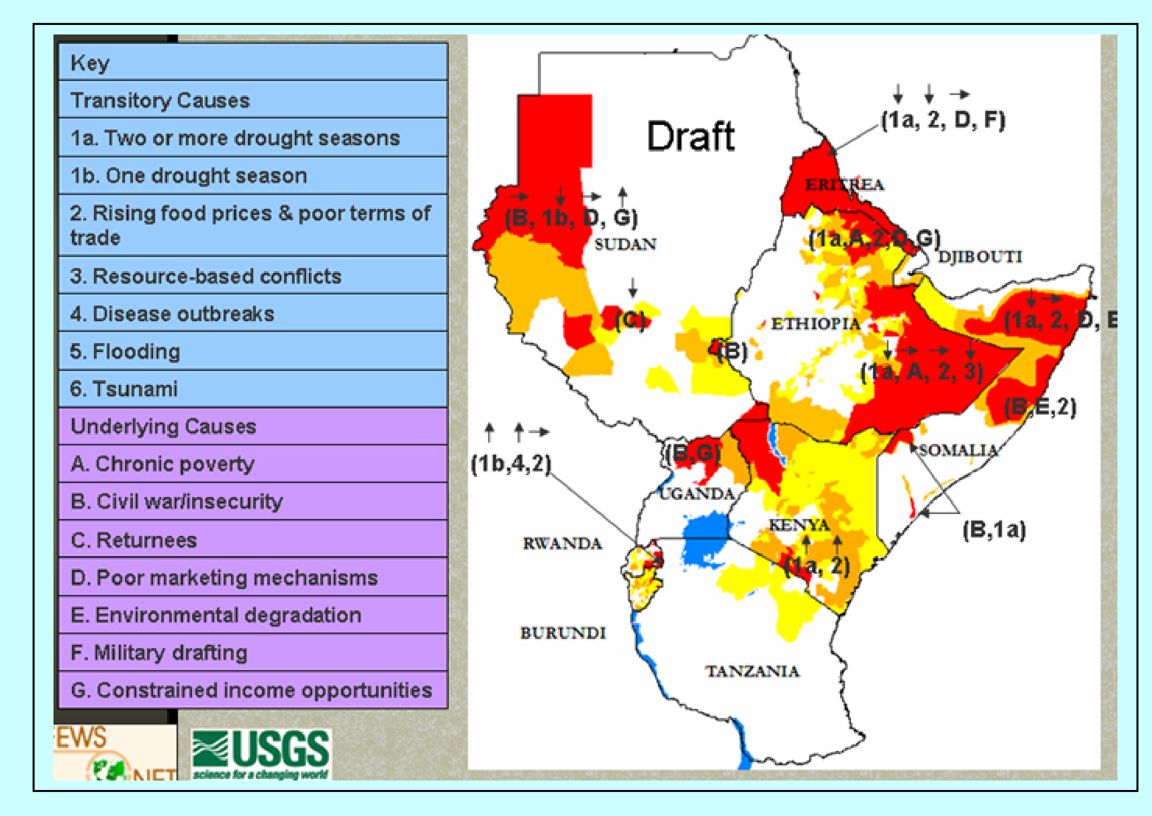

Figure 22. Food Security Outlook for June 2005, generated in February

6.4.7. Next steps

Food Security Outlooks are highly experimental and technically very challenging to produce. With only two of them to date, the basis for verifying their skill is totally inadequate. Nonetheless, given the need for acting quickly in the initial stages to prevent food security situations from becoming worse, there is considerable enthusiasm in the GHA for continuing to seek ways to improve them.

Food emergencies continue to reoccur in the GHA. As a track record is established and confidence in the outlooks grows, the intent is that donors, national governments and perhaps ultimately affected people can use the information to manage food security risks, as opposed to reacting to food security emergencies. Accomplishing this objective will require strengthening linkages between food security analyses and responses, incorporating such measures as response triggers and contingency response funds.

