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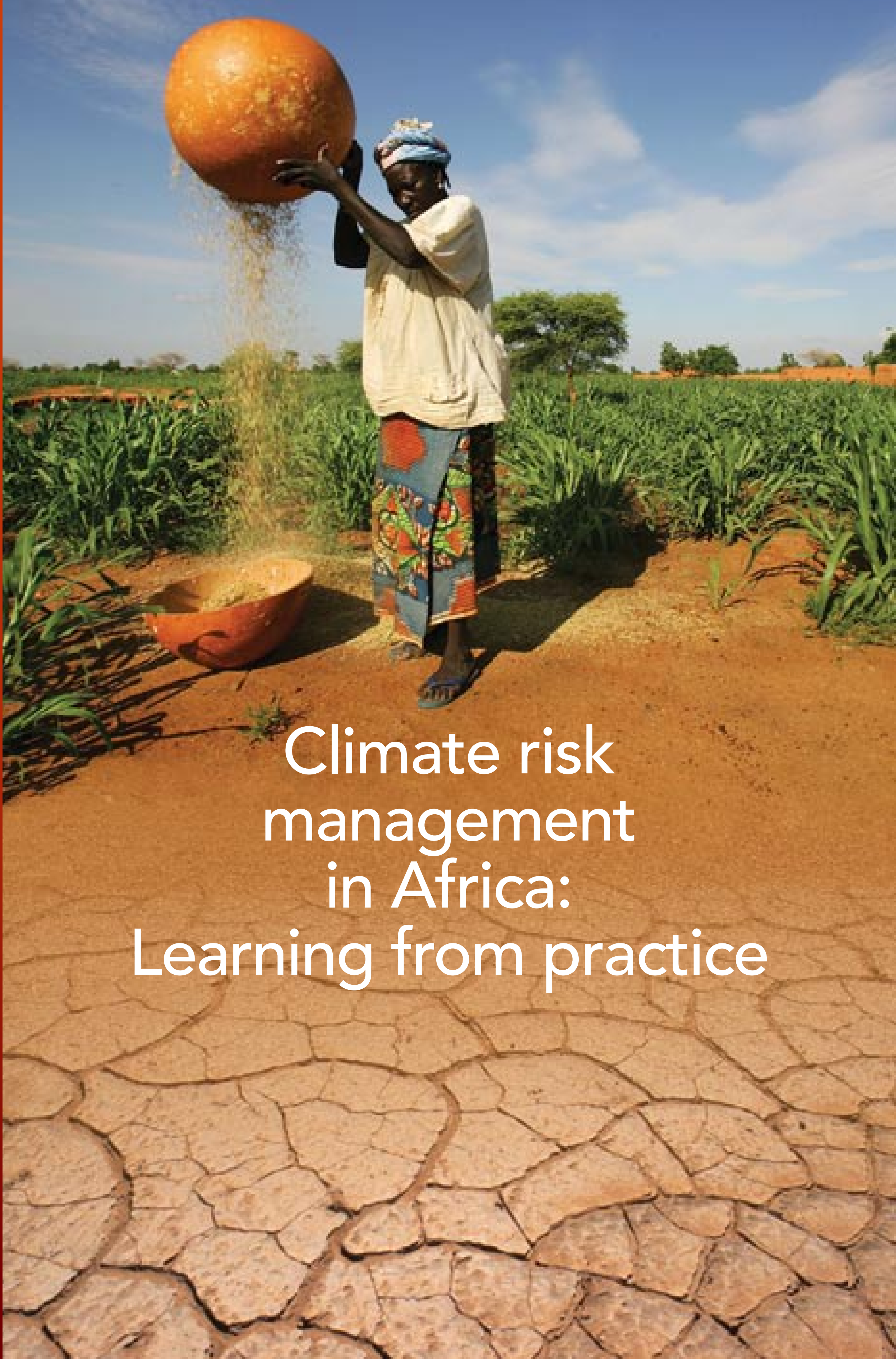

Climate risk management in Africa: Learning from practice

IRI

The Climate and Society series is devoted to providing authoritative and accessible information on climate risk management research, practice, and policy in support of sustainable development.

The series is a program of the International Research Institute for Climate and Society (IRI). IRI aims to contribute to sustainable living and poverty reduction, through the integration of climate information into management strategies for climate-sensitive sectors such as agriculture, food security, water resources, and health. IRI is a member of The Earth Institute at Columbia University, New York.

The Climate and Society editorial team is always looking for new ideas for future issues in the series. Please contact us with any ideas or for further information:

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Climate risk management in Africa: Learning from practice

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The impact of climate change will fall disproportionately on the world's poorest countries, many of them here in Africa. Poor people already live on the front lines of pollution, disaster, and the degradation of resources and land. For them, adaptation is a matter of sheer survival.

UN Secretary General Kofi Annan, addressing the 12th Conference of the Parties to the United Nations Framework Convention on Climate Change, 15 November 2006, Nairobi, Kenya.

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Additional feedback from stakeholders was provided at the recent side-session, Climate for Development in Africa: Learning from Practice, sponsored by IRI, GCOS, UNECA, the African Development Bank, and the African Union at the 12th Conference of the Parties to the United Nations Framework Convention on Climate Change, held in Nairobi in November 2006. At this side-session, the case studies were presented and an advanced draft of the report was made available for comment.

The team gratefully acknowledges the financial support of the UK Department for International Development (DFID) and the US National Oceanic and Atmospheric Administration (NOAA) in the preparation of this report.

The lead authors presenting their case studies at the Twelfth Conference of the Parties to the United Nations Framework Convention on Climate Change, Nairobi, 10 November 2006; Haresh Bhojwani/IRI

Foreword
from the African Union

As one of the most vulnerable regions in the world to the projected impacts of climate change, Africa faces many challenges at this critical juncture. Traditionally, national development plans, poverty reduction strategy papers, and sectoral strategies in climate-sensitive sectors have paid little, if any, attention to climate variability, and even less to climate change. Our ability to turn a threat into an opportunity hinges on actions taken today.

Africans have already begun to take some steps in their region. For example, the African Union Commission (AUC)-supported Environment Initiative of the New Partnership for Africa's Development (NEPAD), and its related Action Plan, acknowledge the economic importance of climate variability and change by including a program area on combating climate change in Africa. In addition, the AUC-supported NEPAD Africa Regional Strategy for Disaster Risk Reduction recognizes the importance of coordination across agencies for proactive disaster prevention and response strategies.

The AUC, in partnership with the UN Economic Commission for Africa and African Development Bank, is supporting a major new initiative, 'GCOS-Africa Climate for Development', beginning in 2007. The program, part of the Global Climate Observing System, is designed to integrate climate information and services into development in support of Africa's progress towards the Millennium Development Goals. A major objective is to mainstream climate information in national development programs, focusing initially on the most climate-sensitive sectors.

This inaugural report in the Climate and Society series is a key resource for climate-informed planning and practice in Africa – as it critically examines five experiences of ongoing climate risk management in the disaster risk reduction, health, agriculture, and food security sectors. The report provides a valuable opportunity to reflect on the positive lessons that can drawn from these experiences, as well as on the key knowledge, information, and capacity gaps we face in managing climate risk in Africa today.

Ahmadu Babagana
Director
Department of Rural Economy and Agriculture
African Union

Foreword
from the African Centre of Meteorological Applications for Development

It is a recognized fact that Africa, because of widespread poverty and consequential limited adaptation and coping capabilities, is one of the most vulnerable regions of the world to the current impacts of climate variability and the projected impacts of climate change. It is also a known fact that most of Africa's disasters are caused at least in part by adverse weather. These disasters pose a serious threat to poverty reduction and sustainable development on the continent.

In 2004, the Heads of State and Government of the African Union reaffirmed their commitment to establishing and strengthening centres of excellence and networks dedicated to agricultural and environmental issues, and to establishing and enhancing regional early warning systems to combat natural disasters.

In 2005, the Gleneagles Plan of Action committed the G8 countries to support Africa's efforts to establish or upgrade its climate observing systems, to fill meteorological data gaps, to expand its capacity for analyzing and interpreting such data, to develop decision support systems and tools for local, regional, and continental needs, and to strengthen the region's existing climate institutions.

At the African Centre of Meteorological Application for Development (ACMAD), we recognize in our own mission statement that all these efforts must be made, with the goal of supporting sustainable development in line with national, regional, and continental strategies for poverty eradication, in the fields of agriculture, water resources, health, public safety, and renewable energy.

The innovative case studies presented here demonstrate that, used successfully, climate information can not only improve livelihoods and economies but even save lives. Together we can learn from these innovative practices, and in so doing help to create a better Africa.

Abdoulaye Kignaman-Soro
Director General
African Centre of Meteorological
Applications for Development

Contents

Introduction

Climate and development

In the early years of the 21st century, sub-Saharan Africa is failing to keep pace with the rest of the world in terms of development. The region has the highest proportion of people living in extreme poverty, a figure that has fallen only very slightly since 1990, while actual numbers have increased (UN, 2006). A total of 330 million people now live in extreme poverty in sub-Saharan Africa. This is in contrast to Asia, for example, which has seen significant proportional reductions in poverty since 1990.

Poverty makes people vulnerable and limits their choices. If crops fail, subsistence farmers have few or no alternative means to provide food for their families. Natural disasters such as floods, or a sudden illness, can overwhelm a poor household, destroying its ability to cope.

Climate variability and extremes are very much a part of life in sub-Saharan Africa, as elsewhere. But where people are poor and vulnerable, these factors can add greatly to the hardship of their lives. An estimated 70% of the population of sub-Saharan Africa survive

Reducing the risks associated with climate variability would encourage farmers to use more inputs; M. Herrick/Chemonics/USAID

Droughts, like floods, can cause sudden increases in the number of refugees; H. Caux/UNHCR

by subsistence agriculture; their livelihoods depend fundamentally on rain, and may fail when the rains fail. The incidence of malaria, one of the region's major health problems, is known to be influenced by climate. Again, the poor are much more vulnerable to this, as to other diseases. Extreme climate events, such as droughts and floods, also threaten the lives and livelihoods of the poor more than other social groups.

The negative impacts of climate at the household level multiply into negative impacts on national economies. Centrally managed infrastructure, vital to a country's development, is also vulnerable to climate variability and extremes. Water resources in particular comprise one sector that is highly dependent on, and influenced by, climate.

Climate thus presents a risk, to livelihoods and sometimes lives at the individual level, and to economy and infrastructure at the national and regional levels. At the same time, it also presents opportunities that can be exploited.

Poor people manage risks, including climate-related risks, regularly, as part of their everyday lives. Using as much information as they can get, farmers make decisions that aim to minimize climate risks and exploit climate opportunities; for example, they try to time the planting of their crops to coincide with the onset of rains. Water managers similarly seek information and make decisions that aim to reduce the negative impacts of variable climate on rivers and reservoirs.

Climate risk management is therefore already being practised at various levels, and with varying effectiveness, across sub-Saharan Africa; but much more can be done. Africa is not currently benefiting from all that climate science has to offer. Climate information, which feeds into decision making as a matter of course in developed countries, is mostly failing to reach decision makers, in useful and usable forms, in sub-Saharan Africa (IRI, 2006).

Most of the sectors on which development efforts focus are climate-sensitive, including agriculture, health, energy, transport, and water resources. Incorporating climate knowledge into these efforts could greatly enhance their effectiveness, yet the opportunities for doing this are largely being missed at present. Some believe this omission is undermining progress towards the Millennium Development Goals (MDGs) (UNDP, 2002). Climate-related disasters, in particular, are threatening development gains in many African countries.

At the same time, the few climate science-driven projects that have been initiated have for the most part failed to address climate within the context of development needs. As a result, the products and services developed by the climate research community have not been as useful as they could have been.

It is becoming clear that what is needed is an integrated approach that incorporates climate science into multidisciplinary development planning and projects. And crucially, the approach must also be participatory, involving all primary stakeholders so as to ensure that their real needs are met. The climate tools used in such an approach will enhance stakeholders' decision making by providing relevant new information that they can incorporate into practice.

Climate is just one strand in a complex web of factors affecting development. Strengthening livelihoods – by, for example, improving agricultural productivity, diversifying on- and off-farm activities, providing better access to markets and to market information, and improving infrastructure – will reduce poor people's vulnerability to climate variability and extremes. But incorporating climate information into development efforts has the potential for synergistic results. For example, in the face of uncertain climate, farmers tend to 'play safe', adopting conservative management strategies. They choose not to invest in new technologies and opt for less risky but also less profitable crops, even when climate conditions are good. Reducing this uncertainty could have a direct effect on their livelihoods, as farmers become more confident that they can boost their productivity by innovating (Hansen *et al*., 2004).

Climate variability and climate change

The weather reflects variability in atmospheric conditions on a daily and weekly basis. The term 'climate variability', in contrast, refers to variations of the climate system, which includes oceans and the land surface as well as the atmosphere, over months, years, and decades. This encompasses predictable variability, i.e. the march of the seasons, but also includes an inherent uncertainty. The rainy season is a predictable occurrence, but the amount, timing, and distribution of the rains is uncertain. Advances in climate science, described below, are improving the predictability of climate fluctuations.

Climate change generally refers to longer term trends in average temperature or rainfall or in climate variability itself, and often to trends resulting wholly or in part from human activities, notably global warming due to the burning of fossil fuels. Climate change scenarios typically consider the climate 50 to 100 years from now. There is high uncertainty in such long-term projections, so current strategies for adapting to change over these time horizons are vulnerable to 'regrets' if our expectations turn out to be wrong. It is clear, however, that learning now to better manage climate variability over seasons and from year to year will increase the resilience of infrastructure and systems and strengthen the capacity to adapt to future climate change. It is anticipated that climate change will lead to more frequent and more damaging extreme events. Learning to better manage such events now will go at least some way to protecting societies against future, even more extreme events.

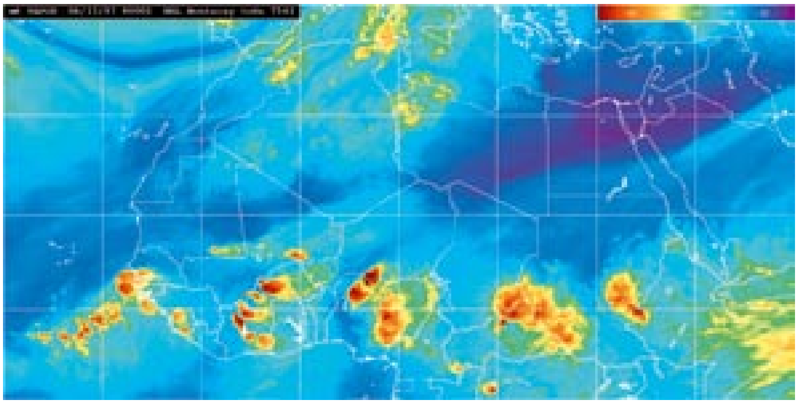
Climate information and climate science

There are three types of climate information:

- Historical data, which help elucidate trends, provide climate statistics, set a context for current data, and allow

Strengthening national and local capacities to manage climate-related risks, as they can be understood now, is the best strategy to be able to manage more complex climate risk in the future. It is also more feasible to mobilize national and international political and financial resources to manage an existing risk scenario than to address a hypothetical future scenario. Medium- and long-term adaptation must begin today with efforts to improve current risk management and adaptation. Lessons from current practices, along with the notion that learning comes from doing, are of critical importance.

UNDP, 2002.



Satellite data are supplementing ground observations: here, water vapor imagery characterizing the West African monsoon; NRL Monterey

variability and the occurrence of extremes to be quantified

- Real-time data, i.e. current climate observations. These aid short-term predictions of the consequences of specific weather events – for example, heavy rainfall leading to flooding
- Climate forecasts, i.e. predictions of the climate, ranging from long-term weather forecasts, through seasonal forecasts, to medium- (10–30 year) and long-term climate change projections.

Advances in climate science are improving the availability and quality of all three information types. Data rescue techniques are extending historical datasets and making them more accessible and useful. Satellite remote sensing is providing large amounts of useful data to supplement ground observations (though the latter remain essential for calibration purposes). Climate modeling capacity is rapidly improving with the development of new methodologies and more powerful computers.

Seasonal forecasts are potentially very useful for planning agricultural activities (Hansen *et al.*, 2004), and as a starting point for early warning and response planning. Of course, such forecasts indicate a 'tilt in the odds' towards a particular outcome; they will never give a 'perfect' prediction – one that turns out to be 100% right. The challenge is to incorporate such probabilistic information, with its explicit uncertainties, into decision making.

Atmospheric conditions only allow prediction of the weather up to 10 days or so into the future. However, the atmosphere itself responds to sea and land surface conditions, which vary much more slowly. Thus by measuring these conditions, particularly sea temperatures, it is possible to predict the

The onset of rains is notoriously difficult to forecast; Christophe Courteau/BIOS/Still Pictures

climate up to several months into the future. Measurements of sea temperatures in the tropical Pacific Ocean are especially useful. The El Niño–Southern Oscillation (ENSO) involves changes in sea surface temperatures in the Pacific, and related atmospheric circulation patterns. El Niño is used to describe warmer temperatures; La Niña cooler ones. ENSO is the most significant source of seasonal climate variability globally, with rainfall in parts of Africa being strongly influenced by it (see 'the African climate').

Ongoing research looks likely to improve seasonal forecasting skills still further in the near future. However, it is a fact that the further a forecast projects into the future, the more uncertain it becomes. For decision makers, this represents a trade-off between, on the one hand, the better preparedness made possible by longer lead times, and, on the other, the greater probability that the preparations made, on the basis of better information, will prove to be justified. This trade-off can be particularly difficult to judge where resources are very limited, as in most African countries.

At the intersection between year-to-year climate variability and climate change lies

The African climate

Distinct wet and dry seasons characterize the climate of most of Africa. The Sahel region, from Chad to the Atlantic, experiences monsoonal rains from May through October, with the bulk falling in July, August, and September. Southern Africa experiences monsoonal rains during the austral summer. Equatorial regions generally have two distinct rainy seasons. The typical seasonality of the rainfall, i.e. when it falls, is determined primarily by the position of the sun. The typical (or average) local patterns of the rainfall are often strongly affected by local geographical features, such as mountains.

The year-to-year variability of rainfall in sub-Saharan Africa is influenced by several factors, among them the sea surface temperatures of the surrounding waters. Most of the seasonal rainfall in eastern and southern Africa exhibits a strong correlation with ENSO, and especially with sea surface temperatures in the Indian Ocean, while the Atlantic exerts an influence on western Africa.

Some regions have better predictability than others (Figure 1). There is a region of high predictability around Lake Victoria in eastern Africa, while the southern Ethiopia region has moderate predictability. Predictability in eastern Africa is stronger for the October–December short rains than for the March–May long rains. Rainfall in western Africa also shows good predictability in the humid coastal region; predictability decreases moving northwards into the Sahel. Much of southern Africa shows good predictability.

On longer time scales, rainfall in parts of Africa, particularly the Sahel, has historically experienced multi-decade-long variations. These variations are thought to be related to slow changes in sea temperatures, primarily in the Atlantic and possibly in the Indian Ocean as well. While improved understanding of these variations is slowly emerging, the predictability of this aspect of rainfall variability is still unclear. On even longer time scales, a general increase in African temperatures emerges clearly from observations and is expected to continue as part of global climate change. However, there is no consensus among current climate models on how global warming will manifest itself in terms of changes in regional rainfall.

