Adaptation

CCAA LEARNING PAPER

Keziya Magawa, a farmer with Nazareti Womens' Group, tends maize in a field school in Chibelela, Tanzania.

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Integrating meteorological and indigenous knowledge-based seasonal climate forecasts for the agricultural sector

Lessons from participatory action research in sub-Saharan Africa

Edited by:
Gina Ziervogel, Alfred Opere

Contributing authors:
Ignitius Chagonda
Jacob Churi
Amadou Dieye
Boris Houenou
Said Hounkponou
Eric Kisiangani
Evans Kituyi
Cromwel Lukorito
Ayub Macharia
Henry Mahoo
Amos Majule
Paul Mapfumo
Florence Mtambanengwe
Francis Mugabe
Laban Ogallo
Gilbert Ouma
Amadou Sall
Greno Wanda

IDRC CRDI
DFID Department for International Development

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Cover photo: Keziya Magawa, a farmer with Nazareti Womens' Group, tends maize in a field school in Chibelela, Tanzania.

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Please send enquiries and comments to ccaa@idrc.ca

About CCAA

The Climate Change Adaptation in Africa (CCAA) program was launched in 2006 and is jointly funded by Canada's International Development Research Centre (IDRC) and the United Kingdom's Department for International Development (DFID). It is hosted and managed by IDRC from headquarters in Ottawa and three regional offices in Africa.

Web site: www.idrc.ca/ccaa

About IDRC

IDRC is a Canadian Crown corporation that works in close collaboration with researchers from the developing world in their search for the means to build healthier, more equitable, and more prosperous societies.

www.idrc.ca

About DFID

DFID is the part of the UK government that manages Britain's aid to poor countries and works to get rid of extreme poverty.

www.dfid.gov.uk

About CCAA Learning Papers

In 2009, the CCAA program launched a series of learning forums, bringing supported research teams together to share knowledge on themes relevant to climate change adaptation. These forums facilitate learning across teams, and aim to generate synthetic lessons and findings useful to government officials, development organizations, donors, communities affected by climate change, and a broad range of institutions working to support adaptation in Africa.

Through a facilitated process of discussion, forum participants share research findings, and progressively deepen their exploration of common themes arising. Facilitators, CCAA staff members, and technical editors work with researchers and subject area specialists to crystallize key learning, and structure knowledge into core topics for further discussion. The results of these successive rounds of discussion are then written up in paper form and extensively reviewed by contributors, external experts, and CCAA staff members.

CCAA Learning Papers can be accessed in electronic format at www.idrc.ca/ccaa along with briefs which accompany most titles. Hard copies are available upon request.

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Dr Carla Roncoli, Associate Director, Master's in Development Practice and Adjunct Faculty, Department of Anthropology, Emory University

Professor Tim Wheeler, School of Agriculture, Policy and Development, University of Reading, and deputy chief scientific advisor to the Department for International Development

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Acronyms

CCAA	Climate Change Adaptation in Africa
CSE	Centre de suivi écologique
GHA	Greater Horn of Africa
ICPAC	IGAD Climate Prediction and Applications Centre
IDID	Initiatives pour un développement intégré durable
IGAD	Intergovernmental Authority on Development
IKF	indigenous knowledge-based seasonal forecast
IRA	Institute of Resource Assessment (University of Dar es Salaam)
KMD	Kenya Meteorological Department
MSU	Midland State University (Zimbabwe)
PAR	participatory action research
SCF	seasonal climate forecasts developed by national meteorological services
SUA	Sokoine University of Agriculture (Tanzania)
TMA	Tanzania Meteorological Agency

Farmers walk through flooded rice fields in Malawi.

Photo courtesy of Gina Ziervogel

Introduction

Extreme climatic events, such as droughts and floods, as well as changes in the mean climate, have a direct effect on crops and livestock and, thus, people's livelihoods. Food security is at risk, particularly in sub-Saharan Africa where local production remains largely rain-fed. Given that climate variability is likely to increase with increasing greenhouse gas emissions, it is more important than ever to understand how this variability can be managed to reduce the negative consequences.