Future IRI food security work in the GHA is currently envisioned in three areas:

1. comprehensive *food security outlooks* incorporating climate forecasts to promote more timely provision of preventative assistance to food insecure populations in the early stages of food crises – this item implies continuing support for an FSOF process led by the appropriate food security and climate institutions in the GHA

2. *creation of evidence* regarding climate's role in food security and nutrition-related outcomes – this item will be addressed through the IRI's climate impacts research in partnership with food security experts

3. demonstrations of how climate information can be used to *measurably improve decisions by specific decision-makers*, leading to improved performance of food and livelihood security-related inputs such as crop production, water supply, trade, human health and road transport – these projects will be similar to the other demonstration projects described in this report, addressing specific factors that promote or constrain food security in specific contexts.

The IRI has also consulted with the IGAD secretariat and WFP about the establishment of a regional food security network. In the event that the IGAD secretariat receives an endorsement from the IGAD member states to do so, the network would provide a logical vehicle for capacity building and downscaling of the regional processes to the national level.

6.5. Protecting pastoralist livelihoods by protecting livestock trade between the GHA and the Middle East through control of Rift Valley Fever

6.5.l. Problem context

Livestock is one of the most important resources for the livelihood of millions of people in the GHA, the main market being the export of live animals to the Middle East. Saudi Arabia, for example, imports millions of live animals for slaughter in religious ceremonies during the annual pilgrimage to Mecca. Hundreds of millions of dollars in livestock trade between the GHA and the Middle East support millions of pastoralists as well as the revenue for many governments in the region. Animals are assets through which the people accumulate their life savings.

Livestock trade has been interrupted by the importing countries repeatedly in recent years, however, because of actual or feared outbreaks of Rift Valley Fever (RVF). RVF is a mosquito-borne, climate/environment-related disease that affects both livestock and people. Outbreaks are a threat to regional livestock trade between the GHA and Middle East because of the potential of transmission on a widespread basis to non-immune human populations during the slaughter of large numbers of animals in Mecca.

The RVF virus was first isolated in Kenya in 1931. Since then there have been occasional outbreaks and viral activity has been detected in areas with epizootic potential throughout the GHA and Middle East (figure 23). Heavy rains associated with the