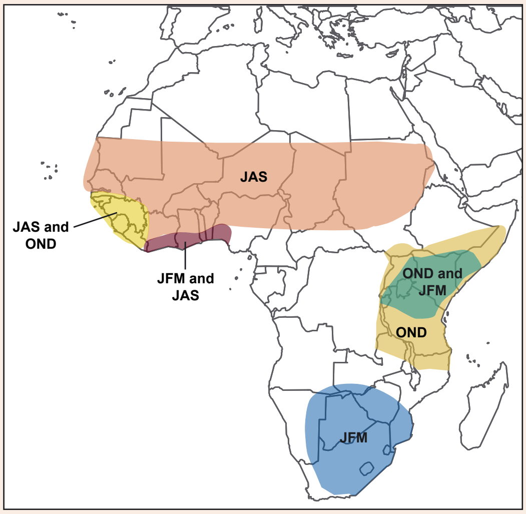


Figure 1.
Regions in sub-Saharan Africa where seasonal rainfall can be simulated with a high degree of skill based on models calibrated over the 1950–1995 period. The labels indicate the season(s) of greater predictability; these generally coincide with the regions' rainy seasons: January/February/March (JFM) for southern Africa; July/August/September (JAS) for the Sahel and western Africa; October/November/December (OND) for eastern Africa. Source: Adapted from IRI (2005).

decadal variability (over one or more decades, usually involving predictions over the next 10–30 years). This timescale has immediate relevance to strategic planning, and is consequently the subject of much ongoing research.

Over relatively long timescales (i.e. 30 years or more) and large spatial scales (i.e. hemispheric, global), today's climate change models broadly agree, both with each other and with physical theory, about what is likely to happen in aggregate, at least with regard to anthropogenic climate change. At shorter timescales and on local and regional scales, there is considerable disagreement among the models, making it difficult to reach conclusions. One of the biggest 'climate' risks faced by decision makers is that of making mistakes based on false expectations about the climate. Scientists are developing strategies and tools for weighing the risks, costs, and benefits of different courses of action in the face of future climate change uncertainty (Callaway *et al.,* 2006).

The livestock sector is especially vulnerable to drought; B. Heger/UNHCR

Incorporating climate information into African development

Africa's variable climate is already contributing significantly to its development problems. The key development sectors of agriculture, water, energy, transport, and health are all particularly sensitive to climate variability. Climate-related disasters – catastrophic floods or prolonged drought, for example – have enormous social and economic impacts that can negate years of development efforts.

Climate information exists that could improve decision making within these sectors, thereby mitigating the effects of adverse climate. But at present this information is seldom incorporated in development decisions. A recent 'gap analysis' (IRI, 2006) examines this omission in detail and explains why it occurs. The analysis found gaps in four main areas:

- Integrating climate into policy
- Integrating climate into practice
- Climate services
- Climate data.

The authors summarized that 'in essence, the problem is one of "market" atrophy: negligible demand coupled with inadequate supply of climate services for development decisions.' They concluded that 'a major, continent-wide effort to integrate climate risk management into climate-sensitive development processes (at all levels) is an urgent and top priority requirement for Africa today.'

Among other problems, the analysis identified a lack of evidence regarding both the impact of climate variability on climate-sensitive development outcomes and the benefits of climate information to improve these outcomes. While heuristic evidence of the benefits of integrating climate information into decision making is abundant, research that quantifies these benefits, together with the costs of climate variability, is lacking. For climate modeling and forecasting, this may be attributable to the fact that many of the interventions offered by climate science are the result of recent advances, such that a significant body of evidence has not yet accumulated. Raising awareness of climate information and providing evidence of its

Recent floods in Kenya drove villagers from their houses, destroyed crops and livestock and caused severe soil erosion; B. Bannon/UNHCR value to decision makers in climate-sensitive sectors is thus an important challenge.

Community-level stakeholders, especially farmers, are the most important group to engage in the drive to incorporate climate information into decision making. As well as being the most climate-vulnerable group, they also comprise the largest group of decision makers within the hugely important agriculture sector. If climate information and services are to support this group, their involvement is crucial. Yet much of the climate discourse so far has been at the national and international levels. This mismatch needs to be addressed if successful practices – and policies – are to be developed that make the best possible use of climate information.

This presents a challenge to communication professionals, in particular the media, as well as to communication infrastructure and networks (Panos, 2006). The need is to engage all stakeholders, to facilitate awareness and education, and to support dialog so that users can help shape the services they receive. Communicating on climate issues presents unique challenges to journalists, including the need to present the uncertainties attached to forecasts and predictions clearly and understandably. Some progress has been made in this area (see 'Communicating climate in Africa'), but more work is needed.

The gap analysis found many limitations in climate services and data in sub-Saharan Africa. The density of meteorological stations is estimated to be eight times lower than the minimum recommended by the World Meteorological Organization (WMO), for example (Giles, 2005). Many of these stations are non-functional, as governments have failed to invest in equipment and trained personnel. These and other services and data limitations need to be addressed.

Climate risk management

Climate risk management (CRM) is an approach to climate-sensitive decision making that is increasingly seen as the way forward in dealing with climate variability and change. The approach seeks to promote sustainable development by reducing the vulnerability associated with climate risk. CRM involves proactive 'no regrets' strategies aimed at maximizing positive and minimizing negative outcomes for communities and societies in climate-sensitive areas such as agriculture, food security, water resources, and health. The 'no regrets' aspect of CRM means taking climate-related decisions or action that make sense in development terms anyway, whether or not a specific climate threat actually materializes in the future.

Successful CRM depends on the following:

- A demand-driven and problem-focused approach
- An effective policy framework
- High-quality climate data and information

Communicating climate in Africa

The mass media have a vital but so far largely neglected role to play in climate risk management. They can communicate with the general public and local communities, both raising awareness of climate issues generally and, when specific threats arise, spelling out the risks and the recommended responses. The challenges facing the media are to ensure that messages are relevant, accurate, and timely, and are received and understood.

Awareness of this role is increasing both within the media and among the suppliers of climate information, and there are positive signs that things are changing. In the past, a flood or famine aroused media attention after the event; now warnings ahead of catastrophe make the news. Journalists are taking seriously their responsibility to report complex issues accurately. Training in science journalism is in high demand, and a new field of 'climate journalism' has appeared in Africa, with the founding in 2000 of the Network of Climate Journalists in the Greater Horn of Africa. A similar network has since been set up in southern Africa. At the same time, scientists are increasingly involving communication professionals, including journalists, in their work. Where doors were previously closed, journalists are now more often invited, for example to climate outlook meetings.

There are also signs of change at the local community level, where information from the media is now reaching increasing numbers of stakeholders and is being used by them. In some countries, for example, farmers are coming to rely on weather forecasts from the radio in their planning.

> *The people wait for the information to come. They say 'I want to plant, but I'm not certain, I'd better wait for the radio'.* Patrick Luganda, journalist, Uganda

Community Association for Development of Bankilare, in the North West of Niger

Radio is still the most effective way of reaching rural stakeholders in sub-Saharan Africa, but new information and communication technologies (ICTs) are also being explored. RANET – Community Radio and Internet – integrates these two media to provide climate-related information from national meteorological services to local communities in usable forms and at locally relevant scales. It is currently functioning in Uganda, Niger, and Ethiopia, and expanding to other countries.

Audiovisual tools also offer good opportunities for raising awareness, supporting capacity building, enhancing the transfer of best practices, and improving participatory processes for managing climate-related risks, particularly in areas where illiteracy is high. Several projects are exploring the use of video. The Malawi Red Cross and Meteorological Services, for example, are working together on a video to train community volunteers in the understanding and use of climate predictions.

Participatory communication is increasingly recognized as a way of increasing responsiveness to climate-related information. Studies have shown that the understanding and use of radio forecasts increases when these are combined with workshops and or listening groups (Patt *et al.*, 2005).

National meterological services need more investment; D. Osgood/IRI

- Appropriate climate services
- Effective communication between different stakeholder groups
- User-friendly decision-support tools and methods that show how climate variables will affect specific development outcomes
- Sufficient resources to allow decision makers to use information effectively.

In turn, these require:

- Full stakeholder participation
- Communication channels and links between stakeholder groups
- Functioning media aware of, and able to perform, their role
- Capacity building at different levels
- Responsive and integrated climate research.

The case studies

The opportunities for incorporating climate information into development activities in sub-Saharan Africa are largely being missed at the moment. However, there are some notable exceptions. In particular, there are several good examples where national authorities, development projects, or private-sector operators have recognized the value of climate information and have sought to systematize its inclusion in their decision making. These cases contain elements of CRM good practice that can inform future efforts in this direction.

Identifying and documenting these good practices is the main purpose of this report. Another aim is to derive lessons, both positive and negative, from within and across the cases, that can feed into future CRM policy and practice.

The case studies cover the three key climate-sensitive sectors of agriculture, health, and water. Food security, closely aligned to agriculture but a distinct issue, is also addressed. The focus is on:

- Flood management in Mozambique
- Food security in Ethiopia
- Epidemic malaria in southern Africa
- Agriculture in Mali
- Drought insurance in Malawi.

The cases include examples of managing 'everyday' climate risks, such as those associated with farming in Mali, and also the risks associated with 'one-off' extreme

Climate is an 'everyday' risk for Mali's small-scale farmers; D. Telemans/Panos Pictures climate events, such as the floods in Mozambique.

Each case study starts with a brief section providing background information. In all the cases except Malawi, the policy and planning framework within which the CRM strategy operates is then described, followed by an account of how climate information is incorporated into decision making in practice, then a section that reflects on the experience and discusses the CRM good practice elements, ending with a conclusions section that draws out the main project-specific lessons. The Malawi case study, which describes a project launched only recently, is structured somewhat differently, placing greater emphasis on the concept and design of the innovation being tested rather than presenting results; the way ahead is then sketched and some tentative lessons and conclusions are drawn.

The final section of the report presents some generic lessons from the cases, then proposes action points to facilitate the transition to more climate-aware and climate-responsive development in Africa.

Flood management in Mozambique

Background

Mozambique is one of the poorest countries in the world, with more than 50% of its 19.7 million people living in extreme poverty. Development has been heavily compromised in recent years by civil war and conflict with neighboring South Africa, as well as spiralling HIV/AIDS rates. Extreme climate events have also disrupted the country's development: since 1980 there have been seven major droughts and seven major floods (Table 1).

Table 1. Climate-related natural disasters in Mozambique since 1980.

Year	Event	Areas affected	Number of people affected
2002–06	Drought	43 districts affected in South and Central provinces	800,000 affected
2001	Floods	Zambezi river	500,000 affected; 115 deaths
2000	Floods	Limpopo, Maputo, Umbeluzi, Incomati, Buzi, and Save river basins, caused by record rainfall and 3 cyclones	More than 2 million people affected; 700 deaths
1999	Floods	Sofala and Inhambane provinces; highest rainfall level in 37 years; EN1 (major road) shut for 2 weeks	70,000 people affected; 100 deaths
1997	Floods	Buzi, Pungue and Zambezi rivers; no road traffic to Zimbabwe for 2 weeks	300,000 people affected; 78 deaths
1996	Floods	All southern rivers of the country	200,000 people affected
1994–95	Drought	South and Central parts	1.5 million people affected; cholera epidemic
1991–92	Drought	Whole country affected	1.32 million people severely affected; major crop failure
1987	Drought	Inhambane province	8000 people affected
1985	Floods	9 rivers in the southern provinces; worst flooding in 50 years followed by 4 years of drought	500,000 people affected
1983–84	Drought	Most of the country affected	Many deaths from drought and war; cholera epidemic
1981–83	Drought	South and Central provinces	2.46 million people affected
1981	Floods	Limpopo river	500,000 people affected
1980	Drought	Southern and Central provinces	No data available

Mozambique's fisheries sector, like its agriculture, is highly vulnerable to climate extremes; Sean Sprague/Still Pictures

Mozambique's high incidence of flooding is explained by two factors. First is the tropical cyclones that form in the south-western Indian Ocean and sweep towards the country's coast. While relatively few of these actually make landfall, an average of three or four get close enough each year to cause high winds and heavy rain, leading to flooding (Figure 2). Second, Mozambique is a 'downstream' country: nine major river systems that drain vast areas of southeastern Africa find their way to the ocean by crossing it (Figure 3). Mozambique must thus manage the downstream effects of rain that falls far beyond its own catchment areas: an estimated 50% of water in Mozambique's rivers comes from outside the country.

Some 80% of Mozambique's population works in agriculture and fisheries – both sectors that are highly vulnerable to climate variability and extreme weather events. Most of these people survive at bare subsistence level. Literacy is about 60% for men and 30% for women. Fewer than 6% of households have electricity, and there are just 16 telephones for every 1000 people. Life expectancy is around 40 years, having fallen sharply over the past decade because of HIV/AIDS.

Since the end of the civil war in 1992, the government has worked hard with international donors to rebuild the country's economy and infrastructure, with some success. Growth rates have averaged 8%, but development has been uneven, with urban

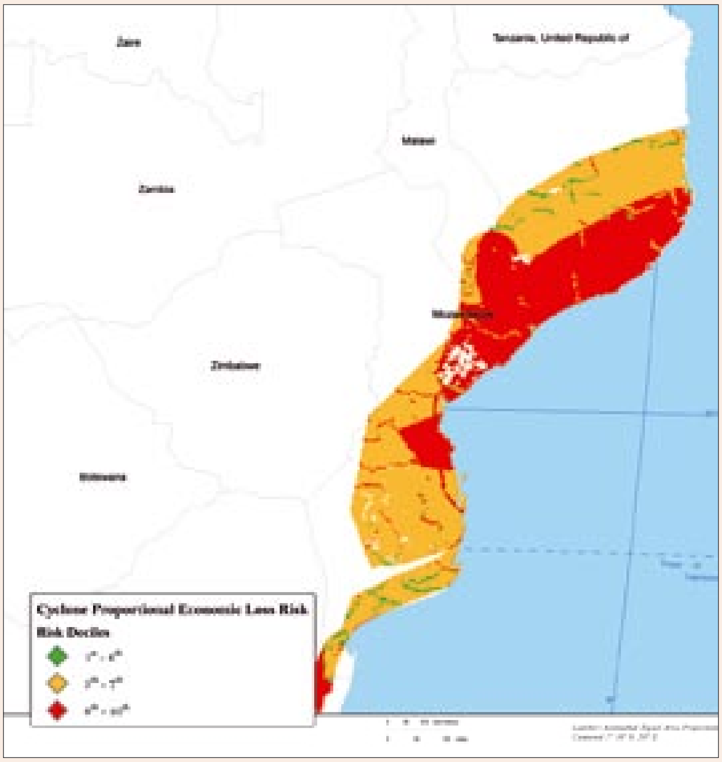


Figure 2.
Cyclone risk map for Mozambique.
Source: Center for Hazards and Risk Research, Columbia University.

areas – where about 23% of the population live – moving rapidly ahead of rural parts.

This case study looks at how Mozambique prepares for and deals with flood events, drawing on experiences in 2000 when the most severe floods in living memory affected large areas of the country. It examines what climate information was available, and how it was used, before and during the disaster. It then reflects on the 2000 floods, and in particular on the best practice elements of the country's CRM strategy.

Policy and planning for floods

Recognizing the risks of climate-related disasters, Mozambique's post-independence governments have tried to put in place structures for managing and mitigating their impacts. The Department for Combating Natural Disasters was established in 1977. In 1999, a new National Policy on Disaster Management was passed, and the Department for Combating Natural Disasters was replaced by the National Disaster Management Institute. This accompanied

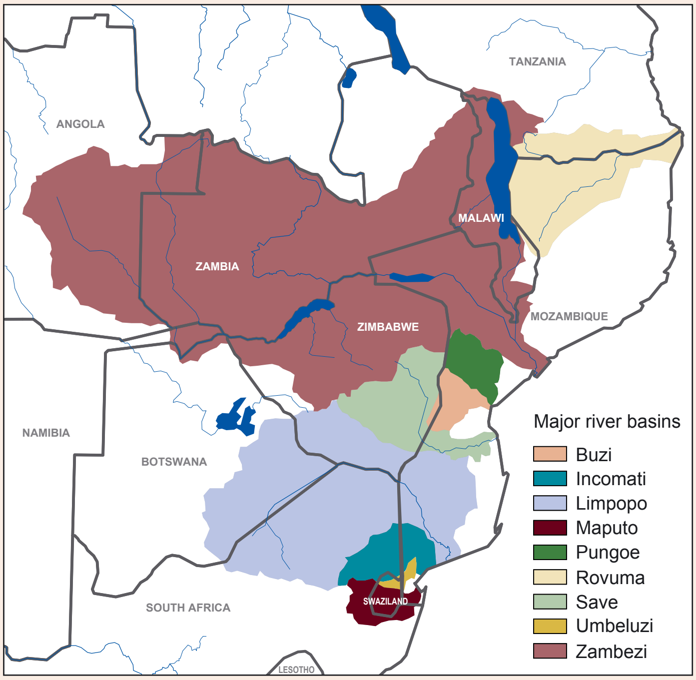


Figure 3.
Mozambique, its neighboring countries, and major rivers basins.

Mozambique has policies and structures in place for dealing with floods: here, food and fresh water reaching affected families; P-A. Pettersson/Still Pictures a change in approach to disaster management, from reaction to preparedness.

Under the new policy, preparedness for floods is facilitated by a flood early warning system. This provides forecasts of flood risk, detects and monitors flooding, and puts out flood warnings when necessary, paving the way for a coordinated response. The flood early warning system is coordinated by the National Directorate of Water, together with the National Institute of Meteorology and the National Disaster Management Institute. This collaboration reflects the essential integration of hydrologic and climate information needed to understand and predict floods and to manage an effective response.

From 1996 onwards, climate forecasts have provided the basis for contingency planning. The National Institute of Meteorology collects meteorological data and prepares a range of forecasts – seasonal (October to March), 4-day and daily. It is also responsible for monitoring cyclones. Ahead of the rainy season, in October, the seasonal forecast informs a meeting of water resources experts, who assess preparedness for the predicted weather. If flooding is expected, a flood team is mobilized. When a flood occurs, the team's role is to monitor the situation, receive and analyze information, recommend responses, ensure collaboration between the different bodies involved, and coordinate activities at central and local levels.

Regional Water Administrations work at the river basin level, monitoring water levels and providing data to the National Institute of Meteorology. The latter also collects data from meteorological stations across the country, from radar equipment, and from satellites. It uses these data to update the forecasts periodically.

The Regional Water Administrations issue flood warnings when necessary, to district governments and local authorities and also to the media (radio, television, and newspapers). District governments and local authorities, in collaboration with the Red Cross and other non-government organizations (NGOs), are responsible for the dissemination of information, and in particular warnings, at the local level, and for the evacuation of people before the floodwaters rise.

A high-level committee of ministers chaired by the Prime Minister becomes the overall decision-making body in the event of a disaster. This is supported by a technical committee comprising experts from the Ministries of Public Works and Housing, Transport and Communications, Health, Agriculture, Environment, Defense, and Foreign Affairs. The committee meets daily while the disaster lasts. The National Disaster Management Institute is responsible for coordinating the response.

Mozambique thus has policies and structures in place for domestic flood management; but it cannot address its water-related climate challenges alone, since weather events outside the country often largely determine the internal situation. Regional cooperation is therefore critical, particularly for flood prediction.

This cooperation is facilitated by the Southern African Regional Climate Outlook Forum (SARCOF), which comes under the umbrella of the Southern African Development Community (SADC). SARCOF's role is to facilitate information exchange and interaction among forecasters, decision makers, and climate information users in the 14 SADC member states. In September every year SARCOF holds a regional meeting to exchange data and to prepare the seasonal forecast for SADC countries. This forecast feeds into Mozambican flood prediction.

The water authorities in the region also exchange data on a regular basis. Interestingly, the need for coordinated water management often transcends political disagreements: Mozambique maintained information sharing with South Africa even when the two countries were virtually at war during the 1980s.

The floods of 2000

The SARCOF meeting of September 1999 warned that there was a high probability of above-average rainfall between October and December 1999 for most of Mozambique, although there was a 45% probability of normal rainfall in much of the Limpopo River basin. For the period January to March 2000, the forecast was for a 50% probability of above-average rainfall in the central region (Buzi and Save river basins), while southern Mozambique had a only 30% chance of above-average rainfall. The updated forecast in December slightly reduced the expectations for central Mozambique to a 45% chance, and increased the prediction for southern Mozambique to a 35% chance, for the period January to March 2000.