The impact is already significant. In Malawi, for example, as a result of the 2002 drought, approximately 5 million people needed emergency food aid, which took a long time to be delivered. A similar situation occurred in Niger in 2004–2005 when approximately 2.5 million people — or a fifth of the population — was in need of food rations (UNDP 2007). In 2009, approximately 3.8 million people in Kenya required food aid because of the prolonged drought (FEWS Net 2010). In 2006, sub-Saharan Africa accounted for 13% of the world's population and 25% of the undernourished people in the developing world (FAO 2006).

Reducing the impact of climate variability and change on food production and livelihoods may be achieved, in part, by using available climate information to anticipate and manage annual climate-related risks (Tarhule 2005; Washington et al. 2006). Climate information is available from two main sources: meteorological seasonal climate forecasts (SCFs) and indigenous knowledge-based seasonal forecasts (IKFs). This information can help farmers and pastoralists manage their crops and livestock to minimize risks during unfavourable seasons and maximize opportunities during favourable conditions. However, exploring the synergies between these two sources of climate information is a challenge. It requires not only an understanding of the current uptake of the information, but also mechanisms and policies to support improvements in generating, disseminating, and using climate information.

SCFs are generated by national meteorological and hydrological services using models and empirical data. These specialized, scientific institutions generate weather and climate-related products under guidelines set by the World Meteorological Organization. Their work is supplemented by other regional and international climate centres including the African Centre of Meteorological Applications for Development, the Centre Régional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationelle (AGRHYMET), IGAD Climate Prediction and Applications Centre (ICPAC), the Climate Systems Analysis Group (University of Cape Town), the United Kingdom Meteorological Office, the National Oceanic and Atmospheric Administration, and others.

Climate information can help farmers and pastoralists manage their crops and livestock to minimize risks and maximize opportunities.

Producing useful forecasts requires a deep understanding of the needs of specific user groups and the benefits and challenges forecasts may present to these users.

IKFs, on the other hand, are produced locally by people who live in the area for which the prediction is made. They are often based on generations of experience and include both biophysical and mystical indicators.

Although for years many communities have successfully relied on indigenous forecasting methods in planning agricultural activities, SCFs have become increasingly available in many parts of Africa over recent decades (O'Brien and Vogel 2003; Patt et al. 2007; Roncoli et al. 2009). However, despite significant advances in the science of seasonal forecasting and increased awareness of these forecasts, most African countries have not experienced significant benefits from using this information to reduce climate impacts. A key challenge has been access to and ability to respond to meteorological climate information, by vulnerable groups as well as institutions and agencies charged with managing the impacts of climate variability.

Producing useful forecasts requires a deep understanding of the characteristics and needs of specific user groups (Ziervogel 2004) as well as a clear view of the benefits and challenges they present to these users. Studies carried out in West Africa (Roncoli et al. 2009) and southern Africa (Ziervogel and Calder 2003; Ziervogel et al. 2006) show limited adoption of SCFs by farmers because of serious resource limitations (lack of land, labour, inputs, credit, and market access) and limited exposure to the use of such forecasts. It is, therefore, important that the needs and concerns of users, in particular vulnerable groups, inform the content and dissemination of forecasts. The fact that many small-scale farmers are unable to take advantage of forecasts due to resource constraints means that socioeconomic and political needs as well as cultural contexts must be addressed in adaptation planning, along with climate information needs.

Combining meteorological and indigenous seasonal forecasting is one way to deal with the challenges faced in the development, communication, and use of climate information. Many farmers already use indigenous forecasts in their farm-level decisions and may only need certain information, such as total rainfall expected in the season, to complement what they already have. Similarly, some farmers use SCFs, but the temporal and spatial scale of these is not precise enough; thus, they could benefit from the local details added by IKFs. It is, therefore, important that policymakers, practitioners, and forecasters (both from meteorological services and indigenous groups) target existing gaps and take advantage of opportunities if they are to support farmers and pastoralists in managing climate risk.