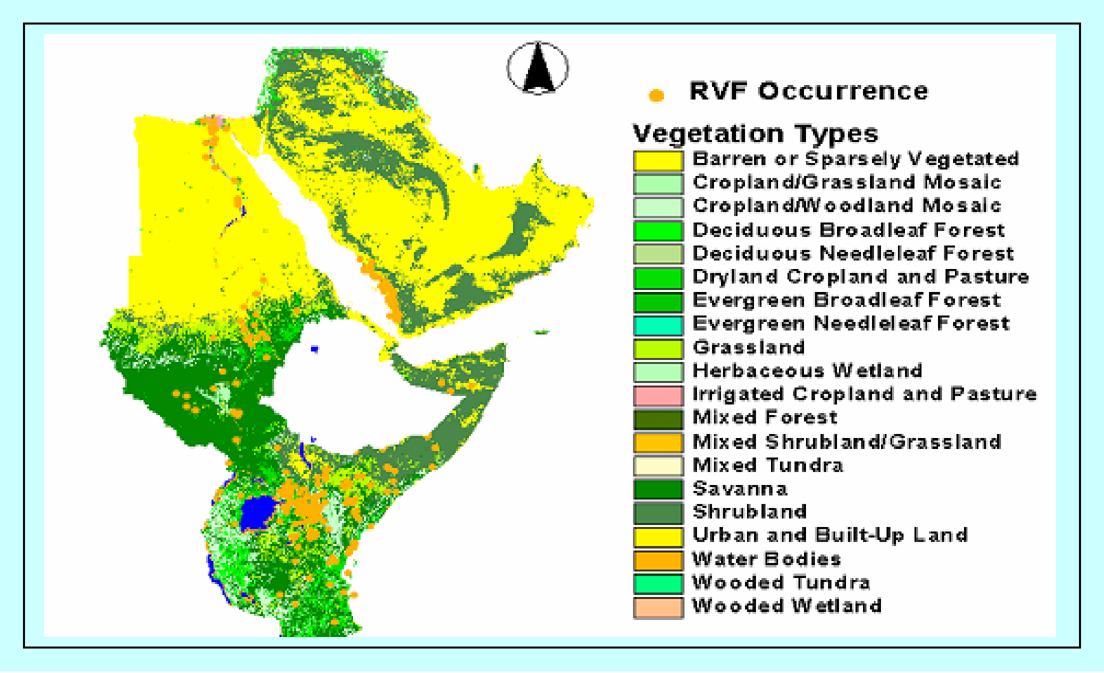

Figure 23. Published RVF data and vegetation types

1997/98 El Niño triggered a major outbreak of RVF in some parts of the GHA affecting livestock and people.[18] Fears of the spread of RVF led countries in the Middle East to ban the import of livestock from GHA for several years, causing hundreds of millions of dollars in losses to pastoralists in exporting countries. The bans continued long after the risks of continued widespread transmission had receded.

6.5.2. Decision context

The RVF project is an attempt to forecast RVF epizootics by developing a predictive model. The objective of the model is to give policy makers a tool to regulate the trade impacts of the occasional outbreaks of RVF. The model will help decision makers to reduce the need for long-term regional livestock trade boycotts by the Middle East. The RVF risk model is designed to predict environmental conditions associated with RVF viral activity.

Work on the model was initiated in 2002 as a collaboration between the Inter-African Bureau for Animal Resources (IBAR), ICPAC and the IRI with technical support from the Regional Center for the Mapping of Resources for Development (RCMRD) and U.S. Geological Survey (USGS) under the auspices of the Red Sea Livestock Trade Commission (RSLTC). The model development effort is also followed closely by the International Animal Health Organization (OIE). Texas A&M University is also a partner.

IBAR, the RSLTC and OIE work closely with governments and traders to coordinate animal health and trade policy. Assuming it can be successfully developed (see below), the model will support animal health and trade decision-making with the intent of minimizing future trade stoppages based on assessment of environmental RVF risks. When operational, a model would support animal health and trade decision-making with the intent of minimizing future trade interruptions based on assessment of environmental RVF risks, including through early warning for surveillance and disease control.

6.5.3. Towards an environmentally-based RVF epizootic predictive model

The idea behind the model is to anticipate environmental conditions associated with mosquito breeding where livestock are present. RVF epizootics are known to be related to rainfall, vegetation, soil moisture and flooding. The basis for a model is to first identify the different environmental habitats and conditions that create the potential for epizootics, then monitor the development of favorable environmental conditions promoting transmission, forecasting those conditions in advance where possible.

Four planned stages for developing a RVF risk model prototype are:

1. A spatial mask to identify areas with RVF epizootic potential (figure 24)

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[18] An Outbreak of Rift Valley Fever, Eastern Africa, 1997-1998. Canada Communicable Disease Report. Vol. 24-12, June 15, 1998. http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/98vol24/dr2412eb.html

2. A temporal analysis to identify critical thresholds for rainfall, vegetation greenness, soil moisture and inundation associated with outbreak of viral activity
3. Verification of the degree of predictability of the environmental indicators using on seasonal climate forecasts, and
4. An analysis of the potential relevance of the model for decision-making.