The National Institute of Meteorology was not happy with this. In the previous year its scientists had noted a correlation between La Niña activity and high rainfall in southern Mozambique, conditions which now appeared to be repeating themselves more forcefully. They are also thought to have noted that 1999–2000 coincided with the cyclic peak of sunspot activity, which had, over the past 100 years, correlated with periods of exceptionally heavy rainfall.

On this basis, the Mozambican weather services raised the probability of above-average rainfall to 50% in their national forecast and warned that there was a high probability of floods. This was a brave move since, two seasons before, a drought had been predicted which had not materialized, putting the service's credibility in question.

The government took the warning seriously and mobilized accordingly. The disaster committee, which normally meets just four times a year, started to meet fortnightly. In November the committee released a national contingency plan for rains and cyclones during the 1999–2000 season. Provincial and local structures developed their own plans and conducted preparatory exercises. There were

Few boats were available when disaster struck; T. Bolstadt/Panos Pictures

attempts to mobilize resources, but few could be spared, bearing in mind that a disaster was still merely a probability. For example, of 20 boats requested, only 1 had been provided when disaster struck. But over December and January (the main holiday season), leave was cancelled for key officials.

It is uncertain whether the mass media were aware of the flood prediction in the months and weeks immediately before the floods. Links between the media and the weather services were weak or non-existent. There was certainly no media coverage of the risk during this period.

Mozambique's flood warnings and preparations proved to be fully justified when, between January and March, the worst floods in over 100 years affected three major river basins – the Incomati, Limpopo, and Save. The flooding was not the result of a single weather event but rather the cumulative effect of a succession of events. While each event was predicted and monitored with some success, the way in which they interacted was complex and less well foreseen.

As predicted in regional forecasts, there were heavy rains in southern Mozambique and adjacent countries (South Africa, Botswana, Zimbabwe, and Swaziland) between October and December. Around the beginning of February, a cyclone over the Indian Ocean, cyclone Connie, caused further heavy rain in the Maputo area. The Limpopo, Incomati and Umbeluzi rivers were all affected by this time, with water levels at their highest since records began. Three weeks later, cyclone Eline made landfall, moving inland and causing serious flooding of the Save and Buzi rivers in the center of the country, and aggravating the flooding of the Limpopo River, in the south. At the beginning of March a third cyclone out at sea, Gloria, came into the picture, contributing to further record flooding of the Limpopo, Incomati, Save, and Buzi rivers. And finally, cyclone Hudah followed Eline and made landfall in April.

Flood warnings were issued as the flooding escalated. However, warnings were not always accurate, and were not always properly understood or heeded.

The mass media's interest increased as the disaster unfolded. Both national and international media began to report on the floods, with dramatic stories of tragedy, and of heroic rescues.

The magnitude of the floods far exceeded anything in living memory. The towns of Xai-Xai and Chokwe, on the Limpopo, and many other small towns and villages in the same region, were completely inundated and remained under water for about 2 months. The government declared an emergency, mobilized its disaster response mechanisms, and made appeals for assistance from other countries. These were supported by extensive coverage in the international media.

The first external teams arrived on 11 February from South Africa. Coordinated by the National Disaster Management Institute, a combined national and international effort resulted in about 50,000 people being rescued by boat and aircraft. The displaced, numbering some 650,000, were accommodated in temporary centers, and public health measures were put in place which successfully avoided measles and cholera outbreaks.

At least 700 people died as a direct result of the floods. An estimated 350,000 livestock

Areas of the lower Limpopo basin were flooded for the first time in living memory; P-A. Pettersson/Still Pictures

Many were rescued by boat or aircraft; P-A. Pettersson/Still Pictures

also perished, and vast areas of agricultural land were devastated, with soils as well as crops lost. Some 6000 fisherpeople lost 50% of their boats and gear. Schools and hospitals were among the many buildings destroyed. In all, economic damage was estimated at US$3 billion, some 20% of gross domestic product (GDP).

Implications for CRM good practice

An effective flood early warning system depends not only on the technical and institutional capacity to produce a good risk assessment, but also on the communication of that risk to vulnerable groups and to the authorities charged with response. Mozambique's flood early warning system performed reasonably well during the 2000 floods, though some shortcomings were revealed.

For a very poor country, Mozambique's policy and planning for flood events were good. Experience of previous floods had led the government to set up flood management structures at various levels, from central to local, and there was active collaboration between these structures. The magnitude of the floods was overwhelming, and the poverty of the majority of Mozambique's people added to their vulnerability. However, the country's flood planning and preparedness provided the framework for massive international support, and management of the disaster was later judged to have been generally successful.

Climate information was available before and during the floods. Floods were forecast by the national meteorological service. Their magnitude was not anticipated, but this is not surprising, since the floods exceeded all those since records began.

> We had never had a similar event, so whatever results we could have come up with, they would not have predicted it because in the data records there's nothing similar to that. …. The catchments are massive areas so there was a level of uncertainty which we couldn't have taken into account.
>
> Filipe Lucio, Director, National Institute of Meteorology.

Although some stations were washed away by the rising water, generally speaking a great deal of hydrological information was available as the floods progressed, as well as climate data from within and outside the country. However, the river basin authorities and meteorological services lacked the capacity and equipment to carry out short-range real-time modeling and forecasting. This would have facilitated forecasting of the extent and severity of flooding, and hence better targeting of flood warnings to specific areas or villages.

Modeling, supported by ground and satellite data, is a vital input to accurate short-term flood prediction. With the exception of the Limpopo, none of the country's river basins had calibrated models in place. Accurate prediction is in turn a prerequisite not only for the credibility of warnings to the public but also for the faith placed in the early warning system, and hence the resources allocated to it, by politicians.

> It's also important that we have reliable information, that what we say to the politicians is true because otherwise we are putting our necks at risk. We need scientific information – we have to have access to satellite data, we have to have stations working that can provide information that we can analyze and say 'This is what will happen'.
>
> Americo Muianga, former National Director of Water Affairs.

Communications between the different front-line groups proved, for the most part, good. Information and data were shared by telephone, radio, e-mail, and fax. Good relations built prior to the disaster, both within Mozambique and with neighboring countries, formed the basis of both formal and informal communications.

> You need to have very good working relationships with all of your partners. In Mozambique we don't have a problem – if I have to call Muianga at 2 o'clock in the morning I will call him, and I know he is going to answer. If I have to call my minister at 3 in the morning I call him at 3 in the morning, and he picks up the phone.
>
> Filipe Lucio.

However, differing information came from different sources, which caused some confusion. The government relied on government institutions, but NGOs, aid organizations, and others received forecasts from the USA or other global sources. The need for a single voice to provide information to all stakeholder groups was a valuable lesson to emerge from the disaster.

Communication of flood warnings to the general public was still more challenging. The media did not have a defined role, and did not begin to report until the disaster was happening. It seems that the risk was not fully understood by many people, who chose not to leave their homes. Some died as a result, while others had to be rescued as the waters rose.

> We had a problem because some of the people didn't believe us, because they had never seen an event like that. This is the reason that a lot of people died. For instance, Xai-Xai and Chokwe had never flooded in living memory.
>
> Americo Muianga.

Resources – human and financial – were limited both in preparing for floods and in dealing with them. Mozambique was not able to maintain a large corps dedicated to disaster management on stand-by, but instead had to mobilize personnel as and when the situation demanded. Donor agencies did not respond adequately to calls for funding for pre-flood preparation, although substantial post-disaster funding was provided.

Much reflection and analysis was done after the floods of 2000 (Wiles *et al.,* 2005), and as a result some improvements have been made to the flood early warning system and to flood management practices.

The crucial importance of regional cooperation was acknowledged with the approval, in 2005, of a regional water policy. New agreements on the exchange of data on floods and droughts and the coordination of responses across national borders have also been signed with neighboring countries. A regional project is installing 50 new gauging stations in the region's main river basins.

A National Disaster Management Strategic Plan has been drawn up and was adopted in 2006. The plan links the need to reduce the risk of disasters with the national priorities for poverty reduction. It has three main objectives: to reduce the loss of life and property during natural disasters; to consolidate the national culture of disaster prevention; and to introduce specific measures to prevent and mitigate disaster. The plan stresses the need to educate and to take preventive measures, which in turn imply changes in human behavior.

A flood risk analysis has been carried out in Mozambique's major river basins, to identify vulnerable areas and people. This found that 40 out of 126 districts are prone to flooding, and 5.7 million people in these districts are vulnerable. This is a valuable starting point for planning and implementing measures to reduce vulnerability. Following the analysis, some equipment has been upgraded and some new equipment installed, including two new radars and 15 new meteorological stations.

A community-based disaster risk management program has been undertaken in the Buzi District of Sofala Province. The project involved raising awareness of risk and building capacity to reduce vulnerability and to respond to disasters. Communities participated in risk assessment and disaster simulation exercises. Between 2004 and 2006, the province's hydrometeorological network was improved, from 6 to 14 stations and from a 1-month timelag between data collection and analysis to the receipt of data on a daily basis.

In addition, Mozambique now has a tropical cyclone warning system, distinct from the flood early warning system. This informs people of the probable arrival of a tropical cyclone at least 48 hours in advance. As shown in Figure 4, color-coded messages, including flags, are used to warn the population. The strength of the wind expected is related to the possible physical impact. Vulnerable populations are advised on the measures they should take.

Figure 4.
Cyclone early warning system for Mozambique.

Predicting tropical cyclones for Mozambique

Can cyclone prediction be improved so that the impacts of cyclones can be reduced in the future?

Several meteorological offices worldwide issue forecasts for tropical cyclone movements and intensity a few days in advance. The UK Met Office and Météo France's Tropical Cyclone Regional Specialized Meteorological Centre, in La Reunión, both provide such forecasts for southern Africa. In the case of tropical cyclone Eline, the forecasts were quite accurate regarding track and landfall position, and the warnings issued by the Mozambique weather forecast offices were based on them.

Some parts of the world, such as the Atlantic and the western North Pacific, also benefit from statistical seasonal forecasts of tropical cyclone activity. These use meteorological and oceanic data, and historical datasets. Such forecasts are not, however, available for the southwest Indian Ocean, because of limited historical data for this region. Analysis of tropical cyclone seasonal forecasts has shown that they are useful, especially at the shortest lead times. Two groups (IRI and the European Centre for Medium-Range Weather Forecasts) now issue seasonal forecasts of tropical cyclone activity based on dynamic models for various regions of the world, including the South Indian Ocean.

The general atmospheric conditions associated with cyclone landfall in southern Africa can be predicted months in advance, based on the occurrence of La Niña and on sea surface temperatures in the South Indian Ocean (Vitart *et al.*, 2003). Using these indicators, 'hindcast' experiments show that the exceptional conditions of 2000 can be reproduced by climate models. This approach holds some promise for predicting landfall risk in the future. Another promising avenue of research has shown that tropical cyclone formation in the South Indian Ocean is affected by the Madden–Julian oscillation (Bessafi and Wheeler, 2006). This is an atmospheric disturbance that originates in the Indian Ocean and travels eastward. Progress in forecasting the Madden–Julian oscillation could lead to better forecasts of tropical cyclone activity in the region.

Lastly, a number of scientific advances may benefit flood early warning in the future. These include improved capacity for predicting tropical cyclones (see 'Predicting tropical cyclones for Mozambique').

In early 2001, heavy rains again brought floods to Mozambique, this time mainly to the Zambezi River region. Although not comparable in magnitude to the 2000 events, these floods demonstrated some improvements resulting from the previous year's disaster, mainly in response activities. The Mozambican military was ready to assist, using boats donated the previous year. Helicopters were serviced and made ready to fly as flooding was once again forecast.

The mass media are beginning to be recognized as an important route for public information relating to floods and other disasters. Efforts are being made to involve the media in the process of flood prediction and planning, as well as in the dissemination of flood warnings. Radio is the most important of the media for such communication, in particular the local languages network of Radio Mozambique. This service broadcasts regular information about risk reduction, as well as specific warnings as soon as they are issued. A TV studio devoted to weather forecasting is now in use by the National Institute of Meteorology.

But more remains to be done. Americo Muianga, the National Director of Water Affairs in Mozambique during the 2000 floods, summarizes the key points and challenges for effective flood management based on his experiences.

'A balance between structural and non-structural measures is necessary for flood mitigation, i.e. both planning and physical measures. A good contingency plan is a prerequisite.

Strong institutional coordination that makes best use of the information and resources available is important. Effective cooperation at the regional level is also essential – sharing data at the regional level is still a challenge for us.

We must involve vulnerable communities in flood preparation, and educate them about the risks. Appropriate, clear, and timely messages during a flood situation are also vital. Ultimately, Mozambique's long-term challenge is to learn to live with floods.'

Americo Muianga,
former National Director of Water Affairs.

Local radio: an important tool for disseminating flood warnings; E. Tobisch/Still Pictures

Conclusion

This case study has examined CRM good practice aspects of Mozambique's flood management system. An effective early warning system is in place, supported by useful climate and hydrological data, and this is linked to disaster response. A national policy framework supports the system, and this was seen to translate into practice during the floods of 2000.

However, competing development needs in Mozambique limit the resources available for both disaster preparedness and disaster response. The extreme poverty of the majority of Mozambique's people also makes them highly vulnerable to floods and other natural disasters, despite the best efforts of the government to protect them.

Although the mass media are beginning to play a more active part in climate information dissemination, communication problems remain, especially limited connectivity in remote areas lacking electricity and telephones. Making sure that people receive early warnings at the right time, understand them, and have the capacity to act on them appropriately remains a substantial challenge, shared by the media and the authorities.

N.Behring/UNHCR

Food security in Ethiopia

Background

The famine in Ethiopia in 1983–84, and its unprecedented media coverage, alerted the world to the harsh realities of food insecurity in sub-Saharan Africa. An estimated 1 million people died, and many more suffered malnutrition and disease. The causes were complex: Ethiopia is prone to drought, but the resulting famine and deaths were also a consequence of policy failures on all fronts. Ethiopian economic policy failed, research and development efforts had been inadequate, Western countries did not respond early enough to the gathering crisis, and ongoing civil war in the north of the country added to inability to deal with the disaster as it escalated. But lessons were learned from the tragedy.

Twenty years on, Ethiopia is much better prepared for drought. The country has developed an early warning system, coupled to response mechanisms, that has been shown to be effective: in 2003 more than 13 million Ethiopians were affected by drought, but a major famine was avoided.

Around 75% of Ethiopia's 74 million people are dependent on agriculture, which is almost entirely rainfed and small scale; coffee, and more recently flowers, are the only major commercial crops. A further 10% earn their living entirely from livestock. Both farmers and pastoralists are highly dependent on the climate for their livelihoods; this is reflected in the remarkable way that GDP fluctuations follow rainfall (Figure 5).

Ethiopia's traditional smallholder agriculture is almost entirely rainfed; S. Chater/Green Ink

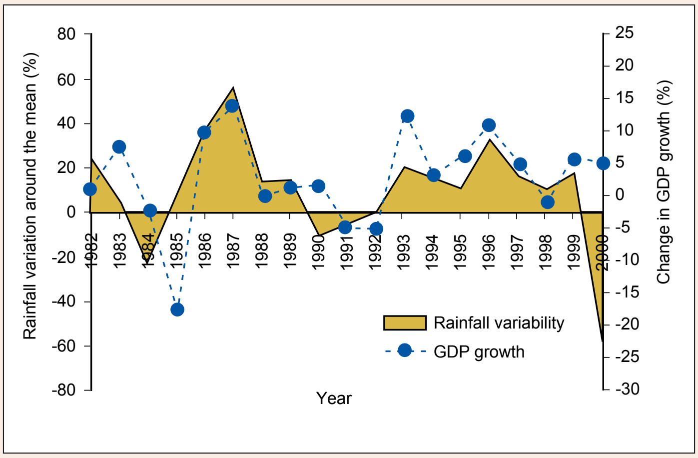


Figure 5.
Rainfall and GDP in Ethiopia. Source: World Bank (2006).

Ethiopia has a diverse climate, both spatially and temporally. Within the main crop-producing regions, annual rains are expected in two seasons. The short rains usually fall between February and May, then, after a short dry interlude, the main rains normally arrive around June and last until September. During the short rains, land is ploughed and short-cycle crops are planted – these account for some 7–10% of national crop production, though locally they may be much more important. If the short rains set in well and do not peter out, this is also a potential sowing time for the country's main food crops, the longer maturing cereals such as maize, sorghum, and pearl millet, which will be harvested in October–December. More often, however, these crops are sown at the outset of the long rains, in June. As well as being important for land preparation, the short rains are vital for the coffee crop, which flowers during this period, and for regeneration of the pastures used to feed livestock. Thus failure of the short rains can have serious impacts on food security, affecting food crops, cash crops, and livestock. The consequences become even more serious when the long rains also fail or are greatly reduced.

The east and north of the country are the most vulnerable to drought and have the highest food insecurity (Figure 6). The west generally receives more reliable rains. But even when the rains fall as expected, Ethiopia is unable to meet its food needs. Since the mid-1970s the country has had to rely on food aid almost every year to feed a proportion of its people (Figure 7).

Ethiopia's characteristically variable climate presents a significant challenge to its people. Poverty, compounded by other factors

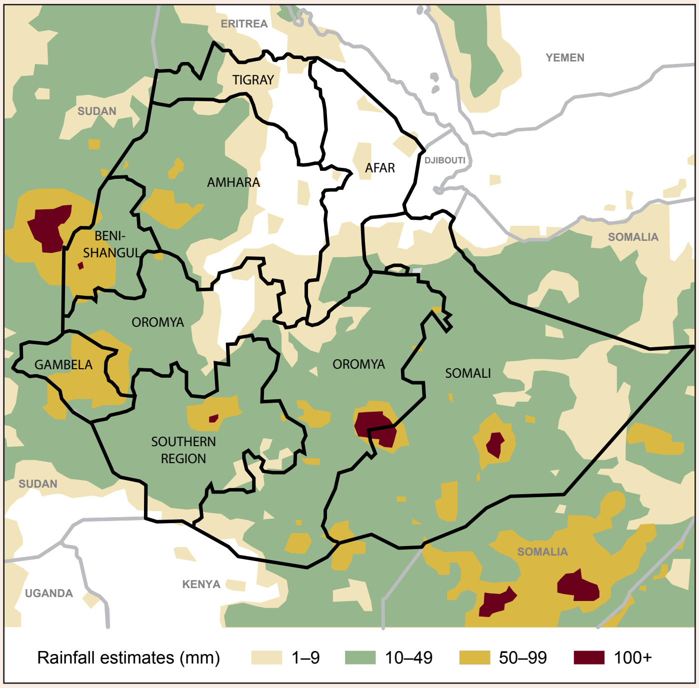


Figure 6.
Ethiopia and its rainfall. Source: Famine Early Warning Systems Network (www.fews.net/centers)

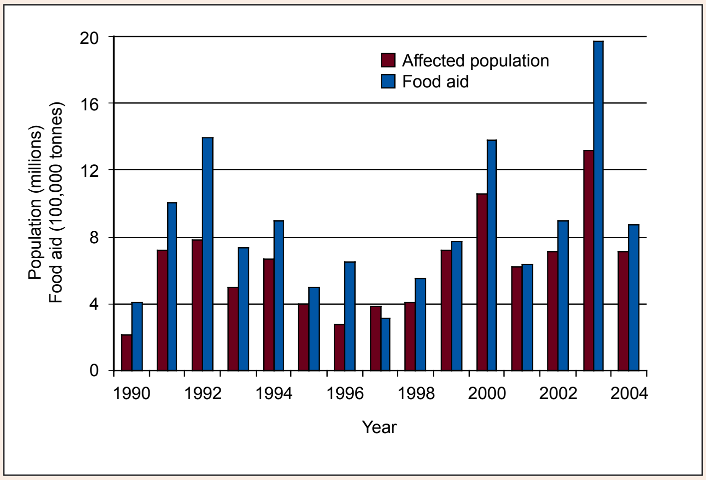


Figure 7.
Population affected by food insecurity and amount of food aid in Ethiopia, 1990–2004. Source: Early Warning Department. Disaster Prevention and Preparedness Agency.