The Climate Change Adaptation in Africa (CCAA) program, funded by the International Development Research Centre (Canada) and the Department for International Development (United Kingdom), has supported a number of projects that have investigated how SCFs might be better integrated into agricultural and pastoral decision-making to strengthen livelihoods and food security. Through these projects, it has become clear that IKFs, which have been used by communities for decades, provide information that is complementary to the SCFs. Some projects set out to investigate links between the two information sources at the outset, while others explored them when they emerged as an important focus in supporting increased uptake of SCF information.

In this paper, we seek to answer two questions. First, how can farmers' and pastoralists' needs be met by the dissemination and application of meteorological information and, second, how can SCFs complement indigenous knowledge about the climate.

Although much research has been done over the past two decades on the challenges of and opportunities for applying SCFs, much of it has been theoretical (Patt and Gwata 2002; Archer 2003; Ziervogel et al. 2006). The CCAA projects provide a new insight, as they are based on participatory action research (PAR) methods, which involve researchers working with farmers, extension officers, meteorologists, and policymakers to explore the realities of disseminating SCFs on the ground. The objective of this

CCAA projects provide new insight, as they involve researchers working with farmers, extension officers, meteorologists, and policymakers to explore the realities of disseminating forecasts.

report is to document the process and lessons learned during the projects with respect to using, applying, and integrating SCFs and IKFs. The individual project teams also intend to analyze in more detail the implications of their specific research projects for practice and policy.

We begin by documenting lessons learned from eight PAR projects on the use of SCFs and their integration with IKFs, as captured in a learning forum hosted by the CCAA program in March 2010 (see "About *CCAA Learning Papers*" on p.i). We then focus on the current availability of seasonal forecasts and indigenous knowledge before exploring how the two types of information have been integrated, as well as the platforms for disseminating this information and the challenges of applying it. We conclude by suggesting ways to strengthen capacity to manage climate variability among farmers, pastoralists, researchers, policymakers, and providers of climate information.

The selected PAR projects and their lead institutions are listed here. Participants in these projects were brought together for a week of learning that provided an opportunity to share experiences and insights developed over the previous three years of the projects' lifespans.

Also invited to take part in the discussions were experts from three institutions — the Niamey-based African Centre of Meteorological Applications for Development, the Hadley Centre in the United Kingdom, and the Nairobi-based ICPAC — that are involved in the production and dissemination of meteorological information. These institutions represented one of the target audiences of the forum's output. Several other participants from a wide range of backgrounds, including the humanitarian aid and development community, government and academia, were also in attendance as observers.

Context

Use of climate information by agricultural and pastoral communities: As small-scale farmers in sub-Saharan Africa face increasingly variable rainfall, in terms of the start and end of season and the amount and distribution of rainfall, the scientific community hopes that seasonal climate information can help them prepare and, therefore, reduce the negative impacts of climate variability. Increased attention has also been paid to indigenous knowledge that draws on local understanding of the environment to inform livelihood strategies. It may be possible to increase food security if these combined forecasts can help improve agricultural yields. Through technical and management