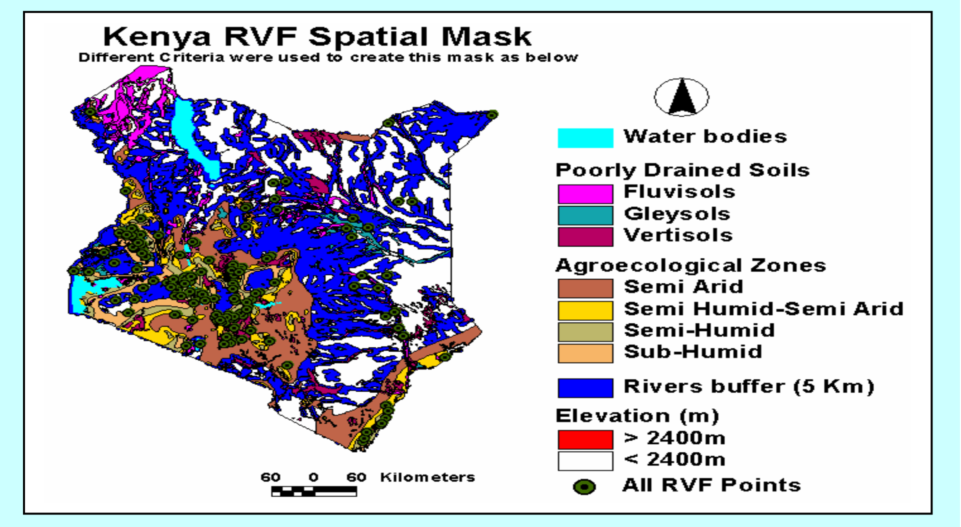

Figure 24. RVF epizootic potential areas

Figure 24 shows areas within Kenya with epizootic potential -- below 2400m in elevation and (within a 3.5-5 km buffer around rivers and water bodies or within a 3.5-5 km buffer around poorly drained soil (fluvisols, gleysols. vertisols and planosols). From this preliminary analysis it appears that poorly drained soil types in non-arid areas are sufficient to identify the areas that need to be monitored for changes in rainfall, surface water and vegetation greenness that could trigger an epizootic (figure 25).

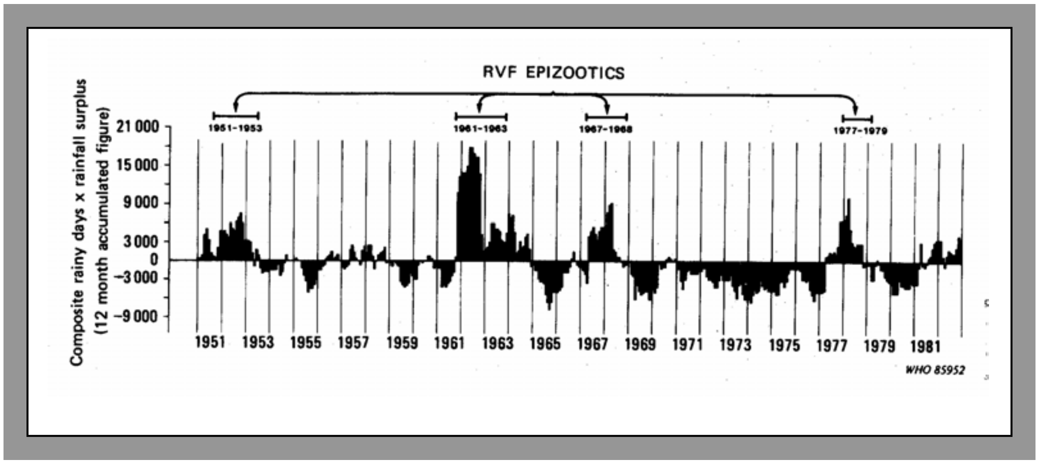

Figure 25. Cumulative rainfall threshold for Kenya outbreaks (Davies)

If critical thresholds of these variables can be identified, predictive capabilities developed under the project can be used to forecast rainfall and other conditions that could trigger epizootics. Vegetation, another RVF risk factor, can be monitored and forecasted using NDVI. The outbreak of RVF in 1997-98 in the Garissa region of Kenya was associated with high values of NDVI (figure 26), consistent with published scientific literature. The project has developed a technique for forecasting NDVI for October, November and December in Kenya (figure 27) as an input for developing the model.