Food aid in Ethiopia is complemented by government 'safety nets'; C. Palm/IRI

including high population density, environmental degradation, and conflict, increases people's vulnerability to drought, leading to food insecurity.

To tackle food insecurity, the Ethiopian government has identified two groups: those who are chronically food insecure, i.e. the very poor, who have very limited livelihood options even in good climate conditions; and those who are normally food secure but who may become food insecure when climate conditions deteriorate. The problems of these groups are tackled in ways that are similar but differ in emphasis. For the chronically food insecure, the government has set up a 'safety net program', which aims to build the resource base of households, increasing employment and income in addition to providing food aid over the short term. Voluntary resettlement to more productive areas is also offered to this group. These approaches aim to reduce vulnerability while also reducing dependence on food aid. The problems of those who are temporarily (or acutely) food insecure are met through the short-term supply of food and other emergency items, with further support being provided through the safety net program according to need. The two groups are not necessarily distinct on the ground, since there is a flow of people between them.

Policy and planning for drought management

Drought is the most important climate-related disaster in Ethiopia, although floods and fires also happen periodically. Serious droughts killed many people and animals in 1957–58, 1964–65, 1972–73 and 1983–84.

To tackle such disasters, the government set up the Relief and Rehabilitation Commission in 1976. In 1995 it launched a Policy on Disaster Prevention, Preparedness and Mitigation, marking a shift in strategy from pure relief provision to the reduction of drought impact. The policy's aim is to provide relief provision when needed and to reduce vulnerability in the longer term by linking relief to development. The Relief and Rehabilitation Commission was renamed the Disaster Prevention and Preparedness Commission, and is now the Disaster Prevention and Preparedness Agency. The agency is under the Ministry of Agriculture and Rural Development, which is headed by the Deputy Prime Minister, reflecting the seriousness of the issues it addresses and the recognized close links between natural disasters and agriculture.

The Disaster Prevention and Preparedness Agency divides its activities into three main areas: disaster prevention, preparedness, and response. Prevention measures aim to tackle the root causes of people's vulnerability, improving their ability to manage periods of difficulty. Response activities take place during an emergency, and include the provision of food, water, shelter, and medical services. Preparedness activities aim both to reduce the impacts of disasters and to allow the response to be more effective. This is where climate information plays an important part, within the national Early Warning System. Other

The World Food Programme partners with Ethiopia's national effort in disaster prevention, preparedness, and response; C Palm/IRI elements of the preparedness strategy are the Emergency Food Security Reserve, the Disaster Prevention and Preparedness Fund, and the Logistics Department.

The early warning system

Appreciation of the value of early warning is not new in Ethiopia – the country's first early warning system was set up in 1976 following the famine of 1973–74. Over the years the system has evolved and improved, so that today it is a complex information management system that gathers data from multiple sources and provides information to a large number of users. The main objective of early warning and response is to act before people's livelihoods are destroyed. Recovery is much easier if people can be supported sufficiently to stay on their land and keep what assets they have left.

There are early warning committees at all levels of the government, down to district level. At each level information is gathered and reported to higher levels.

The National Meteorological Agency plays a crucial role in the early warning system. It collects and analyzes climate data, produces forecasts, and disseminates information to various user groups in the form of regular bulletins. Data are collected at about 100 of the 600 or so weather stations across Ethiopia, and forwarded to the agency's central office for analysis. Satellite data are also used.

Keeping people on the land is a major objective of the early warning and response system; D.Telemans/Panos Pictures

The information released by the meteorological service includes daily weather reports, 10-day weather summaries and 10-day forecasts, monthly weather summaries and 1-month forecasts, and three seasonal forecasts a year covering the two rainy seasons and the dry season. The service also provides rainfall maps showing rainfall received as a percentage of normal rainfall, vegetation conditions, and impacts on crop and livestock production.

Bulletins are disseminated through the Post Office, the websites of the meteorological service and the WMO (http://www.ethiomet.gov.et and http://www.wamis.org respectively), and through the mass media. There is no formal arrangement between the media and the early warning process, but many of Ethiopia's media are government run and are therefore available for the dissemination of public information. Radio and TV stations provide daily weather information and a weekly summary. The newspapers also carry weather information. These communication efforts target users in government offices, UN organizations, donor agencies, and NGOs, as well as the general public.

The Early Warning Department of the Disaster Prevention and Preparedness Agency carries out regular assessments of various food security indicators, and prepares and delivers reports to the government, NGOs, and the international community so that all are informed of impending problems. Specifically, the following main activities are undertaken:

- Regular monitoring of climate, crops, livestock, and markets, as well as the food security situation. Monthly reports are produced and disseminated.
- Two emergency needs assessments are carried out each year in November (the end of the main crop harvest and the end of the second rainy season in the pastoral areas) and June (the end of the short-season harvest and the end of the main rainy season in the pastoral areas). These build on the regular food security monitoring but also gather more details at the household level, for example on coping capacity. These assessments give early indications of any assistance that may be needed, and are also used in planning and decision making, to prepare appeals for aid, and to assist resource allocation later in the season or during an emergency.
- Rapid assessments of disaster areas are carried out as needed (on average there are 10–15 a year). These quantify an identified problem – its severity, the number of people affected, and the need for and type of assistance. At the same time, a nutrition assessment is carried out in order to set priorities for food relief.

The 2002 drought

The forecast for the short rainy season in 2002 was a high probability of normal rainfall in the crop-growing regions. But as the season progressed, it became clear that this would not materialize. Rainfall in February was far below normal; in March it improved, but in April and May it was again below normal.

Regular monitoring under the early warning system began to indicate problems with the short-season crops, as well as potential failure of the long-cycle food crops. A rapid assessment in June confirmed a bleak outlook. The harvest of short-season crops was very poor, long-cycle crops were severely compromised, and a serious food shortage was looking likely for 2003.

Around this time, it was confirmed that an El Niño event was occurring, with its associated impacts on global climate. In Ethiopia this was known to be associated with lower rainfall in the long rainy season. Forecasts for the long rainy season were therefore for the drought to intensify.

Wheels were set in motion. The Disaster Prevention and Preparedness Committee began to meet regularly and plan for possible disaster in 2003. Funds were released to buy seed of short-cycle crops that could be grown during the long rainy season, to replace the failed long-cycle crops. The seed was distributed to farmers.

The rains in June and July were also poor, as had been predicted. They improved in August, but it was too late to save most of the crops.

The Early Warning Working Group organized a mid-season rapid assessment in August, and prepared a contingency plan based on this. This gave projections of affected population, food and income shortfalls, numbers needing food assistance, and food need for both the first 3 months of 2003 and the whole of the year. A multi-agency assessment was also carried out and forecast food requirements for 2003 under three different scenarios (Table 2).

Based on these assessments, an appeal was made in September for external aid. A second multi-agency assessment was carried out in November to establish the final harvest and determine actual emergency needs in 2003. This assessment showed that the situation approximated the worst case scenario.

An intensive public awareness campaign was launched by the Disaster Prevention

Table 2. Forecast food requirements for Ethiopia for 2003 under three scenarios.

Scenario	No. needing food aid	Food requirement (tonnes)
Best case	6.8 million	936,534
Mid case	10.2 million	1,475,862
Worst case	14.3 million	2,176,624

and Preparedness Agency. The media were actively involved. Field visits to the affected areas were arranged for representatives of humanitarian organizations and international development agencies, accompanied by national and international journalists. The President of Ethiopia went on television in November to address the nation about the impending disaster. Meanwhile, monitoring of the situation continued, with information from weather stations and from the field regularly informing the disaster response.

Food shortages reached their peak in April 2003, but the prompt response of the government had paid off. As a result of careful planning and well targeted international and national assistance, food relief was available when and where it was needed.

CRM good practice and challenges

Ethiopia has responded to the challenges of its climate with an early warning system that enables mitigation measures to be put in place before drought-related disaster strikes. Early warning helps the country and international donors to assess the need for emergency relief and to be prepared to deliver when it is needed. The effectiveness of the system was demonstrated in 2003.

The system functions well, but improvements could nonetheless be made. Both the quantity and the quality of data available from the meteorological service are limited. And shortage of trained personnel is another constraint. These problems can be addressed relatively easily.

There are not enough stations collecting local data, and the ones that do exist are often situated along the main roads or in towns. Thus more weather stations are needed, in particular to cover the more remote areas that are currently neglected, but also generally, to capture the full range of localized climates across the country. Increased use of satellite data could compensate for limited ground data to some extent, and also improve their usefulness (see 'Making the most of data'). In parallel with these improvements, more skilled staff are needed, trained in data collection and analysis.

Strengthened capacity for analysis at the district level would greatly improve the performance of the meteorological service and the usefulness of its information. The current centralized analysis and resulting forecasts provide a general view of climate in the country. But given Ethiopia's diverse local climates, this general information is not adequate for detailed planning by users.

Communications – both within the meteorological service and between the service and its users – are currently poor. Within the service, this is mainly a matter of upgrading communication equipment. Improving links with users is more of a challenge, and requires a re-evaluation of user groups. At present the system mainly targets other government departments, development agencies,

Making the most of data

Climate data from developing countries are often limited, in terms of both quantity and quality.

The number of stations collecting climate data is generally inadequate in African countries, and stations are often unevenly distributed, as in Ethiopia. The data therefore cannot fully reflect the range of climates across the country, and averages, in particular, will not have much meaning. A further complication is that national meteorological services are often reluctant to 'give away' their data. They may only release data from a small number of stations, which limits their usefulness for national, regional, and global applications.

New techniques are available that can help overcome these limitations. And concerted local and international efforts are under way to make climate data more available and more useful.

Rescuing data

Many African countries hold historical data in diverse locations and in a variety of formats that, if 'rescued' (i.e. collected and archived electronically in a uniform format), could be very useful. For example, analysis of rescued historical data can provide evidence of trends in climate to support today's forecasting needs. It could also allow assessment of the relationships between climate and different social or environmental outcomes, and could also help to validate theoretical links hypothesized from climate modeling experiments.

In Ethiopia, for example, rescue and analysis of historical data recently confirmed the relationship between El Niño and reduced rainfall in the June–September rainy season. In a combined effort by the Ethiopian meteorological service and IRI, data were obtained from 200 of the country's weather stations. Of these, 78 had mostly complete records for 1960–2005 for the June–September rainy season, and 55 of these had data of high enough quality from 1971 to 2005 to be used in the analysis. A general pattern of below-normal summer rainfall across Ethiopia's highlands was found to be clearly associated with El Niño conditions, while above-normal rainfall was associated with La Niña conditions. These results will support future forecasting in El Niño and La Niña years.

Blending gauge and satellite data

Another solution to the lack of rain gauge data is to compensate by blending what is available with satellite data. Satellites can provide estimates of rainfall for large areas, including those that are remote and inaccessible, and gauge data are then used to calibrate these estimates. A method known as gridding is used to interpolate gauge data to regularly spaced points across the country. The interpolated data are correlated with the satellite data and adjusted accordingly.

Clearly, the more gauge data that are available, the more accurate the results will be. Restricted data availability is often due to limited data being released by the national meteorological service. Ethiopia, for example, currently releases data from about 19 primary stations through the Global Telecommunication System. Yet the country has more than 100 operational stations reporting regularly. The quality of data from some of these stations may not be as good as from the 19 primary stations, but their inclusion would nevertheless substantially enhance the quality of the satellite data.

Data gridding and blending are likely to be most effective if done by the national meteorological service, with external expert help as needed. This could overcome the problem of data access: the national service has access to all available data, can use them in the gridding and blending exercise, and should be less reluctant to share these gridded and blended data. Another advantage is that the gridded gauge data and the gauge-adjusted satellite data can be prepared in a format that is easier to import into geographical information systems (GIS), where they can easily be combined with other data that further enhance their usefulness. The blending technique has application both for current and for historical satellite and gauge data.

The role of the media in relation to drought is changing; S. Sprague/Panos Pictures

> The local media would wait for a BBC report to say there is famine, then local papers would pick it up. But by the time the BBC or CNN came in to report a drought, many people would have died. In recent years that's no longer the case. The media have started reporting there is likelihood of a drought…Then [1984 drought], where would the media go to get such information? The little information they had was about the weather tomorrow: it will rain or not rain. But now this information is fed to the media well in time, so people can plan. So instead of having people dying before assistance is coming in, assistance is coming in well before the drought even starts.
>
> Patrick Luganda, journalist, Uganda.

NGOs, and similar groups; and it reaches these groups effectively, as evidenced by the successful response in 2002–03. However, the largest, and arguably the most important, user groups – farmers and pastoralists – are being neglected. A concerted effort to reach these groups more directly, with timely and useful information as well as related advice, could bring huge benefits.

The role of the media in reporting on droughts and disasters has changed in recent years. During the drought of the early 1980s, the national media were constrained in their reporting, as they were under a more restrictive government regime than today. Also, there were few links with the meteorological service, and information was not easily available to them. They played almost no part in publicizing the drought and its impact on the country. The international media did report on the drought when it reached the scale of a disaster, and with great effect: the general

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The early warning system is a food security-focused or relief-focused system. It is designed to monitor the performance of crops throughout the growing season and to apply for food aid depending on that performance. And it is okay for that specific purpose. But it would be more beneficial if it were delivered directly to the individual farmer. It would be useful if it could influence the decisions of the farmers. It would be more beneficial if we were able to advise the farmer on what to do based on a given climate situation. For example, if we know that the short rains are not going to be good, then we should be able to advise the farmer to look for other alternatives instead of long-maturing crops like maize or sorghum. We need to have a mechanism whereby the farmer is informed about a coming weather problem and what he could do to minimize the effects.

Farmers do always try to adjust to variations in rainfall patterns. They replant their land, sometimes more than once, whenever rain fails during the season. But they may not be doing this at the right time or with the right crop. They lack appropriate information and advice. But if they are given the right information and appropriate advice they can definitely make use of it. It would be more useful if the early warning information were integrated with the extension program.

Birhane Gizaw,
Director of the Federal Food Security Coordination Bureau.

Reaching farmers and pastoralists more directly with climate information could benefit development as well as relief efforts; C. Palm/IRI

public in Western countries were quickly made aware of the crisis, and both they and their governments responded generously.

Ethiopia is one of two African countries that has piloted these approaches at both national and farm levels – work that will complement the progress made in developing an effective early warning system.

Conclusion

Ethiopia is seeking to reduce the numbers of people vulnerable to both chronic and acute food insecurity, through a variety of approaches. Development efforts aim to lift the poorest out of long-term reliance on food relief, by strengthening their livelihood options. These efforts are complemented by the country's early warning system, which has made considerable progress since the dark days of 1983–1984. It is important that the country build on this progress to improve the system still further, since droughts are a recurring feature of Ethiopia's climate and are likely to continue and intensify as global warming takes hold.

Today, both the national and the international media play a wider role in providing public information ahead of a potential disaster. The national and local media in particular have an expanded role, though it needs to be strengthened further. The challenge of conveying useful messages in local languages to the millions of rural people with climate-sensitive livelihoods in Ethiopia can only be solved through imaginative use of local media.

At the moment, the early warning system mainly functions to ensure that sufficient external food aid reaches the country. It could play a much more useful role if it could also reach farmers and pastoralists more directly, with timely advice on specific problems as well as general information. This implies tailoring climate information to specific local needs, and would require greater involvement of agricultural sector specialists than is currently the case.

Malaria control in southern Africa

Background

Malaria is a huge burden in sub-Saharan Africa, causing between 1 and 3 million deaths each year as well as debilitating millions of others. It is a major impediment to development on the continent (Sachs and Malaney, 2002). The disease is caused by a parasite, *Plasmodium*, which is transmitted to people by mosquitoes. It is endemic throughout large regions of sub-Saharan Africa. In these endemic regions, conditions, including climate, are favorable for malaria transmission. At the geographical margins of these regions, there are areas where conditions are normally not favorable and malaria seldom occurs. However, from time to time conditions change briefly, and malaria becomes a threat, in the form of an epidemic. The changes are usually in climate conditions, and typically involve higher than normal rainfall in desert fringes (where it is normally too dry for malaria) and higher than normal temperatures in highland fringes (where it is normally too cool). Areas in Africa at risk of epidemic malaria are shown in Figure 8.

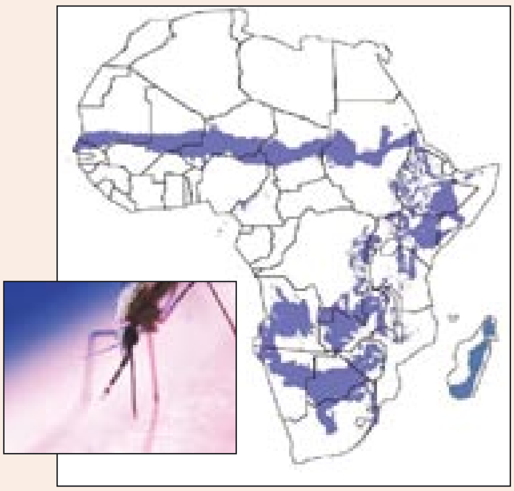


Figure 8.
Areas at risk of epidemic malaria in Africa. Source: Adapted from WHO/UNICEF (2003). Photo inset: Female Anopheles gambiae; WHO/TDR/Stammers

Although endemic malaria is the major burden in sub-Saharan Africa, especially for children under 5 and pregnant women, epidemic malaria is also a significant problem (Worrall *et al.*, 2004). An estimated 124 million Africans live in areas prone to epidemics, which cause between 12% and 15% of all malaria deaths. Because they are rarely exposed to the disease, people living outside endemic regions have low or no immunity, and all age groups are vulnerable. When an epidemic occurs, health services in these areas can easily be overwhelmed.

Importantly, and rarely appreciated, endemic and epidemic malaria need different approaches to their control and prevention. Endemic malaria needs ongoing routine measures, whereas the control of epidemic malaria relies on measures being applied in the right place at the right time. This is particularly important where resources to tackle the disease are limited.

Partners in the Roll Back Malaria initiative (see below) have developed a new epidemic malaria early warning and response approach that includes seasonal forecasts and climate monitoring as well as vulnerability assessments, case surveillance, and response planning (Figure 9). It is currently in experimental use in several epidemic-prone countries in southern Africa. This case study examines experience so far with this approach, which also holds promise for use beyond Africa, in malarial areas of Asia and Latin America.

Climate and malaria

Rainfall, temperature, and humidity are the three climate variables that most influence malaria transmission. High rainfall tends to increase the number of mosquitoes, because more surface water breeding sites become available. It also leads to increased atmospheric humidity, which supports mosquito survival. Relative humidity generally needs to be above 60% for mosquito survival and malaria transmission. Temperature affects the development of both the mosquito and the *Plasmodium* parasite. Under warmer conditions mosquitoes develop faster, and the parasite also multiplies more rapidly.

In endemic regions these three variables are regularly within the range for malaria transmission, while in epidemic-prone areas at least one of the variables normally falls outside the range. Epidemics occur when that variable temporarily changes to favor malaria transmission. This knowledge has been exploited to develop tools that can be used to predict areas that might expect malaria epidemics (see 'Climate information tools for malaria control').