CCAA projects that contributed knowledge to the learning forum

Project title and lead institution	Short form in text
Strengthening the Capacity to Adapt to Climate Change in Rural Benin, Initiatives pour un développement intégré durable	Benin (IDID)
Infoclim: Platform for Helping Vulnerable Communities Adapt to Climate Change in Senegal, Centre de suivi écologique	InfoClim (CSE)
Integrating Indigenous Knowledge in Climate Risk Management to Support Community Based Adaptation in Western Kenya, ICPAC	IK in Western Kenya (ICPAC)
Managing Risk, Reducing Vulnerability and Enhancing Productivity under a Changing Climate in the Greater Horn of Africa, Sokoine University of Agriculture	Managing Risk in the GHA (SUA)
Resilience and the African Smallholder : Enhancing the Capacity of Communities to Adapt to Climate Change in Seven African Countries, University of Zimbabwe	African Smallholders (U. of Zimbabwe)
Building Capacity to Adapt to Climate Change in Zambia and Zimbabwe, Midlands State University, Zimbabwe	Zambia and Zimbabwe (MSU)
Strengthening Local Agricultural Innovation Systems in Tanzania and Malawi, Institute of Resource Assessment, University of Dar es Salaam	Tanzania and Malawi (IRA)
Enhancing Adaptation to Climate Change among Pastoralists in Northern Kenya, Practical Action	Pastoralist Adaptation (Practical Action)

adjustments, farmers might be able to take advantage of good seasons and minimize risks during less favourable ones. The PAR projects explored these opportunities in their various regional contexts.

Although gains have been made in bringing together users and suppliers of climate information, numerous challenges remain associated with its use. Among farmers, there is often confusion over terminology (e.g., "seasonal" and "weather" forecasts used interchangeably and what is meant by below and above normal rainfall). In some cases, it is not clear what information is of most use. The most widely available information from the seasonal forecast is total seasonal rainfall. However, users are often interested in the onset, cessation, and intra-seasonal variations to support decisions about what crops to plant, when to plant, which technologies to use, and when to harvest.

Rationale for exploring the integration of meteorological and indigenous forecasts: Meteorological services have been producing SCFs for the last few decades, and these are available in most countries in Africa (O'Brien and Vogel 2003; Washington et al. 2006; Patt et al. 2007). However, their uptake by small-scale farmers and pastoralists has been limited (Archer 2003; Luseno et al. 2003; Ziervogel et al. 2006). The research community hopes that SCFs can be better used to inform decisions on crop types, planting date, and the need for measures to safeguard yields (Patt and Gwata 2002; Ziervogel 2004; Patt et al. 2005).

It is often hard for farmers and others, including chiefs and extension officers, to interpret probability-based forecasts and know how to respond to them.

In some places, targeted research has helped farmers understand the nature of the information and how it might be used (Patt and Gwata 2002; Roncoli et al. 2002; Ziervogel 2004; Patt et al. 2005; Roncoli 2007). Research has also shown that users like to have interaction with those knowledgeable about the forecast before making decisions about how to use it (Ziervogel 2004).

Currently available climate information and farmers' views of it

Seasonal climate forecasts: The SCFs produced by the meteorological services are disseminated at the national level in every country. The country is usually divided into regions where different seasonal rainfall totals are expected. The information about expected rainfall is given in probabilities, e.g., 40% chance of above-normal rainfall, 30% chance of normal, and 30% chance of below-normal rainfall. According to project teams in Zambia, Zimbabwe, Tanzania, and Kenya, it is often hard for farmers and others, including chiefs and extension officers, to interpret these probabilities and know how to respond to them.

There is also concern because the forecasts cover too large an area. In eastern Zimbabwe, for example, project participants wanted to minimize their losses associated