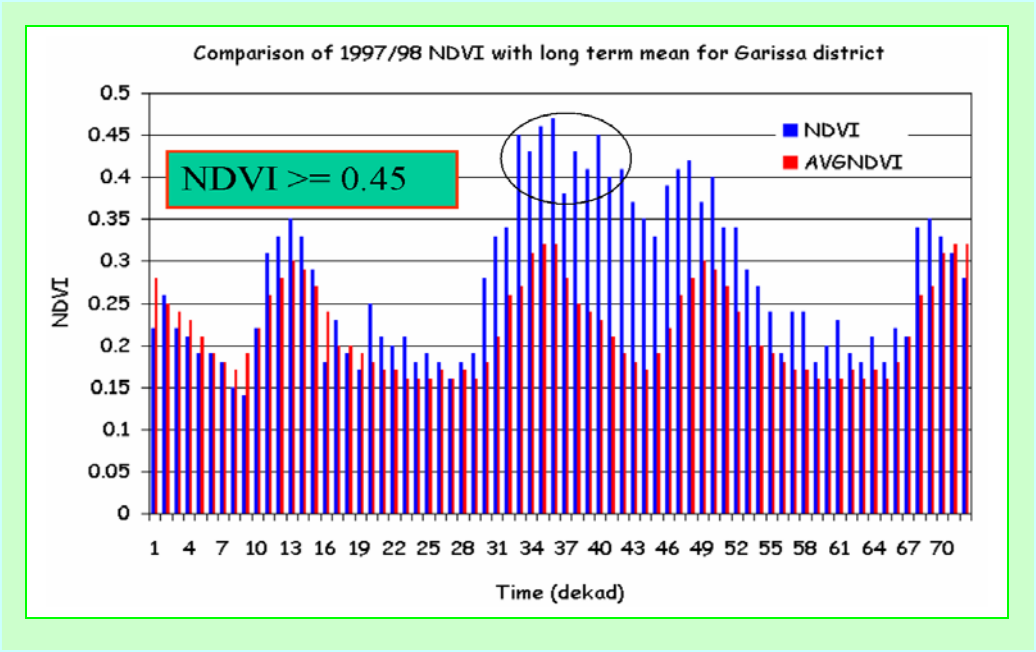

Figure 26. NDVI threshold, 1997 outbreak (Gadain and Funk, 2003)

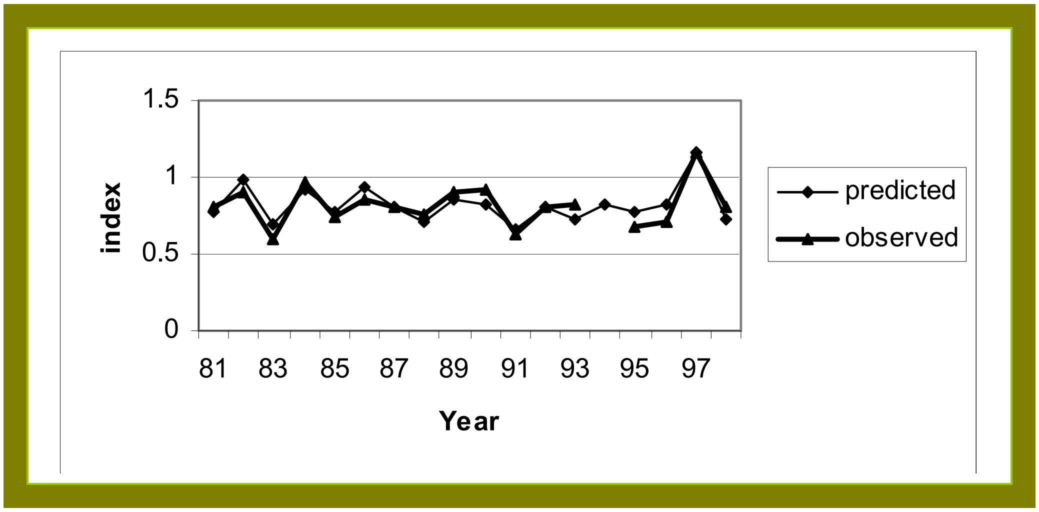

Figure 27. NDVI forecast, OND, Eastern Kenya (Indeje)