Recent research using historical rainfall data and malaria incidence figures from Botswana has linked higher rainfall totals with increased malaria incidence several weeks later (Thomson *et al.*, 2005). Malaria transmission is complex, being influenced by other factors besides climate, but when trends

Rain increases mosquito breeding sites; W. Dolder/Still Pictures

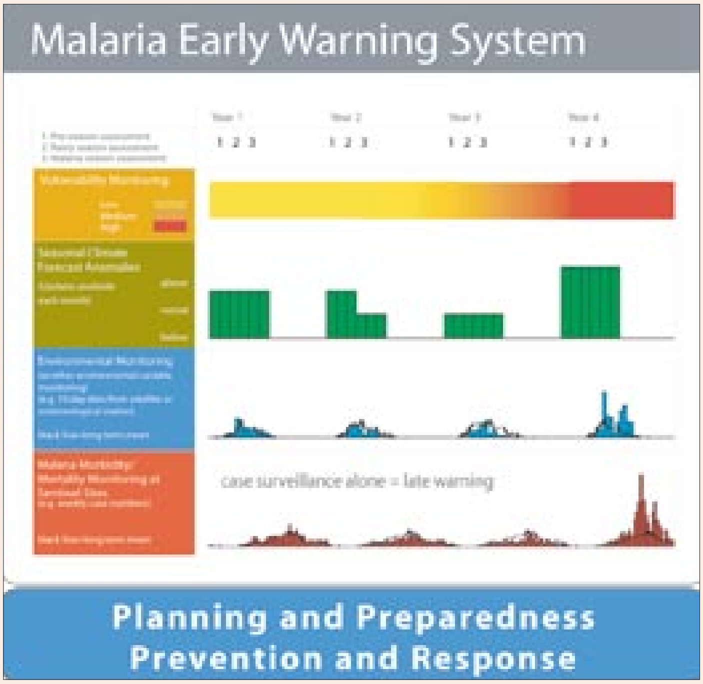


Figure 9. Malaria early warning system framework. Source: Adapted from WHO (2004).

in non-climate factors were quantified and accounted for, rainfall variability was found to explain more than two-thirds of the variability in incidence. This means that rainfall monitoring can give several weeks advance warning of possible epidemics; but the same research went further, linking malaria incidence with sea surface temperatures, which affect continental rainfall and are used for seasonal forecasting. Subsequent analysis confirmed that seasonal forecasts can provide useful indications of the likelihood of an epidemic several months in advance (Thomson *et al.*, 2006).

The policy context

The New Global Malaria Strategy, developed by the World Health Organization (WHO) and adopted by the community of affected nations in 1992, recognizes that malaria control cannot be achieved by a single quick-fix solution, but requires a range of interventions (WHO and UNICEF, 2003). The four basic technical elements of the strategy are:

- Provide early diagnosis and prompt treatment
- Plan and implement selective and sustainable preventative measures, including vector control

Climate information tools for malaria control

The IRI's Climate and Malaria Resource Room (http://iridl.ldeo.columbia.edu/maproom/.Health/.Regional/.Africa/.Malaria/) contains products that illustrate the historical and modeled occurrence of climate conditions that favor malaria transmission in Africa, as well as dynamic products that monitor some of these conditions (e.g. rainfall) for epidemic early warning purposes.

Tools for endemic malaria

In the absence of adequate epidemiological data on the distribution of malaria in Africa, climate information has long been used to develop malaria risk maps that illustrate climatic suitability for endemic transmission.

For example, the Seasonal Climatic Suitability for Malaria Transmission (CSMT) tool (see Figure 10) is an interactive map that displays the number of months during the year when climatological conditions are considered suitable for malaria transmission. Suitability is based on empirically derived thresholds of monthly precipitation, temperature, and relative humidity (i.e. precipitation at least 80 mm, mean temperature between 18 and 32°C and mean relative humidity at least 60%).

The distribution model of climatic suitability for malaria transmission developed by the Pan-African Mapping Malaria Risk in Africa (MARA) Collaboration is also included in the Climate and Malaria Resource Room. Like the CSMT, it is not based on actual malaria data but on long-term climatological averages, and therefore provides insight into the potential for transmission across the continent during the average year. Both tools are compatible with the WHO HealthMapper tool, which makes them easily accessible by health experts.

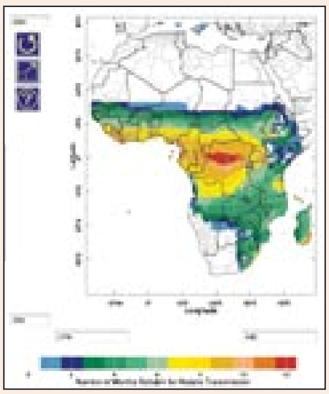
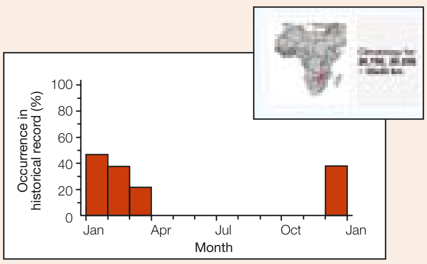


Figure 10.
Interactive map showing seasonal climatic suitability for malaria transmission.
Users can gain insight on where, when and for how long the combination of climatic conditions may be suitable for malaria transmission in the Africa continent, by clicking on the map at the location of interest.



Tools for epidemic malaria

A set of tools has been developed to assist the malaria control community in monitoring rainfall and related environmental conditions in epidemic-prone areas. All of these tools are automatically updated when new data become available (approximately every 10–16 days).

The Malaria Early Warning and Response System (MEWS) interface facilitates understanding of the current rainy season by providing a seasonal and historical context. It displays the most recent decadal rainfall estimates and generates time-series graphs based on user-specified parameters, which provide an analysis of recent rainfall compared to that of recent seasons and the short-term historical average.

Two additional maps provide a spatial context to the temporal analyses generated by the MEWS interface. The rainfall estimate differences map displays the difference between the most recent decadal rainfall estimates and the same short-term historical average utilized in MEWS. The second map, rainfall estimate percentages, illustrates the most recent decadal rainfall estimates as percentages of the short-term average.

Vegetation information has also proven useful in understanding recent rainfall. The resource room therefore includes various vegetation analysis tools, including high spatial resolution (250 m) TERRA-MODIS images and interactive tools that analyze the Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI). These tools currently focus on epidemic-prone areas of western and eastern Africa, in addition to Madagascar, but will soon be extended to cover additional areas of Africa.

Epidemics can be prevented by spraying potential breeding sites; G. Pirozzi/Panos Pictures

- Detect early, contain, or prevent epidemics
- Strengthen local capacities in strategic and applied research to permit and promote the regular assessment of a country's malaria situation, in particular the ecological, social, and economic determinants of the disease.

Various initiatives have targeted malaria in Africa. In 1996 an Accelerated Strategy for Malaria Control in the Africa Region was approved by the WHO, and in 1997 the Meeting of Heads of State of the Organisation of African Unity (OAU) made a declaration on malaria control. In 1998 the

WHO, the United Nations Development Programme (UNDP), the United Nations Children's Fund (UNICEF), and the World Bank launched the Roll Back Malaria Global Partnership, which now has more than 90 partners. Roll Back Malaria aims to identify stakeholders, consolidate research, and deliver concerted support to malaria control through the development of stronger national and regional health systems. It aims to elicit more commitment from the private sector in a drive for new control tools through its Medicines for Malaria Venture; through the Malaria Vaccine Fund; and through the Global Fund for AIDS, TB and Malaria. African Heads of State endorsed the Roll Back Malaria initiative in the Abuja Declaration of 2000.

Under the Abuja targets for the Roll Back Malaria initiative in Africa, national malaria control services are expected to detect 60% of malaria epidemics within 2 weeks of onset, and to respond to 60% of epidemics within 2 weeks of their detection. To do this, they need good information on where and when epidemics are most likely to occur – in other words, an effective early warning system.

The Malaria Early Warning and Response System

The new Malaria Early Warning and Response System (MEWS) has been developed by the partners of the Roll Back Malaria initiative, including national ministries of health. It has five components.

- *Vulnerability assessment and monitoring.* Knowledge of vulnerable populations and areas helps control services plan their response ahead of an epidemic. Factors that increase vulnerability include co-infection with other diseases, malnutrition, resistance to anti-malarial drugs, and population migration, whereby non-

Migrants can be particularly vulnerable to malaria; B.Bannon/UNHCR immune people move into endemic areas or 'parasite carriers' move into epidemic-prone areas.

- *Seasonal climate forecasting.* Given the established link between climate and malaria incidence, reliable forecasting can help predict epidemics. Seasonal climate forecasts can give several months lead time, allowing effective control and other measures to be put in place.
- *Environmental monitoring.* This also gives advance warning of possible epidemics, but with a shorter lead time of 1–3 months. Rainfall, temperature, and humidity are monitored, together with vegetation status and flooding.
- *Sentinel case surveillance.* A surveillance system that quickly detects a rise in malaria cases, i.e. the beginning of an epidemic, is crucial.
- *Planning, preparedness, and response.* The four components above allow planning and preparedness for epidemics, so that response activities can be implemented in the right place at the right time.

The MEWS has been introduced over the past few years in southern African countries with epidemic-prone areas, including Botswana, Madagascar, Mozambique, Namibia, South Africa, Swaziland, and Zimbabwe. Botswana has provided a particularly useful testing ground (WHO, 2004). Straddling the southern margins of Africa's malaria transmission zone, Botswana has extensive epidemic-prone areas. The country also has a stable government and a relatively well resourced health service with a long history of malaria control efforts. Thus, given early warning of malaria epidemics, Botswana has the capability to respond effectively.

Botswana carries out routine vulnerability monitoring. For example, the authorities conduct regular assessments of drug efficacy at key sites, and of mosquito susceptibility to insecticides. They are also kept informed on drought status and food security in the epidemic-prone areas. Furthermore, extra vigilance is applied among groups suffering from other diseases such as HIV/AIDS and TB.

Seasonal forecasts are a new development for the MEWS and could prove very useful for planning and preparedness, providing lead times of several months. The annual SARCOF meeting in September provides the starting point in southern Africa, but a demand for more tailored information led to the setting-up, in 2004, of a second annual regional meeting, the Southern Africa Regional Epidemic Outlook Forum (also called the Malaria Outlook Forum, or MALOF). The MALOF provides the opportunity for malaria control services to review the regional climate forecasts, examine vulnerability factors, map vulnerable areas, and, based on these, develop action plans for epidemic preparedness over the coming season. Held in November, the MALOF occurs at the optimal time for seasonal forecast skill in southern Africa. The forum also promotes relevant advances in science, such as new computer-based tools for the application of climate forecasting to malaria epidemic prediction.

> In order for the needs of the health community to be best served, it is absolutely crucial for the climate services to have both high-quality science-based products and operational timeliness.
>
> Stephen Connor, IRI.

As the season progresses, environmental monitoring is carried out at the country level. The two main sources of information are satellite-derived data and data from ground measurements at meteorological stations. In Botswana, these services are adequately funded and provide reliable and timely data; other African countries may have less well resourced meteorological services, limiting the real-time use of ground station data.

The WHO's Southern Africa Inter-Country Malaria Control Programme also provides regular regional and country-specific information throughout the year. The program interacts with national malaria control programs every 10 days, providing 10-day rainfall estimates and helping to review the current malaria situation based on these and on surveillance in the country concerned. The WHO program also puts out regular bulletins containing information such as epidemic risk maps and country malaria trends as well as rainfall estimates. After the malaria season is over, 'post-mortem' bulletins give details of epidemics and country activities to control them, and reflect on successes and failures during the season, including lessons learned.

Case surveillance is also vital. Again, Botswana is exemplary, with three levels of alert linked to increasing numbers of cases (thresholds) per week. The three thresholds each have distinct predetermined actions associated with them, eliminating confusion about what to do when an alert arises. For example, a threshold of 600 unconfirmed cases per week triggers Action 1, which is to deploy extra medical staff to the area. A threshold of 800 unconfirmed cases per week triggers Action 2, which is to deploy mobile treatment teams. When a threshold of 3000 unconfirmed cases per week is passed, the area is declared a disaster area – and a disaster response plan is put into action.

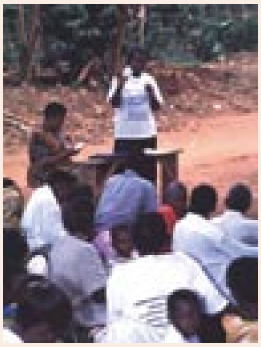
Medicines may need to be made available quickly in epidemic areas; A. Crump/WHO-TDR

Community engagement in epidemic malaria control


A. Crump/WHO-TDR

Current malaria control strategies rely mostly on individuals and communities taking action themselves to reduce mosquito breeding sites, hang and sleep under bed-nets, welcome spray teams, and treat symptoms of malaria with anti-malarial drugs, either at home or in nearby health facilities. These strategies will succeed only when communities understand the causes of malaria and how to prevent and treat the disease – and are persuaded to act on this information. This means that communication on these subjects is vital.

In epidemic-prone areas, communities, including local health staff, are often unfamiliar with malarial symptoms, which may occur only once every 10 years or so. In these areas communicating epidemic risk promptly, identifying malaria when it occurs, and defining and enacting appropriate response strategies are even more vital if many lives are not to be lost. Decentralization of health services has been the mantra of health provision since the 1980s, but it is a huge challenge to the control of epidemics where rapid responses are required with resources that are often not available at the community level.


A. Crump/WHO-TDR

With a functional early warning system in place, epidemic-prone countries can plan their response to malaria epidemics. In Botswana, if an epidemic looks likely ahead of the malaria season, emergency containers are prepared that hold mobile treatment centers and necessary medical supplies. These can be quickly transported to epidemic areas if needed. As the season progresses, environmental monitoring narrows down the areas under immediate threat, so that control activities such as insecticide spraying and community awareness raising can be better targeted (see 'Community engagement in epidemic malaria control'). If surveillance indicates the beginnings of an outbreak, measures such as mobilizing the emergency treatment centers and additional health workers are implemented.

The 2005–06 malaria season

The September 2005 SARCOF meeting predicted above-normal rainfall for much of southern Africa ahead of the malaria season. The MALOF meeting in November that year assessed vulnerability to malaria outbreaks based on an updated rainfall forecast. Most countries had had poor rains for the previous three seasons, so the forecast indicated a high probability of malaria epidemics in epidemic-prone areas.

The rainfall proved to be both higher than normal and prolonged. The WHO Inter-Country Malaria Control Programme's first bulletin of 2006 reported that 'malaria epidemics and incidence increase can be expected during the months of April and May. There is an increased relative risk of malaria epidemics in Botswana, Namibia and highlands of Madagascar, Mozambique, Zambia, and Zimbabwe'.

Malaria outbreaks were subsequently reported in Botswana, Madagascar, Namibia, South Africa, and Zimbabwe. Zambia also reported a flood-related increase in malaria incidence that triggered an emergency situation.

The WHO Inter-Country Programme's post-mortem bulletin reported on the countries' responses. Below are some excerpts:

Namibia: Preparedness for the season was much better this year when compared to the previous season. Most malaria prevention activities were timely [sic] undertaken and reached satisfactory coverages. However, due to prevailing risk factors and vulnerability, malaria epidemics still occurred in certain areas of the country and they were responded to properly.

South Africa: In the current season epidemics were only reported in Limpopo Province in the months of December and January… Extensive health education was undertaken, targeting communities at risk. The media were also used extensively in getting the message out to communities at risk

Bed-nets are widely promoted for malaria control; they are especially effective when treated with insecticide ; USAID and surveillance was strengthened with daily updates until the outbreak was brought under control.

Zimbabwe: Some districts faced shortage of staff and some logistical problems... Epidemic investigation and reaction to localized outbreaks was not conducted timely [sic] due to lack of fuel for vehicles. Quality control of spraying activities was also problematic due to transport problems in some parts of the country.

Botswana: Malaria epidemics in Okavango region were related to increased rainfall in the Okavango Delta. Indoor residual spraying coverage was 60% and insecticide-treated nets were distributed in response.... There has been a downward trend in malaria incidence in the country for the past 5 years.

Figures for recorded malaria cases during this season are emerging at the time of writing (August 2006). As a point of comparison, 1996–97 was also a wet year that followed several dry years, and there was a high incidence of malaria as a result. The figures obtained so far show that, in Botswana, the number of cases in the 2005–06 season was about 10 times lower than in 1996–97. In Zimbabwe the number was about half, and in South Africa it was about one-third. Several factors will have contributed to the reduced number of cases; in particular, control measures such as drug treatments are more widely available than 10 years ago. However, early warning and the preparedness that enables prevention have also contributed.

Implications for CRM good practice

The MEWS has great value for countries that suffer from malaria epidemics, particularly those with scarce resources which need to target their control efforts accurately and effectively (Da Silva *et al.*, 2004). Those southern African countries that have introduced MEWS into their malaria control programs have substantially improved their preparedness and response.

Some countries inevitably have more resources and capacity than others for implementing the MEWS and exploiting its full benefits. While implementation in Botswana

> The quality of epidemic response in countries implementing MEWS has improved significantly. National malaria control programs are able to forecast for the transmission season, detect early epidemics, and mount very effective responses to control them before they get out of hand, and therefore minimize suffering and deaths. So definitely the MEWS is making a difference in the way malaria epidemics are handled in southern Africa.
>
> Joachim Da Silva, Epidemics and Emergency Officer, WHO Southern Africa Inter-Country Malaria Control Programme.

South Africa is making use of the media to warn about malaria; R. Giling/Still Pictures

has been very successful, various political and economic problems have limited success in other countries. Zimbabwe's recent crisis has compromised its malaria control program and its ability to use the MEWS to full effect, as revealed in the post-mortem bulletin excerpt. Mozambique and Angola are both emerging from long-term conflict, and have many competing development needs in the short term which restrict their malaria programs. And most African countries have very limited funds for implementing both early warning systems and response measures. More funds are, however, being made available to national malaria programs from the Global Fund for AIDS, TB and Malaria and from the African Development Bank.

Malaria is one of many development issues that cross national borders. MEWS activities at the regional level demonstrate good collaboration in addressing this shared challenge, but more integrated management efforts may be needed as the full complexity of the malaria situation at the regional level becomes better understood. For example, high rainfall in Angola may cause increased river flow into Botswana and Namibia, increasing available breeding sites for mosquitoes in those countries. In addition, people migrate across borders, and from one level of endemicity to another, for a variety of reasons. These and other factors need to be incorporated into successful malaria management strategies at the regional and national level.

Now that the MEWS has been successfully 'prototyped' in southern Africa, it is time to ask how it can be improved. Promising ways forward include:

- Improved climate services and decision support tools, developed specifically to meet the needs of malaria control services (i.e. dynamic risk maps for malaria early warning, using appropriate satellite information)
- Improved sentinel site surveillance, informed by changes in the assessment of epidemic risk
- Better use of the media. The role of the mass media in malaria early warning seems underdeveloped in most of the countries using the MEWS. South Africa appears to have recognized the potential for mass media involvement, but other countries have yet to begin exploiting it.

Conclusion

The MEWS is demonstrating its usefulness in southern Africa, and has potential application in all African countries where epidemic malaria occurs. It is currently being piloted in Eritrea. It also has potential outside Africa, in malarial parts of Asia and Latin America.

The MEWS approach is strengthening health information and surveillance systems, and this in turn will have benefits for managing other climate-sensitive diseases. Indeed, building public health infrastructure was identified by the Intergovernmental Panel on Climate Change as 'the most cost-effective and urgently needed adaptation strategy' in the face of climate change. Thus lessons from MEWS can inform progress in public health services towards meeting the health-related targets of the MDGs, at the same time as aiding adaptation to climate change.