Table 1: Comparison of IKF and SCF methods

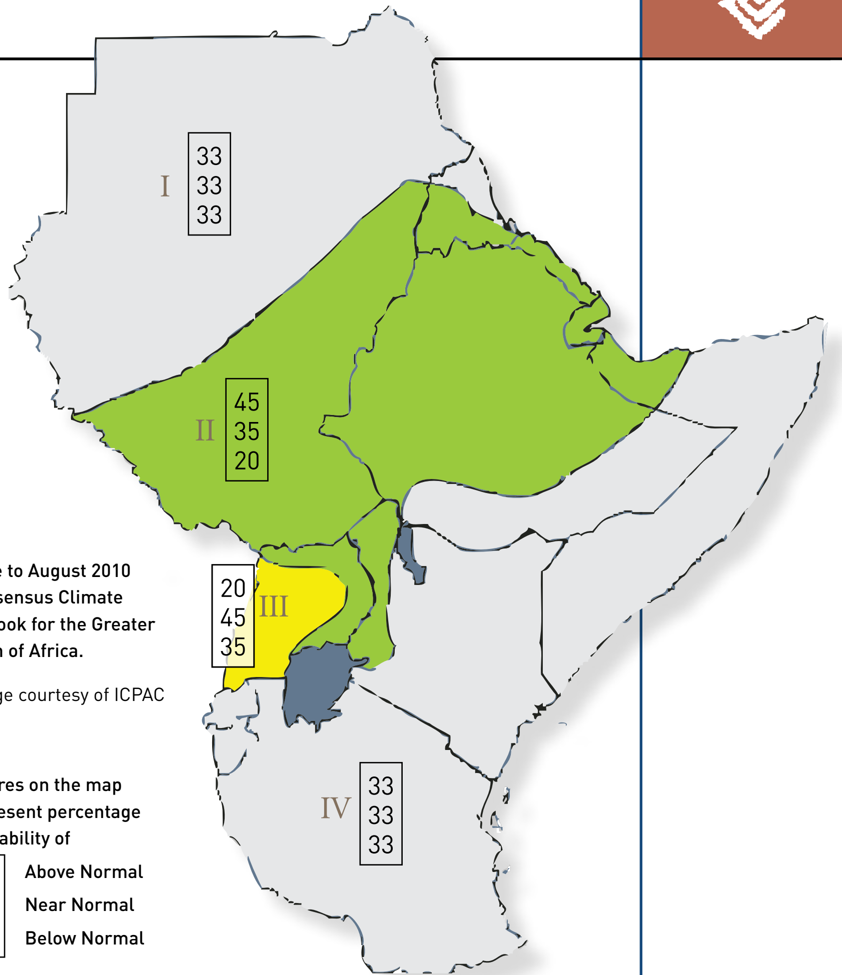
IKFs	SCFs
Use biophysical indicators of the environment as well as spiritual methods	Use weather and climate models of measurable meteorological data
Forecast methods are seldom documented	Forecast methods are more developed and documented
Up-scaling and down-scaling are usually complex	Up-scaling and down-scaling are relatively simple
Indicators are mostly observed	Indicators are usually measurable
Application of forecast output is less developed	Application of forecast output is more developed
Communication is usually oral	Communication is usually written
Explanation is based on spiritual and social values	Explanation is theoretical
Taught by observation and experience	Taught through lectures and readings

with climatic variation. Farmers might want to sell their livestock before an imminent drought and restock when conditions become favourable. Alternatively, they might move their livestock to localities where more favourable conditions are expected and where relatives or friends could keep the cattle in trust until conditions improve in their home range. When presented with the SCF, they said the information covered areas that were too large for them to have local relevance and inform their decisions.

They also thought that the short-term weather forecasts on radio and television were for cities and holiday resorts and not for farm areas, because city names were given on the weather map as reference points. This example highlights the fact that communities' requests for information are different from what is provided by the national forecasters. Table 1 compares IKFs and scientific methods of forecasting.

Although national climate information is often disseminated by radio, the project in Benin found that this method is only useful if broadcasts occur at times when farmers can listen, which vary according to season. They have learned that when farmers are tilling, the broadcast should be in the evening, but when farmers are waiting for the rains to start, the broadcast can be in the afternoon. The project team also found that local discussion forums facilitated by climate information providers and local stakeholders can improve follow-up and uptake of information heard on the radio. However, it is important to first assess community access to radio.