6.5.4 Next steps

Many steps remain in the analysis before a feasibility of developing a prototype RVF model can be fully demonstrated. These include:

- consolidation and verification of RVF viral activity data assembled by the project
- definitive characterization of the geographic factors determining the spatial distribution of areas with epizootic potential, first in Kenya, then for the GHA and affected areas of the Middle East
- establishment of critical thresholds of rainfall, NDVI, soil moisture and flooding associated with epizootics, data permitting
- a full analysis of the lead times with which the behavior of these predictors can be anticipated
- integration of all of the above into a prototype model, assuming that a model is feasible
- completion of an analysis of decision options

Continuing interaction with animal health and livestock trade stakeholders will be essential to ensure that any model is credible and geared towards decision-support in real world situations. Even if a prototype can be developed, additional years of work will be needed to verify it with surveillance and on-going user feedback. With the expiration of the project, the IRI is taking steps to complete the feasibility analysis for developing the prototype model, after which additional funding will be needed if work on developing an operational version is to be continued.

7) Upscaling

Achieving successful and widespread management of climate-related risks across multiple climate-affected sectors in support of disaster prevention and sustainable development implies a significant upscaling of current activities. In addition new, related activities will also need to be undertaken.

The current project has sought to promote upscaling by involving local, national, regional and global stakeholders in demonstration projects designed to address particular problems. The skills, capacities and lessons learned during this process enable all stakeholders, including the IRI, to undertake similar work on a wider basis. Plans have been made for beginning to systematically capture knowledge developed during the COFS and demonstration projects in a knowledge management system to be shared and refined within and between African regions.

During the project efforts were made to promote upscaling of the tools, techniques and project resultsthrough work in three areas. These are forecast improvement, knowledge management and improved communication of climate information to the public through the media. Further development in these areas is expected to continue in the period following the project, resources permitting.

7.1. Forecast improvement

Sections 4 and 5, above, described how advanced forecasting techniques have been developed through the project, introduced into the region, and tailored to support specific kinds of decisions. Section 6 provided concrete examples of how the resulting products have been applied in specific decision-making contexts.

Capacity building by the IRI, ICPAC and WMO of technical specialists – primarily from national meteorological and hydrological services -- in forecasting and other climate related services, has been an important part of the project (section 3.2). The next phase in this collaboration is to put the MOS technique for statistical correction of global climate model output into regular use for generating continuously updated forecasts at the national level in GHA countries.

Continued capacity building and training in downscaling science and tailored product development for targeted countries in the GHA is part of the upscaling process. Tailored forecasts in support of specific regional sub-projects will continue.

An important factor in developing national level capacity is achieving widespread operational use of the IRI Climate Prediction Tool (CPT) in GHA countries. The CPT not only facilitates the development of MOS forecasting models, it can be used to forecast streamflow, NDVI and other climate-related variables needed for particular applications.

Data collection, collation, and forming gridded data at the country level for CPT validation and for application of forecast products will continue and be expanded. Through regional collaboration and with the involvement of international partners, the IRI, ICPAC and WMO are supporting the creation of a regional databank of observed and model-downscaled climate forecast variables -- rainfall, temperature, and moisture. This will help in the process of upscaling of the various products that incorporate climate and forecast information.

Operationalizing these new regional forecast tools and improved human capacity in the National Meteorological Services will promote the further development of tailored forecast products in GHA countries. Countries will be increasingly able to develop their own tools and processes for managing climate-related risks along the lines described in this document.

7.2. Knowledge management

Much of the exchange of information and knowledge described above has been through regional meetings and training courses. It is increasingly clear that more cost effective ways of reaching a wider audience is needed.

The IRI intends to continue to be a catalyst in the GHA and in Africa to improve climate risk management capacity through access to knowledge and networking. The idea is to use the internet or other distance technology to consolidate, maintain and develop knowledge resources related to the COFs and demonstration projects.