C.Shirley/UNHCR

Agriculture in Mali

Background

About 65% of Mali's land area is either desert or semi-desert, and less than 4% is used to grow crops. Rainfed agriculture is, however, the mainstay of most rural peoples' livelihoods, and it is in the south of the country, where most of the rain falls, that the bulk of the population lives (Figure 11). Even here, frequent droughts make cropping a high-risk venture, reflected in high levels of poverty and undernourishment. Some 64% of Mali's 12 million people live below the poverty line and literacy rates are low. While the proportion of the population that is undernourished decreased marginally from 29% in 1991 to 28% in 2002, the number of undernourished people increased by approximately 800,000 due to the rising population.

Recognizing that rural communities need help in managing the risks associated with rainfall variability, Mali's Direction Nationale de la Météorologie (DNM), the national meteorological service, launched a project some 25 years ago, with external funding, to provide climate information to rural people, especially farmers. Over the years, the project has evolved into an extensive and effective collaboration between government agencies, research institutions, media, extension services, and farmers. The project was highly innovative from the outset – the first in Africa to supply climate-related advice and

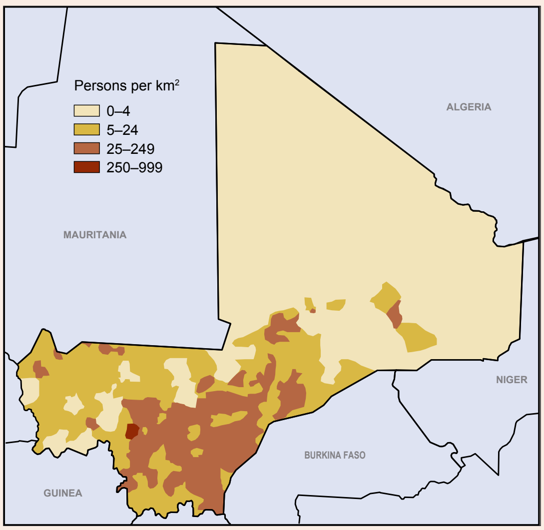


Figure 11.
Mali and population densities.
Source: Centre for International Earth Science Informatiion (CIESIN), www.ciesin.org

Recurrent drought plagues smallholder agriculture in Mali; C. Jaspars/Panos Pictures

recommendations directly to farmers, and to help them to measure climate variables themselves, so that they could incorporate climate information into their decision making.

Policy and planning for sustainable agriculture

Following severe droughts in the 1970s, the Sahelian community banded together to create regional institutions and partnerships that would pool resources in an effort to minimize the impacts of future droughts. In September 1973, the Comité Permanent Inter-États de Lutte contre la Sécheresse dans le Sahel (CILSS) was established. This was followed, in 1975, by the creation of the Centre Régional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle (AGRHYMET) by UNDP, WMO, the Food and Agricultural Organization of the United Nations (FAO) and the international community in cooperation with CILSS. AGRHYMET's mandate to promote training, information, and research in the fields of food security, desertification control, and natural resource management.

AGRHYMET works to strengthen meteorological and hydrological services in the Sahelian region. In 1982, assisted by AGRHYMET and with technical support from the WMO and financial support from the Swiss Agency for Development and Cooperation (SDC), the Malian meteorological service embarked on a project to bring agrometeorological information to rural communities and authorities, to help them in their decision making concerning farming activities and food security. The project is ongoing today.

The agrometeorology project

The project began in 1982 with a 5-year experimental phase, which was to be followed by evaluation, capacity building, and scaling-up phases. In fact, the evaluation and capacity building phases began soon after the experimental phase had started and then ran concurrently with it. Supported by SDC for the first 23 years, the strategy from the beginning was for the Malian government to take over the project's planning, management, and financing. After a gradual transfer of responsibility over the years, the Malian government assumed full responsibility in 2005.

When the project was launched, farmers were already receiving advice from agricultural extension workers, for example on soil management, fertilizer use, appropriate crop varieties, and crop rotations. The project aimed to identify whether and how climate information might also be useful to them.

At the outset, a multidisciplinary working group composed of technical, development, and research experts was created to plan and execute the project. This group, which still meets today, includes members from the meteorological service, the Ministry of Agriculture, agricultural research institutes, rural development agencies, farmers, and the media. The different group members provide inputs as follows:

- Users define the climate-related data and products they need
- The meteorological service analyzes technical aspects of these data and products
- The Ministry of Agriculture, extension services, and research groups work on issues related to food production, crop health/protection, and choice of crop varieties
- The rural development agencies focus on capacity building and information dissemination

Farmers are regularly asked for feedback on how well the project meets their needs; M. Hellmuth/IRI

- The media sensitize users and disseminate climatic and agrometeorological information.

One of the group's most important functions has been to act as a 'boundary institution' – bridging the gap between the climate and agricultural communities by 'translating' climate information into useful information and advice for farmers.

As a first step, project staff visited farmers to ask what kinds of information might be useful to them. Basic farmer needs were found to be information on the onset and end of the rainy season, and the amount and distribution of rainfall. These findings fed into the experimental phase, which looked at ways of enabling farmers to access and use such information.

In the first year the experimental work focused on 16 farmers who were growing pearl millet, sorghum, maize, cotton, and groundnut in the region of Bancoumana, in the south of the country. These were 'representative' farmers; that is, they worked directly with the project and also provided links to the farming community as a whole. The farmers managed two plots: one experimental plot in which they made decisions based on agrometeorological information, and another in which they relied on traditional indicators in their decision making. The farmers traditionally relied on observations of the moon, as well as signs such as the appearance of certain birds, the dropping of fruits from certain trees, and the movement of termites, to indicate the onset and character of the rainy season. Decisions included when to prepare the fields, how and what to sow, when to weed, and when to apply inputs such as fertilizers and pesticides.

The farmers were also given rain gauges to measure rainfall in their fields, and were trained in using them in conjunction with sowing calendars, which indicate suitable planting dates and appropriate crop varieties in the different locations, depending on rainfall as measured by the gauges. In addition, throughout the May–October growing season farmers received 10-day bulletins, which provide summary information on hydrological, meteorological, agricultural,

Farmers learned how to measure rainfall in their own fields; M. Hellmuth/IRI and pest conditions, as well as corresponding advice and recommendations. They were also given daily and 3-day weather forecasts.

As well as the farmers' experiments, the first phase of the project worked on fostering participation and building capacity among agricultural extension agents, establishing routes for information flow between stakeholders, and developing methods for rapid processing of data and their conversion into appropriate and useful advice. The project also built the capacity of farmers to collect and use agrometeorological information.

Every year the project staff visited participating farmers at the beginning, middle, and end of the cropping season, to gather feedback.

The results from the field at the end of the first year showed increases in yields for the plots where the farmers had used agrometeorological information, as compared to the traditionally managed plots (Table 3). As a result, in 1984 there was a high demand from neighboring communities for rain gauges, agrometeorological information, and training. The project expanded gradually over the next

Table 3. Sorghum and pearl millet yields in experimental and traditional plots, 1983–1986.

Crop	Year	Place	Yield (kg/ha) Traditional (T)	Yield (kg/ha) Experimental (E)	Change in yield (%)
Sorghum	1983	Bancoumana	1403	1489	6
		Kéniéroba	732	897	23
	1984	Bancoumana	1440	1530	6
		Kéniéroba	1081	1284	19
	1985	Bancoumana	1249	1469	18
		Kéniéroba	503	783	56
	1986	Bancoumana	1367	1351	–1
		Kéniéroba	667	1021	53
Pearl millet	1983	Kongola	479	643	34
		Makandiana	611	733	20
	1984	Kongola	899	1019	13
		Makandiana	802	1256	57
	1985	Kongola	846	979	16
		Makandiana	878	1075	22
	1986	Kongola	864	1071	24
		Makandiana	746	908	22

Source: Data from the Société Nationale d'Etudes pour le Développement.

few years, and by 1990 some 80 representative farmers had been formally trained.

The media began to play a central role in disseminating agrometeorological information around 1988, when national and rural radio and television networks were brought into the project.

The scaling-up phase of the project, still in progress today, began in earnest with a large stakeholder workshop held in 1993, during which participants evaluated their activities over the years from 1989 to 1993. These evaluation workshops are now held in each region every 2 years. The scaling-up phase has resulted in the following:

- The number of representative farmers involved in the project has increased to over 2000
- The number of districts involved has increased to five
- Local production of rain gauges has begun; these are beginning to replace the more expensive imported gauges
- Two local-level multidisciplinary teams were created in 2001, to help reach rural communities more efficiently. Two more groups are currently being developed in other regions. These groups complement the national-level group, allowing the project to work more closely with farmers
- Over 50 bicycles have been provided to representative farmers to facilitate the recording and transmission of rain gauge data to the national meteorological services, via regional offices

Farmers take their rainfall data to regional offices by bike; M. Hellmuth/IRI

- Agrometeorological information is being provided to an expanding number of farmers' organizations, rural programs, development agencies, and NGOs; for example, the Compagnie Malienne de Coton, the Office de Riz Ségou (ORS), the Organisation de la Haute Vallée du Niger (OHVN), and the Programme d'Appui aux Initiatives des Producteurs et Productrices Agricoles (PAIP/HELVETAS), a Swiss NGO.

Climate information is collected from diverse sources – WMO, IRI, the African Centre of Meteorological Application for Development (ACMAD), the national meteorological service, rural development and agricultural extension agents, and farmers

– before analysis, formulation of advice, and dissemination of information. The information is processed and provided at three levels:

- Seasonal forecasts are produced by ACMAD using data from international sources. Information from these forecasts is not provided directly to farmers, but is processed by the multidisciplinary working group for use in preparing 10-day bulletins. The information is also supplied to government for use in food security planning
- Daily to 3-day weather forecasts are prepared by the meteorological service according to WMO standards and are downscaled to specific target areas or regions. They are broadcast by national and local radio stations. The information is used by farmers in decisions such as when to prepare the land, when to sow, and when to apply fertilizer and pesticides
- The 10-day bulletins produced by the multidisciplinary working group provide the basis for information and advice to farmers (Table 4), as well as to national policy makers on the food security status of the country. They are disseminated by radio and television, as well as in printed versions. The bulletins report on the state of crops, water resources, and weather conditions, as well as crop health issues, pastoral issues, animal husbandry, and agricultural markets. They also predict future conditions.

As mentioned above, the media began to play a central role in disseminating agro-meteorological information around 1988, when national and rural radio and telvision networks were brought into the project. Radio in particular is an important means of reaching rural people. According to an audience survey

Table 4. Advice for farmers based on agrometeorological conditions during the period 11–20 July 2006 and valid for the period 21–31 July 2006.

Location	Advice to farmers
Sikasso, Bougouni, Kolondiéba, Koutiala, Kangaba, Kéniéba, Kita, Bancoumana, Siby, Dangassa, Dialakoroba, and Naréna	Can plant 90-day pearl millet or sorghum during the 10-day period 21–31 July 2006
Banamba	Can plant 90-day maize, groundnut, or cowpea if cumulative rainfall during 21–31 July 2006 is equal to or exceeds 10 mm
Mopti, Bankass, Koro, San, Kolokani, Nara, Nioro, Diéma, and Yélimane	Can plant 90-day pearl millet, sorghum, groundnut, or cowpea
Pastoralists and agropastoralists are advised to provide more feed for their livestock and to respect local rules regarding herd management and grazing areas, in order to ensure that livestock do not damage growing crops.	

Rural radio has proven an effective tool for scaling up the use of agromet information; R. Jones/Panos Pictures

carried out in 2003 by Mali's Office du Radio et de la Télévision, 80% of radio audiences in the project areas follow the agrometeorological bulletins. Television is a less useful medium, as fewer than 1% of Malians own a television set, and these people are unlikely to be farmers. Nonetheless, the same survey found that 50% of the television audience followed the agro-meteorological bulletins. Climate information is broadcast in French (the country's official language) and in all major local languages (e.g. Bamana, Bobo, Bozo, Dogon, Peulh, Soninke, Sonrai, and Tamatcheque).

Results and impact

Results from the 2003–2004 cropping season show that crop yields and farmers' incomes were higher in fields where agrometeorological information was used compared with those where it was not used (Table 5). The increase in income is substantial, notably for maize in the OHVN zone, where farmers earned 80% more income from 'agromet' fields.

Testimonies from farmers indicate substantial production increases in maize, sorghum, pearl millet, groundnut, and cotton. However, more research is needed to evaluate these results, as it is difficult to single out agrometeorological information as the main reason for the increased yields without rigorous analysis of field conditions, the farmers sampled, and the use of inputs. It is, however, clear that agromet farmers feel they are exposed to lower levels of risk and are

Table 5. Crop yields and farm incomes for farmers taking management decisions with and without agrometeorological information, in the 2003–2004 season.

Crop	Development zone	Field type	Area (ha)	Average yield (kg/ha)	Gross income (US$/ha)	Income gain in agromet fields (%)
Pearl millet	OHVN	Agromet	2,600	1,204	175	26
		Non-agromet	67,168	957	139	
	DRAMR	Agromet	750	757	110	10
		Non-agromet	45,790	690	100	
	ORS	Agromet	10,400	1,247	181	48
		Non-agromet	461,915	840	122	
Sorghum	OHVN	Agromet	5,375	1,427	193	42
		Non-agromet	470,996	1,005	136	
	DRAMR	Agromet	28,275	955	129	10
		Non-agromet	222,662	871	118	
	ORS	Agromet	2,850	1,562	212	56
		Non-agromet	179,853	1,002	136	
Maize	OHVN	Agromet	6,075	1,984	249	80
		Non-agromet	27,079	1,105	139	
Groundnut	DRAMR	Agromet	6,060	874	237	25
		Non-agromet	102,113	702	190	

Note: DRAMR = Direction Régionale d'Appui au Monde Rurale
Source: SDC *et al.* (2004).

therefore more confident about purchasing and using inputs such as improved seeds, fertilizers, and pesticides, all of which boost production.

After nearly 25 years of practical experience, the capacity of the national and local multidisciplinary working groups to collect, analyze, and disseminate agrometeorological information has greatly increased. Farmers' understanding of this information, and their ability to assimilate it, has also increased. By

If I had to choose between agrometeorological information and fertilizer? Agrometeorological information! For without that, the fertilizer would be useless… Of course, if you are offering a choice between irrigation or agrometeorological information, I would take the water.

Konimba Traoré,
farmer in Ouielessebougou.

keeping close records of rainfall, the farmers are now building valuable 'climatological profiles' of their own fields.

The Malian government has recognized the positive impacts of this project, and endorsed it in 2001 with a financial commitment to strengthen the meteorological service. Improved buildings for the service opened in 2004, and about US$1.2 million was allocated for new weather stations and equipment in 2005–06.

Implications for CRM good practice

Several factors have contributed to the achievements of this project:

- The drought-induced famine of the mid-1970s was a stark demonstration of the effects of climate on peoples' livelihoods; thus politicians began to give higher priority to managing climate risks
- Long-term support from the principal donor SDC, as well as technical support from WMO
- The project's farmer-centered approach, which has led to the development and delivery of climate products and services that meet their needs
- Effective communication channels, especially between representative farmers and multidisciplinary working groups
- The use of radio as an effective medium for information dissemination.

From the beginning, the project worked directly with community-level stakeholders and established two-way information flows.

> Most of us have been working with these farmers for 10–20 years. Over the years, the farmers have become better at asking us questions, and their training has helped them perform their tasks better… Do we give the farmers enough information?
> It's always too little… but they use what we give them.
>
> Saliko Berthe, Director of Rural Development, Ouielessebougou.

Saliko Berthe, Director of Rural Development in Ouielessebougou and a long-standing project enthusiast; M. Hellmuth/IRI

> When I hear on the radio that it will rain tomorrow in Koulikoro, I bring the wood inside to keep it dry, or decide not to wash the clothes that day, or begin to prepare my fields for planting. Even if it doesn't rain on my field, I know it will rain on someone else's field in Koulikoro, and I have lost nothing in being prepared.
>
> Sali Samaké, farmer in Koulikoro.

Providing climate services to livestock producers could have a high payoff; C. Hughes/Panos Pictures

Farmers receive climate data that, while they originate with the meteorological service, have been processed by the multidisciplinary working groups into useful information and advice. Representative farmers are also encouraged to feed back to the project team their perceptions regarding the usefulness of what they receive. And farmers have also learned to collect and use their own climate information.

But aside from these successes, the project has come up against some limitations. It has so far focused on just a small range of crops, mainly cereals and cotton. More staple food crops need to be included if there is to be a significant impact on food security. The needs of livestock producers – a large and economically important group in both cropping and pastoral areas – have been largely neglected. There are also limitations in providing reliable local-scale information to farmers. More data are needed, for example, on local soil conditions and water availability. Communication problems include difficulties in translating the more technical terms into local languages; poor radio reception in some areas; and low literacy and little formal education among farmers.

The multidisciplinary team approach has sometimes run into difficulties because of the different disciplinary 'takes' on a given problem. For example, while the agrometeorologists tend to advise delayed sowing in order to minimize the risk of early-season

Access to markets is essential for success; B. Press/Panos Pictures

drought, the agriculturalists prefer to promote more drought-resilient crop varieties and other technologies as the solution.

This is a symptom of a broader challenge: agriculturalists' understanding of the implications of weather and climate for farmers' practices has developed markedly in recent years and there is now a sizeable body of knowledge, together with some useful products, ready for extension (see 'Agricultural research and climate'). If this knowledge and these products could be used to complement the advice to farmers currently provided by the project, the additional impact on yields and incomes could be substantial. In addition, advances in climate science, notably the increased skill of seasonal forecasting, could be used to provide farmers with a longer lead time for their decision making.

Finally, links to markets are crucial to the success of projects such as this one. Without access to a market, there is little or no incentive for farmers to increase production.

Conclusion

The results of this long-term project indicate that the regular provision of agrometeorological information helps farmers to manage the risks associated with increased climate variability. The project has successfully built a framework for gathering, analyzing, processing, and disseminating information that

Agricultural research and climate

In Mali as elsewhere in Sahelian Africa, priorities in agricultural research and development are evolving to reflect the changing needs of resource-poor farmers. Agricultural research at the international and national levels over the past 25 years has led to increased understanding of the agricultural implications of climatic variability and change. These affect the priorities for both crop improvement and natural resource management.

Crop improvement research challenges

Crop improvement aims at increasing the adaptation, i.e. the yield and yield stability, of crops in a target region. Major challenges for crop improvement research in the light of climate variability and change lie in:

- Exploiting genetic diversity in order to enhance adaptation
- Foreseeing future needs and initiating appropriate breeding programs in time.

Within a crop species, different varieties show different adaptability to environmental stresses such as temperature and rainfall (Table 6). This can be exploited by studying variety-by-location interactions and developing adaptation maps for different varieties. Doing this for a range of species can enhance production for a whole region.

Stresses that vary unpredictably, such as drought, which may occur at any time during the rainy season, are difficult to handle. But some species and varieties have specific adaptation mechanisms that make them resilient to such stresses. These may be evident at an individual plant level (individual buffering) or within a plant stand (populational buffering).

Traditional varieties of sorghum and pearl millet – the main staple foods of the 100 million or so people living in semi-arid western and central Africa – have such adaptation mechanisms. Some pearl millet varieties, for example, show huge variability for flowering time and high tillering capacity – two mechanisms that ensure that not all plants in the stand will be affected by a drought spell during flowering, which is the most sensitive stage of the plant's growth. The plant breeder's challenge is to maintain such adaptation traits while raising yields.

Climate change may affect not only the occurrence of drought but also the appearance of diseases, pests, and parasites. Little is yet known on this subject, but such knowledge will be essential for the design of appropriate resistance breeding programs in response to climatic change. Since the development of new cultivars using traditional breeding techniques takes 6–10 years, there is little time to lose.

Improving soil fertility and water management

The need for more food for increasing populations in the Sahel has so far been met largely by expanding the cropped area rather than by raising yields. As a result the traditional practice of restoring soil fertility through long fallow periods (10–20 years) after a short period of cultivation (3–5 years) can no longer be practised in most areas. Small-scale farmers use insufficient organic and inorganic

R. Jones/Panos Pictures

fertilizers to replenish the nutrients removed from the soil by cultivation. Animal manure plays a strategic role, but is not available in quantities large enough to meet the demand.