A number of projects found that SCFs are not received when farmers most need them, although it was not clear why. Farmers would like forecasts at least a month in advance of the short (October–December) and long (March–May) rainy seasons. Sometimes they are received a few weeks before the season starts, by which time farmers have already made key decisions about their crops — types of seeds, when to plant — and have purchased inputs, such as fertilizer. For this reason, in Same district, Tanzania, IKFs are being used to complement SCFs. IKFs are available early enough to give



June to August 2010 Consensus Climate Outlook for the Greater Horn of Africa.

Image courtesy of ICPAC

Key
Figures on the map represent percentage probability of

A	**Above Normal**
B	**Near Normal**
C	**Below Normal**

In Benin, research found that radio broadcasts of climate information are only useful if they occur at times when farmers can listen, which vary according to season.

farmers time to prepare. A key lesson for meteorological departments is that timeliness of information dissemination is critical to farmer uptake.

In Same district, farmers used to struggle to interpret SCFs from the Tanzania Meteorological Agency (TMA). But now, as a result of the Managing Risk in the GHA (SUA) project, a team has been established to interpret and disseminate the forecast, with the result that people are becoming more interested.

In general, distribution of SCF information is still too supply driven at the national level. Participants felt that this reflects a lack of understanding of specific user needs. However, tailoring of climate information will depend on disseminators and users of the information ensuring that their preferences are communicated to the meteorological services.

Another shortcoming of the current national-level seasonal climate information is that it does not provide advice on interventions. Some meteorological services integrate the forecast with agricultural advice, producing an agro-meteorology bulletin with suggestions on what agricultural strategies might be most appropriate given the expected rainfall. However, project participants felt that this type of information remains too broad to be useful: the information

Table 2: Comparison of IKFs, SCFs, and an integrated forecast for selected seasons and locations in Kenya and Tanzania

Season and location	IKF summary report and indicators	SCF report	Integrated report	Performance of integrated forecast
MAM 2010 Same, Tanzania (Managing Risk in the GHA project site)	Frogs making a lot of noise, ants moving and spreading across roads, signifying that the Masika (rainy) season is about to start. IKF indicators show that rains during the Masika season will decrease especially in May.	Seasonal rainfall will be normal. The main indicators include sea surface temperatures of the Indian and Pacific Oceans and wind strength.	The IKFs and TMA forecasts indicate normal rains, expected to decrease as the season progresses.	Reported as "very good" meaning almost all predicted events came to pass.
SOND 2009 Nganyi community (IK in Western Kenya projects)	Stars and bubbles in water pots in shrines suggest rains will start in the 2nd week of August. Mid-August to end of September: light rain. October to early December: increased rainfall intensity. 2nd week of December to mid-January: light rain. Rains will be accompanied by heavy storms, but not as severe as those in the previous season (March–May 2009). Early rains will be polluted. The overall distribution of rains over the season will be good.	August to September: low-intensity rainfall. October to November: more intense rainfall. Rains to continue into January 2010. Good overall distribution of rain throughout the season with no extended dry spells. There will be heavy storms and high winds.	The Nganyi forecast provided a more detailed version of the KMD forecast and was therefore adopted as follows: 2nd week August: onset of the rainy season. Mid-August to end of September: light rains. October to early December: increased rainfall intensity. 2nd week December to mid-January 2010: light rains.	Reported as "very good" meaning almost all predicted events for the season came to pass.

> The integration of indigenous knowledge is very important as it is highly localized, and often comes with practical advice on measures to take in light of the forecast conditions.

is insufficiently downscaled to provide advice at the local level, and farmers in different parts of a district may need to respond differently because of unique local environmental conditions. The integration of indigenous knowledge is very important in this process, as it is highly localized, and often comes with practical advice on measures to take in light of the forecast conditions. Using local languages and terminology familiar to farmers is also essential to the usability of forecast information, and too often overlooked in the provision of SCFs.