Participating institutions have already selected focal points from the COF networks in East, West and Southern Africa who will work with the IRI to implement this important activity. When completed the knowledge management portal will be a space for decision support tools, research results, a virtual library, lessons learned from various demonstration projects, and best practices. Thematic communities of practice in different sectors will also be established to improve their capacity and solve sectoral problems. The portal will also give an opportunity for the regions to sustain the achievements so far made in the use of seasonal climate information for development. Related activities are already underway in the GHA. The idea now is to strengthen the network and make the approach to knowledge management more robust and systematic and the results more accessible within and outside the region.

The IRI has already engaged in several rounds of consultations with the stakeholders on the issue of knowledge management. A knowledge management design workshop is planned for 2005 to be followed by the implementation of the portal.

7.3. Communication of climate information to the public

One important challenge faced by institutions engaged in seasonal climate forecasting and decision makers is the process of communicating the information to users and the general public. The public plays a vastly important role in climate risk management, ranging from multiple small adjustments to climate conditions made by individual decision makers to major decisions at the institutional level.

Barriers to communication include that the probabilistic and inherent uncertainty of forecasts and the unfamiliar terminology is sometimes confusing to users. The capacity and background of the media professionals who disseminate the information is also limited. The GHACOFs have made great strides in involving the media in the COF process to help them understand the forecast process and its content and to help climate specialists understand how to communicate with a broader audience.

Journalists have been invited to the COFs not only to report on the seasonal climate outlooks but also to participate in media workshops to improve their capacity in the dissemination of the forecast information. The media workshops have helped journalists to understand the concepts of the forecasts and to disseminate them as accurately as possible. In the GHA, this interaction resulted to the creation of the NECJOGHA. A similar network has now been created in the SADC region.

As, if not more importantly, the journalists have educated climate scientists about the barriers to understanding they themselves create by using specialized jargon and needlessly obscure terminology. The interaction between journalists and climate specialists has made it obvious that communication is a two-way street and that issuing highly technical, and needlessly unclear forecast bulletins is nearly useless. This has raised awareness among climate scientists of the need to speak precisely but clearly when seeking to communicate to the public. The media, as specialists in communicating with the public, have a great role to play in promoting this education process.

The GHA and SADC networks of climate journalists collaborate on curriculum development and training. The journalists continue to participate in the COFs and they have been helping in the design of seasonal climate forecast press releases during the COF meetings for popular consumption.

Continued upscaling in the area of communication will require expansion of national workshops as well as online training of journalists and climate scientists in the area of formulating and disseminating climate information for development. The creation of knowledge management portal mentioned above will support such networking activities.

8) The Way Forward

It is hoped that some of the promising findings in the GHA project will provide opportunities to solve significant climate-related societal problems. The next step is to continue to develop and upscale the results of the demonstration projects to promote national development in the region. To accomplish this, the IRI and partners are working vigorously to ensure that climate risk management receives the recognition it requires within the international development agenda for Africa.

One of the demonstration projects that has excited project partners and other stakeholders is the effort to develop and operationalize a Rift Valley Fever predictive model. The project assembled a model development team and relevant data sets and has demonstrated a general relationship between RVF and the environment and that specific environmental variables such as rainfall and vegetation can be skillfully predicted under certain circumstances. The next activity is to fully ascertain the feasibility of developing a prototype model by integrating the various spatial and environmental variables. If feasible, the model will be tested and operationalized in collaboration with national, regional and international partners. Concurrently, the IRI and partners are working on an exploratory basis to develop techniques for integrating results from a prospective model into decision processes affecting livestock trade.

Water resource development is crucial for the national development of GHA countries. The GHA river basins are not yet fully developed, however, with the exception of some reservoirs mainly for the production of hydro power. The reservoirs, which provide water for irrigation and hydroelectric power, are currently at the mercy of climate variability. Initial work on a Tana River reservoir management decision support system demonstration project is completed. After verification of the model and the decision making interface with the reservoir managers of KenGen, the model will be introduced through a workshop in 2005 for use by other reservoir managers in Africa.