Soil fertility and plant water use are closely linked. For example, many experiments have shown the positive effect on pearl millet growth of phosphorus fertilizer applied at sowing (e.g. Buerkert *et al.*, 2001). It is thought that this leads to better development of the root system, so that the plant can access a larger volume of soil to extract water, making it less vulnerable to dry spells. Application of fertilizer at sowing also gives rapid early growth of leaves, which reduces soil water evaporation (Sivakumar and Salaam, 1999).

Thus, addressing soil fertility becomes more urgent where water availability is limited. In Africa the use of mineral fertilizers is constrained by limited availability and high cost. Efforts are being made to address these constraints, for example by repackaging fertilizers in smaller amounts and building networks of agrodealers to market them. To complement these initiatives, researchers are adopting a participatory approach to the introduction of such innovations as the combined use of animal manure and mineral fertilizers, intercropping with legumes, and the making of compost. Better links to market and a switch from food to cash crops will also help, by increasing farmers' returns to fertilizer use.

Source: ICRISAT (2006).

Table 6. Effect of climate variability on pearl millet crop performances and adaptation options.

Climate parameters	Effects on crops and natural resources	Adaptation options
Late onset of rains	Shorter rainy season, risk that long-cycle crops will run out of growing time	Early-maturing varieties, exploitation of photoperiodism, P fertilizer at planting
Early drought	Difficult crop establishment and need for partial or total re-sowing	P fertilizer at planting, water harvesting and runoff control, delay sowing (but poor growth due to N flush), exploit seedling heat and drought tolerance
Mid-season drought	Poor seed setting and panicle development, fewer productive tillers, reduced grain yield per panicle/plant	Use of pearl millet variability: differing cycles, high tillering cultivars, optimal root traits, etc; water harvesting and runoff control
Terminal drought	Poor grain filling, fewer productive tillers	Early-maturing varieties, optimal root traits, fertilizer at planting, water harvesting and runoff control
Excessive rainfall	Downy mildew and other pests, nutrient leaching	Resistant varieties, pesticides, N fertilizer at tillering
Increased temperature	Poor crop establishment (dessication of seedlings), increased transpiration, faster growth	Heat tolerance traits, crop residue management, P fertilizer at planting (to increase plant vigor), large number of seedlings per planting hill
Unpredictability of drought stress	See above	Phenotypic variability, genetically diverse cultivars
Increased CO_2 levels	Faster plant growth through increased photosynthesis, higher transpiration	Promote positive effect of higher levels through better soil fertility management
Increased occurrence of dust storms at onset of rains	Seedlings buried and damaged by sand particles	Increase number of seedlings per planting hill, mulching, ridging (primary tillage)
Increased dust in the atmosphere	Lower radiation, reduced photosynthesis	Increase nutrient inputs (i.e. K)

Source: ICRISAT (2006).

farmers can use. A particularly important role has been played by the project's multidisciplinary working group, which has served as a boundary institution by 'translating' climate data into practical advice.

The evidence suggests that when farmers have good climate information:

- They are able to make better management decisions that lead to higher yields and incomes
- They are also prepared to take more risks, investing in new technologies that can raise yields and incomes still further
- They start to seek information from other sources to improve their decision making.

The Malian government has witnessed the project's success, and has consequently committed itself to funding the project now that the external donor agency has withdrawn. The government is also investing further in the meteorological service, in new equipment and stations, in recognition of its important role in the country's development. Some challenges remain, however. Funding for extension is still very limited, so that, for example, field visits have had to be reduced. And it is recognized that better integration of the products and knowledge developed through agricultural research could significantly enhance the benefits to farmers.

Drought insurance in Malawi

Background

Malawi is one of Africa's poorest countries, with 65% of its population of 12 million living below the poverty line and a per capita GDP of only US$ 200. It is also a very rural country, with over 80% of its people engaged in farming. The vast majority of farmers are smallholders, cultivating areas of 1 ha or less. The main food crop is maize, while tobacco and groundnut are the two principal cash crops.

Farmers won't invest if there is a high risk of crop failure; C. Hughes/Panos Pictures

Over 90% of crop production is rainfed, taking place during a single rainy season lasting from December to April. Rainfall during this period tends to be highly erratic and drought is a recurrent problem, often causing widespread crop failure. In addition, the risk of drought is a major factor keeping productivity low, since even in good years farmers are wary of using inputs such as improved seeds and fertilizers for fear of losing their investment.

This case study describes a pilot project that is testing a new way of dealing with drought risk: the provision of index-based weather insurance directly to smallholders (see 'Insuring against adverse weather'). The project, which is primarily driven by the private sector, goes to the heart of food insecurity in Malawi by tackling the major cause of low levels of farmer investment in new technology.

A coalition for innovation

The novelty of drought insurance has led to the development of a coalition of stakeholder groups, some of whom have not previously worked together.

Insuring against adverse weather

Insurance has long been an important tool in risk management, but the concept of weather-related insurance is new. It is currently being tested in a number of African countries.

Traditional insurance contracts insure against crop failure, but these lead to perverse incentives for farmers to allow crops to fail. There is also an incentive for less productive farmers to buy insurance and for more productive farmers not to do so. These problems imply more and higher payouts, which would in turn lead to higher premiums, ultimately making this type of insurance too expensive to be workable.

The new contracts are written against an index that describes an established relationship between, for example, lack of rainfall and crop failure, ideally verified by long historical records of both rainfall and yields. If rainfall turns out to be low, falling below an agreed trigger point, the farmers receive payouts. But whether the insurance pays out or not, farmers still have the incentive to make productive management decisions.

The main advantage over crop insurance is that, when rainfall is low enough to cause crops to fail, insurers will pay out to farmers quickly, so that farmers do not need to sell off their assets to survive. The money will see them through the drought period, and they will then be able to continue farming when the rains resume. Without insurance, farmers or pastoralists are often forced to sell equipment or animals to survive a drought, and this means they become dependent on aid for a much longer period after the drought has ended. Drought insurance should thus reduce the repeated need for donors to find large sums of money quickly in emergencies. Another major advantage is that, with this insurance in place, farmers feel more able to take risks in order to increase their returns, for example by investing in fertilizers or improved seeds. Drought insurance is thus at its most powerful when it is combined with loans for the purchase of such inputs. Any payouts due are simply added to the final settlement at the end of the season, when farmers receive cash for their harvest and repay their loans. Index-based insurance is also cheaper to implement than conventional crop insurance because the insurance company does not need to send employees to the field to verify crop losses.

C. Palm/IRI

There are some disadvantages. The farmer is insured only against drought. If crops fail for some other reason, such as pests and diseases, he or she receives no compensation. But index-based insurance is still worthwhile if the risk it insures against is the most important one in a given production system. It is best applied as a part of a larger risk layering strategy in which other tools, such as traditional risk management and government social safety nets, complete the package.

Lastly, while index-based insurance is the key to raising productivity and incomes in the smallholder farming community, it does not protect the poorest of the poor, most of whom do not have access to land and/or are too marginalized or vulnerable to be economically active. It does not, therefore, obviate the need for governments and donor agencies to invest in the emergency relief and safety nets needed to assist this group.

Organized markets for inputs and outputs facilitate administration of the loan plus insurance bundle; J. Banning/Panos Pictures

The Malawi project has its origins in work by the World Bank's Commodity Risk Management Group, which was instrumental in developing the concept of drought insurance, raising awareness of it, and stimulating the interest of potential partners in trying it out. IRI was asked to provide technical support to the group in its work with private-sector partners to design and evaluate the insurance product.

The Malawi government has welcomed the project and facilitated its pilot phase. It is actively involved through the participation of the national meteorological service, which is the source of the climate- and weather-related data and expertise essential for the design and implementation of the insurance scheme. The data needed for design include historical rainfall and evapotranspiration, together with soil characteristics and agronomic information. Needed for implementation are reliable monitoring and timely reporting of rainfall, since these are the basis for determining payouts.

Another important partner is the National Smallholder Farmers Association of Malawi (NASFAM), an umbrella association embracing 40 or more local farmers' associations. NASFAM's roles are to provide access to seed inputs and to buy members' harvests. When paying for the harvest it also performs the important role of ensuring loan recovery, by deducting the loan, adjusted for any insurance payout, from the cash payment. NASFAM was keen to participate because it saw the project as a means of lifting the burden of indebtedness amongst farmers, who were previously obliged to repay loans in full when crops failed (see 'Strengthening Malawi's micro-credit system').

Two micro-finance institutions are participating as loan providers: the Malawi Rural Finance Company (MRFC), which was already lending to the smallholder sector, and Opportunity International Banking Malawi (OIBM), a newcomer to the sector. Both expressed interest in drought insurance as a way of safeguarding repayment of their loans. In fact, for OIBM the insurance was the key component that secured its willingness to lend to smallholders.

To aid learning during the project's pilot phase, Malawi's leading insurance

NASFAM is a key partner in the project; D. Osgood/IRI

Strengthening Malawi's micro-credit system

Malawi's drought insurance scheme has not been developed in a vacuum. Rather, it is able to build on an existing tradition in the provision of micro-credit to smallholders.

In the past, micro-credit schemes have been targeted to specific crops, mainly tobacco, that are considered profitable enough to enable farmers to repay credit without difficulty, and that are traded in an organized marketing system that allows systematic recovery of the loans. The collateral is based on the social capital of the club system, whereby farmers who know and trust one another form groups of 10 to 25 who are mutually and collectively responsible for repayment. If anyone defaults, all the group's members are liable. This system has worked well, delivering loan recovery rates of at least 95%.

Problems with this system arise when, for drought or other reasons, all the members of a club lose their harvests. When this happens, the entire club is unable to repay the loan, which is then deferred for repayment the following year. However, most small-scale farmers need a new loan to start cropping the following season, leading to rising levels of indebtedness and deepening poverty.

The provision of drought insurance can offset the risk of systemic failure of this kind. The objective must be to design schemes that are robust enough to pay out to large numbers of farmers when drought is widespread and severe.

Two finance companies are providing micro-credit; D. Osgood/IRI

Malawi's insurance companies are collaborating as a consortium; D. Osgood/IRI

companies are participating as a consortium, the Insurance Association of Malawi. Once the insurance scheme and the mechanisms for administering it have been developed and tested, the companies will operate individually, in competition with one another. For the companies, the project offered an entry point into the smallholder sector, where they have had virtually no presence in the past.

Designing the pilot project

Malawi's drought insurance project began with a stakeholders' meeting organized by the World Bank in July 2005. Stakeholders realized the potential of the new concept and expressed their interest in participating in a

> Drought index insurance is a real breakthrough, as it provides the opportunity not only to re-access the commercial farming community but also to access rural smallholder folk, who need it most. The fact that claims are settled based on weather station data removes both moral hazard and assessors' fees, making administration of the product easy.
>
> Ben Kautsire, liaison officer, Insurance Association of Malawi.

pilot phase to test it. On the strength of their enthusiasm, the project was launched without further delay.

The first task was to select the commodity on which to test the concept. The initial list was made on the basis of the portfolio of crops handled by NASFAM. The choice was then narrowed, using the selection criteria shown in Table 7. Obviously, the main criterion had to be drought sensitivity, but other criteria were also important. These included the level and cost of inputs needed, which justified the provision of financing; the existence of an organized marketing system, which would ensure efficient loan recovery; the value of the crop, which needed to be profitable enough to allow farmers to pay off the loan while retaining a decent income; and the crop's suitability for smallholder farmers – in other words, not involving intensive management, complicated processing, or rapid perishability.

Groundnut, which scored well against most of these criteria, was chosen for the pilot phase. The only doubt surrounded the crop's marketing system, since farmers could in theory decide to sell their harvests to outside traders instead of through NASFAM, thereby jeopardizing loan repayment. To get round this problem, NASFAM undertook to offer higher prices than other traders. The variety chosen was Chalimbana 2000, a new hybrid that combines high yields with drought resistance and other desirable traits.

Table 7. Selection criteria for crops covered by Malawi's weather risk insurance project.

	Selection criteria (1=not suitable 5=highly suitable)				
Crop	Sensitivity to drought	Input usage	Marketing system	High value	Suitability for smallholders
Chillies	1	1	4	5	5
Cotton	2	5	3	2	5
Groundnut	5	3	4	4	5
Maize (grain)	5	4	1	1	5
Maize (seed)	5	4	5	5	1
Paprika	3	5	4	4	3
Rainfed rice	Not applicable	3	3	3	4
Irrigated rice	Not applicable	4	4	3	4
Soya	4	2	1	2	4
Tobacco	4	5	5	5	4

Groundnut was chosen as a test crop for the pilot phase; D. Osgood/IRI

The next step was to identify the sites for the pilot phase. Four sites were selected, based on NASFAM presence, groundnut production, and proximity to a meteorological station (see Figure 12). Consultations with the meteorological service, the extension service, and farmers suggested that farmers within 20 km of a station would experience roughly the same rainfall patterns as the station itself. Thus, during the pilot phase, only farmers who were within this radius were insured.

Meetings to select participating farmers were held in August 2005. Farmers had to be members of NASFAM, to be growing groundnuts, to have adequate land to sow 0.5 ha to the new variety while maintaining some land in other crops, and to have not previously defaulted on a loan. A total of 882 farmers in the four project sites were selected, grouped in clubs of 10 to 20 members each.

The insurance contracts were designed to pay out if the rainfall data from the nearest meteorological station showed a deficit at one or more critical stages of the growing season. Each contract had a 'no-sow' clause that would pay out if insufficient rain fell during the early part of the season, from mid-November to early January. This was followed by clauses specifying the different levels of rainfall that would trigger payments during the three major phenological stages of establishment, flowering, and maturation.

Figure 12. Location of the pilot areas in Malawi.

The overall loan package was designed so that it would fit into the standard smallholder farm. The technology inputs should not place too great a strain on labor resources, while the total amount lent should not pose too great a challenge in terms of repayment. Table 8 shows the components and overall package.

Before the beginning of the rainy season, each participating farmer club entered into a formal loan agreement that incorporated the weather insurance premium. It is important to stress that individual farmers did not receive any money in advance; instead, each club transferred the loan, partly to NASFAM, for the

Table 8. Components of the loan package for the pilot phase in Malawi.

Components	US$
Loan processing fee (applicable to MRFC clients only)	0.32
32 kg seed at US$ 0.90/kg	29.20
Interest at 33% per annum, for 9 months	7.23
Insurance premium at 7.5% of loan package	2.79
Surtax on insurance premium at 7.5 %	0.21
Total	39.75

purchase of seeds, and partly to the Insurance Association of Malawi, for the weather insurance premium. The farmers agreed to sell their harvest to NASFAM at a guaranteed price. After the season, NASFAM would use the proceeds of the harvest to repay the bank loan and pay the surplus income to the farmers. The fact that the farmer receives no cash in advance reduces the risk of non-repayment to the bank. (Linnerooth-Bayer *et al.,* 2006).

Initial experiences: the 2005–2006 season

The season unfolded with rainfall recorded at the meteorological stations close to normal levels for the various production areas. In three of the four pilot locations adequate rainfall was received to avoid payouts, but farmers in the Kasungu area received a small payout of US$ 0.68 each.

One concern expressed by the farmers was that the rainfall data used to determine payouts were from a single rainfall station that could be up to 20 km away. As a result some farmers were winners and others losers, as rainfall on their farms differed from that at the station. This is one of the major challenges facing the design and implementation of index insurance in heterogeneous rainfed environments.

Another complication that arose during the season was poor seed quality. A middleman working for a commercial seed company sold expired seeds that did not germinate. This provided an interesting test of the project's acceptability to the farming community, since this is exactly the kind of thing the insurance scheme does not cover. Farmers showed that they understood the scheme, since they did not demand payouts from it but instead put pressure on the seed company.

Participating farmers had to live within 20 km of a meterological station; D. Osgood/IRI

A further issue was that of so-called 'side-selling' – farmers marketing to opportunistic traders who offered a higher price than NASFAM. Groundnut seed prices rose sharply as the season progressed, eroding the premium offered by NAFSAM at the start of the season and thus tempting farmers to break contract. Only a few did so – but the incident revealed that the combined insurance and loan package may be vulnerable to this kind of behavior, even within an organized market. NASFAM responded to this challenge by offering to reimburse anyone who had sold early to the association with the difference between the price paid and the higher price obtaining at the end of the season.

Experience in the formation of clubs showed that these performed best when they are self-selecting, evolving 'naturally' into a group that is socially cohesive. Under these conditions, the principle of collective liability works well. Because project planning had to be rushed, a small number of farmers were compelled to form clubs. These clubs tended not to function well and look unlikely to last through the second season.

The way forward

Pending completion of an assessment study that is still under way, it is impossible to quantify the impact of the project during its first season. However, there is anecdotal evidence to suggest the potential for substantial positive impact. In interviews, farmers indicated that they greatly appreciated the scheme and that they would like it to be expanded to cover a larger area per farmer and to include other crops, particularly maize. The main attraction was that the scheme facilitated access to production loans.

Practically all the farmers involved are keen to participate again in the second year, and demand from new farmers greatly outstrips the capacity of the project to enroll, educate, and manage them. Farmers said that signing up for the insurance scheme is their preferred way of adapting to climate variability and change.

Are you going to expand this project to other crops such as maize, seed maize or tobacco? With access to finance to buy certified seed, our chance to get a good yield is increased. Please expand this to other crops and do not limit the acreage as you have done in the pilot. It is good to note that, in case of severe drought, I do not have to worry about paying back loans in addition to looking for food to feed my family. In future I hope to send my children to school with income from this project.

Quent Mukhwimba, Ukwe Farmers' Association.

As this publication goes to press, scaling up is taking place during the 2006–07 season as planned. Initial estimates are that several thousand contracts have been signed so far. In response to demand, the number of farmers in existing pilot areas is being increased, new areas are being added, and the scheme is being extended to cover maize as well as groundnut.

The inclusion of maize poses new challenges. The lack of an organized market for this crop will complicate the task of loan recovery. It will be important to work with policy makers to clarify and stabilize the policy environment regarding subsidies and other factors that affect the design of the package and the costing of its components. It will also be important to protect the package from price fluctuations so as to ensure that farmers can repay their loans. To overcome these challenges, the maize loan, for the first year at least, has been bundled with that for groundnut.

Training for field staff will be essential as the program expands. To facilitate this, program partners plan to develop a manual, together with standardized procedures. Eventually, a software tool for more generic use in designing projects will also be developed and disseminated. These tools should ease the scaling up challenge, by allowing a wider range of stakeholders to design their own projects.

In the longer term, it is planned to engage a broader range of participants. This may include commercial farmers, in addition to a more diverse array of input suppliers and

Including maize will pose new challenges; C. Palm/IRI produce buyers. These moves will encourage competition and ease the administrative burden borne by NASFAM. The cost of the insurance premium, currently about 7.5% of the loan, is likely to remain a barrier for the poorest farmers, who often live in the areas at greatest risk of drought. Competition may create some scope for reducing this cost, but affordability for poor farmers will doubtless remain an issue as the program expands.

Another long-term aim is to broaden the range of financial products available. At the pilot stage, insurance is necessary in order to guarantee the loan. However, as farmers participate in the program, building up savings and a reliable credit history, they should start to enjoy a broader range of options, including stand-alone insurance, loans that are guaranteed without insurance, and various savings schemes.

The program's future evolution towards a broader range of commodities and financial products may allow farmers to make more effective use of climate information, particularly ENSO-based seasonal rainfall forecasts, which show some skill in Malawi. Farmers have expressed an interest in adapting their crop mix in response to such forecasts, shifting towards drought-tolerant crops when a dry season is forecast and towards high-risk but high-productivity crops when the forecast is for a wet season. Work is therefore being done to reflect the seasonal forecast in the design of the insurance and loan package, so that this offers the best mix of seeds and financial tools for the seasonal rainfall expected.

The spatial variability of rainfall and the lack of rainfall stations with reliable long-term records are limitations that will need to be addressed if scaling up is to be successful. Models for estimating rainfall in areas where there is no station will need to be developed and calibrated, making use of satellite imagery, data interpolation, and data blending, as is being been done in Ethiopia (see 'Making the most of data', p. 40). At the same time, the country will need to invest in a denser network of automatic weather recording stations.

Conclusion

The pilot project in Malawi has demonstrated that weather risk insurance can be implemented in the small-scale farming sector. Although its impact has not yet been quantified, it seems likely that this innovation will prove the 'missing ingredient' needed to enable farmers to adopt new, yield-increasing technology, including improved seeds and fertilizers, and to adapt their enterprises and practices in response to seasonal forecasts. The outcome should be higher and more stable crop yields, sustained over the years as soil fertility also starts to recover.

This is the first time that weather insurance for smallholders has been implemented in Africa. In Malawi, the key players are in

> We are very excited to be part of the first successful weather index pilot launch in Africa. As an industry, to ensure portfolio diversification, we would want to see this product expanded to include more crops and more areas around the country. We hope insurers in our neighboring countries will also adopt this high technology product.
>
> Ben Kautsire.

place and are willing to turn the project into a fully fledged program. The project here has been a valuable learning experience, providing useful guidance for the design and implementation of similar pilot projects in other countries, including Kenya and Tanzania, where activities are being launched for the 2006–07 cropping season.


L.Taylor/UNHCR

Lessons learned and next steps

The role of climate risk management in Africa

Widespread poverty and dependence on rainfed agriculture make the people of rural Africa extremely vulnerable to both climate variability and climate change. Many development efforts focus on climate-sensitive sectors, yet fail to integrate climate information and knowledge into their activities. If this were to change, it could curb the losses associated with climate variability and change while increasing the chances of favorable social and economic outcomes, especially for the poor.

The case studies presented in this report describe experiences in building CRM into development activities in Africa in two broad categories:

- Disaster risk reduction (floods, famines, and epidemics), and
- Agricultural development (agrometeorology and index insurance).

Disaster risk reduction strategies are coordinated mainly at regional and national levels, with necessary communication also at sub-national and community levels. The cases in this category illustrate components of prevention (creating more resilient communities), preparedness (use of early warning systems to bring forward interventions), and response (using monitoring information to organize government and international aid). The agricultural development cases, in contrast, focus at the farm level (improving farmer decisions using climate information, and improving farmer access to credit using index insurance).

Although different in scope, all the cases demonstrate elements of CRM good practice while also revealing areas that need improving. They contain valuable lessons for other countries and sectors as they begin to recognize the importance of climate considerations and the need to develop similar CRM approaches. Some key lessons are highlighted below; these are followed by a set of related recommendations that, if implemented, could facilitate the transition to more climate-aware and climate-responsive development in Africa.

Lessons from the case studies

■ Climate information is most effective when integrated into decision-making frameworks

Climate information is most likely to improve development outcomes when it is integrated with other information into a framework for decision making in relation to specific risks. In most cases it cannot, by itself, lead to better decisions. For example, effective epidemic malaria control in southern Africa depends on the identification of 'at-risk' areas and populations as well as a functioning health system if climate information is to play a role in improving preparedness and early response. The kind of information product needed will differ according to the level of decision making (household, district health team, national malaria control team) and the types of intervention (health message, spraying program, drug procurement) that can be made in response to it.

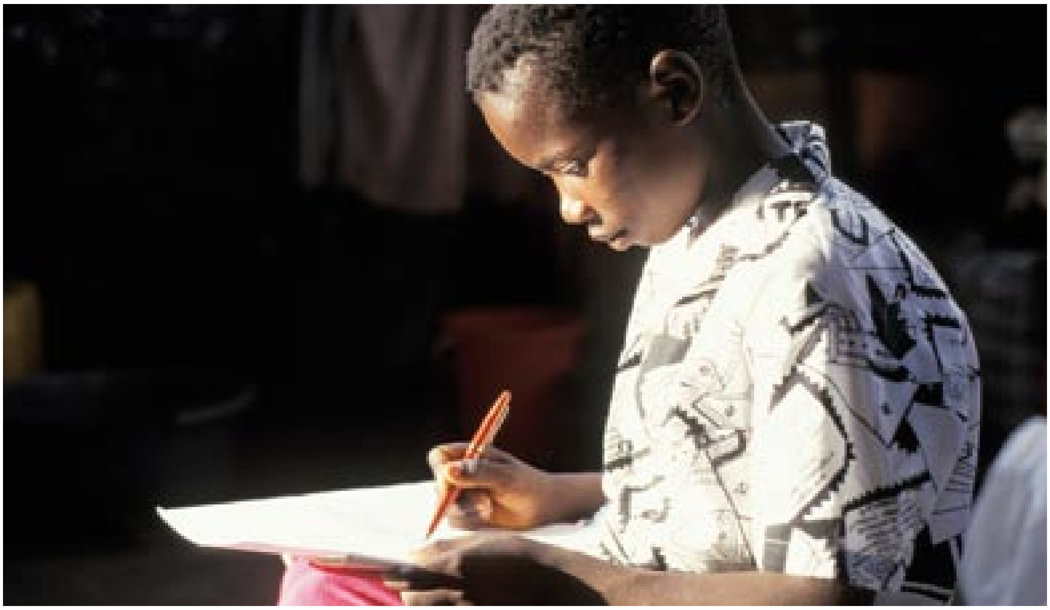
■ Reducing climate-related risks requires multi-level stakeholder coordination and communication

All the case studies demonstrate the importance of coordination and communication amongst a concerted group of multi-sectoral stakeholders working at different administrative levels. In the disaster reduction cases, coordination across national borders is vital if river basin flood risk is to be predicted in a timely manner, cross-border epidemics are to be controlled, and food insecurity is to be understood in the context of regional production and markets. Although Mozambique's flood management provides a positive example of cross-border communication (even in times of conflict), these networks typically require further strengthening – politically, legally, institutionally, operationally, or technically – if they are to become fully effective. For example, operational flood management in Mozambique would clearly benefit by a shared (transboundary) monitoring system. The Mozambique case also illustrates the need for a single 'authoritative voice' at the national level, to ensure coherent communication with different government departments, response agencies, and at-risk populations.

In both the disaster risk reduction and agricultural development cases, coordination and communication at the *local* level are also absolutely essential if communities are to become more resilient and adept at managing climate-related risks and opportunities. In Mozambique this was clearly recognized as a shortcoming of the flood response in 2000, and as a result the country has launched a new capacity building initiative geared towards building resilience at the community level. In Malawi, the pro-active role of the national- and local-level farmers' associations in coordinating the public–private partnership to promote drought insurance has ensured local buy-in and the tailoring of the product to suit local needs.

■ Climate information must be credible if it is to be used in decision making

Credibility is hard to build and easy to lose. It attaches to the source of information as well as to the information itself. Note that the declaration of a famine, epidemic, or flood disaster is often highly sensitive politically, as well as implying the commitment and



Mozambique's government has launched initiatives to build resilience at local level; G. Pirozzi/Panos Pictures

mobilization of very substantial resources, so credibility of the information used for decision making is extremely important. Seasonal climate forecasts, in particular, present a notoriously difficult problem in terms of communicating probability to decision makers who are typically more comfortable with deterministic information. The development of credible seasonal forecasts for malaria control depended critically on adjusting the timing of the forecast from September (the SARCOF meeting) to November (the MALOF meeting), when the increased predictability of the climate has been shown, through detailed analysis, to be useful for malaria early warning in Botswana.

In Malawi, the areas that can be covered by the index insurance scheme are limited by the number of meteorological stations with long-term, credible rainfall data. It is no coincidence that three of the four stations used in the pilot phase are associated with airports, where sufficient investment has been made to ensure that data are available and of high quality.

There is often a gap between the information most frequently requested by users (e.g. timing of rainfall onset, as requested by farmers in Mali) and the capacity of climate service providers to produce scientifically valid products that meet this need (onset being particularly difficult to predict in many areas).

Reinforcing and sustaining climate observation networks is essential if the full potential of climate information for decision making is to be realized

Strengthening observing systems in southern Africa's epidemic malaria zone will reinforce the region's malaria early warning system and also provide baseline information for food security. While satellite data may partially compensate for network deficiencies, rainfall estimates derived from satellite imagery can only be calibrated well if 'ground-truthed' against data from meteorological stations.

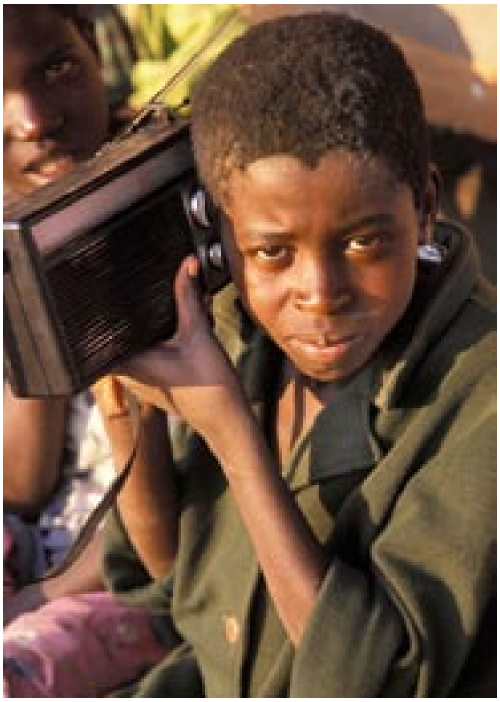
A greater number of stations will be required in countries such as Ethiopia, where the complex terrain makes interpolation of station data difficult. In less complex terrain the density of the network required to calibrate satellite imagery may be lower. The Ethiopian case study also showed the importance of using the national network of stations in the assessment of seasonal forecast skill. In Ethiopia as in many other African countries, meteorological stations, data, and services are particularly sparse in the remote rural areas where the poorest farmers and pastoralists tend to live.

In the Malawi case study, the uptake of drought insurance is constrained by the scarcity of high-quality meteorological stations. Even within the pilot project, scale was found to be an important issue as local climate variability created winners and losers within a 20-km radius of the rainfall gauge: insurance payouts were based on information from this central point, irrespective of the amount of rain that actually fell on farmers' plots.

Information and communications technologies, the media, and extension services are vital components of improved information systems

Use of ICTs, the media, and extension services varies considerably among the case studies. With regard to ICTs, while the communication environment has improved rapidly in most urban areas of Africa, coverage outside the cities tends to focus only on high-income/population-dense corridors, which are not necessarily the critical areas for climate information. Coverage is still very poor in the more deeply rural areas, where the poorer smallholders live.

The media are vital for communicating with the general public and are often a primary source of information for decision makers. The timeliness and credibility of the information they provide are essential – as is communication in a manner (language, conceptual framework, etc) that resonates with the reader, listener, or viewer. The role of the media in the case studies has evolved in parallel with the intervention paradigm (see 'Food security in Ethiopia'), from a solely 'reactive' one – reporting a disaster after it has happened – towards a more proactive approach involving the dissemination of early warning



The media can save lives when disaster looms; J. Schytte/ Still Pictures

information and the provision of advice for farmers in response to weather forecasts. In Mali, rural radio has proven the ideal tool for disseminating information to widely scattered communities in local languages and in terms that are understood by farmers. In the malaria example, local-level awareness raising, which depends on effective and timely communication, is essential for saving lives in areas where epidemics occur only rarely and populations are both highly vulnerable to the disease and unaccustomed to dealing with it. The more extreme the event predicted, the harder it may be to elicit a response as the tragic examples of Xai-Xai and Chokwe, in the Mozambique case, demonstrate all too clearly. These two towns had never flooded within human memory, leading many inhabitants to ignore the warnings.

ICTs and the media are not sufficient for a functioning information system, however. They need to be complemented by local institutional communication networks. These may consist of agricultural extension workers, health workers, teachers, traditional rulers, farmers' or other civil society groups, or other entities, including those created by specific projects. In the case of Mali, for example, the multidisciplinary (boundary) groups established at the outset of the project have played a key role in enabling farmers to integrate climate information into their existing management practices. These groups also ensure that farmers' information needs are conveyed back to the information suppliers. Thus effective human interaction is used to process, refine, and guide the application of information available from other sources.

■ Innovations for managing climate-related risks are being developed and deployed

The tools for analyzing and managing climate risks are evolving rapidly at present and some exciting new options are becoming available. For example, drought insurance, as designed and tested in Malawi, offers a promising way of protecting resource-poor farming communities against climate variability while promoting the uptake of yield-increasing technologies; sophisticated cyclone monitoring off the coast of Mozambique provides essential early warning to this disaster-prone country; and satellite data have facilitated the management of malaria in southern Africa by bolstering risk assessment and monitoring. Seasonal forecasts are becoming a routine source of information in many settings. However, such innovations often require long-term investment if they are to be widely taken up at the community level or effectively institutionalized in national systems. Note that, in the Mali project, it has taken more than 20 years of sustained donor support for the project's innovative agrometeorology activities to take hold.

Economic analysis of the value of climate services is lacking

Although the case studies show that climate information can usefully be incorporated into decision-making, only one – that of Mali – has provided limited quantitative evidence to indicate the resulting economic benefits. Such evidence greatly reinforces the case for providing such information – a case the Malian government has accepted. Detailed economic analysis is essential if governments and donors faced with competing priorities and limited budgets are to prioritize the provision of climate services over other development activities. Furthermore, an understanding of the development economics of climate variability and change can stimulate the creation of new products and services – as in the Malawi case, where the provision of microcredit, identified as an important catalyst for development, is now supported by drought risk insurance based on climate services.

The case study countries could benefit from each other's experiences

All the case studies contain elements of good practice in bringing climate information to bear on policy, planning, and practice. There are opportunities for transferring these elements to other countries where they could also prove useful.

For example, the Mali study demonstrates how information and resources already used for planning and ensuring food security at the national level can also be used to meet farmers' needs, with direct positive effects on crop yields and incomes. Ethiopia, where the national meteorological service plays a similar role in national food security, could learn from this experience. Similarly, the Malawi case shows how farmers can gain access to credit and adopt new yield-increasing technology when provided with drought insurance, which reduces the moral hazard associated with conventional crop insurance by using rainfall as a proxy for drought risk.

Could drought insurance benefit other African countries? Farmers in Kenya may soon be given a chance to find out; P. Sanchez/IRI

Since Mali has invested in strengthening both its meteorological services and its links with farmer groups, there is considerable potential for combining drought insurance with the provision of agrometeorological information. The MEWS system in southern Africa is based in part on the concept of famine early warning systems, such as the one developed in Ethiopia. This indicates the considerable overlap in information requirements between the different sectors – a feature that can be further exploited to secure efficiency gains. Mozambique's increased investment in community resilience to flood disasters provides an important focus of effort which can both learn from and inform other disaster risk reduction efforts in food security and health.

Recommendations

The recommendations that follow are generic rather than project-specific. They are directed towards national policy makers responsible for research and development efforts, leaders of national disaster risk reduction efforts, national meteorological services, research institutes and line ministries for climate-sensitive sectors, and relevant international development and research partners, including donor agencies.

Women, who provide much of the labor in rural Africa, stand to benefit as much as men from timely climate information; Isabelle Jeanne/Unité Santé Environment Climat CERMES

Recast climate as a 'development' issue

Climate has long been understood as an important issue for sustainable development, but it has largely been ignored by development planners and economists. It must be recast in development terms if it is to be perceived as a core development issue. That means spelling out the economic implications of climate-related risks such as famine, malaria, flooding etc. It also means establishing the potential of climate information and services to improve the management of risk and promote sustainable development. Investment in judiciously chosen studies to quantify the economic impact of climate variability and change as well as the benefits of climate information in climate-sensitive sectors is therefore recommended.

Encourage institutional innovation

There are centers of excellence throughout Africa that can play key roles in developing, managing, extending, and sharing knowledge on how to better manage climate-related risks. Creating institutional networks and partnerships that can develop and implement innovative, problem-focused CRM programs is essential if these centers are to continue to achieve positive development outcomes as climate change takes hold. These programs will need to do business differently to those of the past, bringing together the different R&D communities needed for effective CRM and integrating their knowledge to develop new approaches, tools, and methods.

Specifically, investment in 'boundary institutions' can help to bring climate information to bear on sectoral planning and decision making. These institutions can act as intermediaries between scientists and decision makers or between climate specialists and sectoral managers. They can translate scientific knowledge into practical guidance for the organizations that wield decision-making authority, and can help clarify the needs of decision makers so that these guide scientific enquiry.

Orient meteorological services towards achieving development outcomes

Many national meteorological services at present have little incentive, are not sufficiently resourced, or are not mandated to provide agriculture and other climate-sensitive sectors with the full range of services they need. Governments are urged to make the necessary institutional changes, including the provision of new resources where necessary, to reorient national meteorological services towards sustainable development outcomes.

Strengthen research in support of climate risk management

Innovative strategic and applied climate research has a key role to play in improving CRM as we embark on an increasingly uncertain climatic future. This research should span the continuum from daily or near-term weather and seasonal forecasting to long-term predictions. But climate science by itself will not be enough: also needed is sector-specific research to understand the implications of climate change and its relationship with the sector concerned, and to improve sectoral decision making under climate uncertainty. With regard to the latter, it is important to understand why people and institutions do what they do and what it would take to change their decisions for the better.

Promote systematic knowledge sharing

A knowledge management system allows the efficient sharing of approaches and experiences among institutions so as to promote the rapid and effective uptake of innovative practices, technologies, and research results. Almost everywhere in Africa, however, the development of such systems is afforded low priority and is inadequately funded at present, leading to critical information gaps. This needs to be addressed through better funding, improved partnerships, and concerted knowledge sharing, across both sectors and scales.

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Acronyms

ACMAD	African Centre of Meteorological Application for Development
AGRHYMET	Centre Régional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle
AUC	African Union Commission
CILSS	Comité Permanent Inter-États de Lutte contre la Sécheresse dans le Sahel
CRM	Climate risk management
CSMT	Seasonal Climatic Suitability for Malaria Transmission
DFID	Department for International Development of the UK
DNM	Direction Nationale de la Météorologie (Mali)
DRAMR	Direction Régionale d'Appui au Monde Rurale
ENSO	El Niño-Southern Oscillation
FAO	Food and Agricultural Organization of the United Nations
GCOS	Global Climate Observing System
GDP	Gross domestic product
GIS	Geographic information system
ICTs	Information and communication technologies
IRI	International Research Institute for Climate and Society
MALOF	Malaria Outlook Forum (also known as Africa Regional Epidemic Outlook Forum)
MARA	Pan-African Mapping Malaria Risk in Africa
MDGs	Millennium Development Goals
MEWS	Malaria Early Warning and Response System
MRFC	Malawi Rural Finance Company
NASFAM	National Smallholder Farmers Association of Malawi
NDVI	Normalized Difference Vegetation Index
NEPAD	New Partnership for Africa's Development
NGOs	Non-government organizations
NOAA	National Oceanic and Atmospheric Administration
OAU	Organisation of African Unity
ORS	Office de Riz Ségou
OHVN	Organisation de la Haute Vallée du Niger
OIBM	Opportunity International Banking Malawi

PAIP/HELVETAS	Programme d'Appui aux Initiatives des Producteurs et Productrices Agricoles
R&D	Research and development
RANET	Community Radio and Internet
SADC	Southern African Development Community
SARCOF	Southern African Regional Climate Outlook Forum
SDC	Swiss Agency for Development and Cooperation
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNICEF	United Nations Children's Fund
WHO	World Health Organization
WMO	World Meteorological Organization

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