Based on recent experiences to date with introducing advances in climate prediction for food security outlooks with a lead time of several months, the IRI hopes to continue to work with development partners in the region and globally to formalize and make operational tailored forecasts for the climate-sensitive components of food security. As shown in the demonstration project described in section 6, the combined use of seasonal climate forecasts, analyses of trends in climate, vulnerability and environmental monitoring can increase the lead-time, accuracy and geographic specificity of the various components of food security. The successful upscaling of the food security outlook forums will need the commitment of national governments to introduce the results into their planning and response activities. The positive endorsement through IGAD for future regional food security network activities would create a positive institutional environment.

Until recently most collaborative research in forecasting and the production of tailored products was through ICPAC on a regional basis. In the future the IRI, ICPAC and WMO increasingly expect to support forecasting and tailored products at the national level.

As a result of the capacity building workshops and demonstration project research collaboration described above, a community of practitioners has emerged in the region. Formal knowledge sharing and virtual networking have been virtually absent in GHA, however. In the future greater effort will be made to see that networking and collaboration will continue through a knowledge management infrastructure. A knowledge management system will provide a more structured means to share skills and information and improve capacity in the GHA. This would strengthen the media networks and enable the communities of practice in agriculture, health, climate forecasting to collaborate to solve specific, defined problems. This will enable regional policy makers and professionals to get information on lessons learned and share information with their colleagues in and outside the region.

In the coming years the IRI expects to continue to upscale the results from the current project into a comprehensive continental-scale program built on regional initiatives. The latter will follow the lines described above, built from relatively small scale sector-specific activities combined with capacity building and upscaling measures. The long term strategy is for the GHA region to be able to cope with risks related to climate variability by applying the findings of current and future demonstration projects. Through this work, decision makers may increasingly incorporated climate variability as an important factor, leading to better development outcomes.

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Acronyms

AEZ	Agro-Ecological Zones
AMJJ	April, May, June, July
BBC	British Broadcasting Corporation
COF	Climate Outlook Forum
CPT	Climate Predictability Tool
DMCN	Drought Monitoring Centre Nairobi
ECHAM	European Center Hamburg Model (global climate model)
EI	The Earth Institute at Columbia University
ENSO	El Niño and Southern Oscillation
FEA	Food Economy Approach
FAS	US Department of Agriculture, Foreign Agricultural Service
FEWSNET	USAID Famine Early Warning System Network
FSAU	Food Security Analysis Unit- Somalia
FSOF	Food Security outlook Forum
GCM	Global Circulation Model
GHA	Greater Horn of Africa
IBAR	Inter-African Bureau for Animal Resources
ICPAC	IGAD Climate Prediction and Applications Centre
ICRAF	International Centre for Research in Agro-Forestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IGAD	Inter-Governmental Authority on Development
IRI	International Research Institute for Climate Prediction
IRIN	United Nations Integrated Regional Information Networks
KenGen	Kenya Electricity Generating Company Limited
KMD	Kenya Meteorological Department
MDGs	Millennium Development Goals
MOS	Model Output Statistics
MSLP	Mean Sea level Pressure
MW	Megawatts
NDVI	Normalized Difference Vegetation Index
NECJOGHA	Network of Climate Journalists in the Greater Horn of Africa
NGO	Non-Governmental Organization
NMSA	Ethiopian National Meteorological Services Agency
OFDA	Office of Foreign Disaster Assistance
OND	October, November, December
RSM	Regional Spectrum Model
RCMRD	Regional Centre for Mapping of Resources for Development
RSLTC	Red Sea Livestock Trade Commission
RVF	Rift Valley Fever
SFM	Streamflow Model
SSA	Sub Saharan Africa
SST	Sea Surface Temperature
UN	United Nations
UNEP	United Nations Environmental Program

UNOCHA	UN Office for the Coordination of Humanitarian Affairs
USAID	US Agency for International Development, Washington
UN	United Nations
USGS	United States Geological Survey (US Department of the Interior)
WFP	World Food Program
WMO	World Meteorological Organization