Learning forum participants observed that improvements in infrastructure and capacity building among staff at local meteorological stations might help address some of the challenges around producing useful forecasts and increase coverage. In Tanzania, the meteorological services have been decentralized, and participants felt that this could support direct interaction and engagement with communities.

Indigenous knowledge about climate: Traditionally, farmers have based their decisions about crop and irrigation cycles on indigenous knowledge of weather and climate patterns. This knowledge has been gained through many decades of experience and has been passed down through generations. The knowledge is also adapted to local conditions and needs.

One of the reasons indigenous knowledge plays a big role in farmers' decisions is because traditional societies' livelihoods are closely intertwined with nature (UNEP 2007). Their survival has depended on the sustainability of resources in their local environment, thus, they have conserved these resources by adhering to strict traditional laws — including taboos and heavy penalties — under the guidance of elders (DMCN 2004). Particular plant and animal species were considered sacred or associated with bad omens that hindered people from overexploiting them. Some species were associated with shrines and water sources protected by effective clan laws. Plants or animals that provided medicine and food became the subject of strict rules and practices to ensure their continuing availability (Ocholla-Ayayo 1976).

Indigenous communities recognize that to be able to live with natural hazards, they must monitor environmental conditions, including the weather and climate, to make relevant predictions and advise on appropriate actions to reduce the impact of variable climate (UNEP 2007). Observing stars, wind patterns, cloud movement, and the position of the moon and sun allows weather and climate forecasts to be made. Knowledge also exists about patterns in the occurrence of local natural hazards. People know that they have to plan to be able to cope with natural disasters and various ways are sought to recover from hazards. Such knowledge is not properly documented, but depends on oral education by elders. Accumulated indigenous knowledge is passed from one generation to the next through traditional socialization processes.

Because of the oral nature of indigenous knowledge, little has been published on the process of integrating it into environmental conservation, management of natural disasters, or indicators of and responses to climate variability. Another challenge is maintaining this information base in the face of the demise of older generations and the current wider scale of interactions of communities with other cultures. It is important to record this precious knowledge before it becomes "extinct" (Ocholla-Ayayo 2003).

Various indicators and predictors (environmental, biological, and traditional belief) are commonly used by farmers to support farm decisions and adaptive measures. This knowledge is based on locally defined conditions and needs and is dynamic and nurtured by observation. The experience of men and women farmers is incorporated into the indicators, modifying them slightly to meet current needs and situations. As an example, Table 2 gives the forecasts and indicators used by the IK in Western Kenya (ICPAC) project and the Tanzania component of the Managing Risk in the GHA (SUA) project.

In the Zambia and Zimbabwe (MSU) project, the key indigenous knowledge indicators used for weather and climate forecasting included fruiting patterns, the emergence of leaves and weeds, and wind movement. North to south winds are called male winds, while south to north are female winds. When either is strong, rainfall is expected. The observation of clear cloudless days has also been linked to some meteorological processes in this area.

Western scientists have tended to reject the traditional knowledge of local communities as primitive, non-quantitative, employing non-conventional methods, and unscientific. However, indigenous knowledge systems have more recently attracted the attention of many people in both developed and developing countries, and the importance

Nganyi IK forecasters explain the use of some of the tools they use in interpreting natural indicators.

Photo: IDRC and DFID/ T. Omondi

In Zambia and Zimbabwe, indigenous knowledge indicators included fruiting patterns, the emergence of leaves and weeds, and wind movement.

of this information is beginning to be recognized. Practitioners are starting to realize the importance of recognizing and working with indigenous knowledge that builds on generations of experience (Orlove et al. 2010) to best support the adaptive capacity and strategies of rural communities.

Integration of IKFs and SCFs

It is clear that IKFs and SCFs both have strengths and weaknesses. A major challenge is how to bring them together in a way that respects their different values and builds on their strengths. This is set against a backdrop of a changing climate, which means that indigenous knowledge indicators might not be as reliable as they were in the past. Some projects have noted that increasing variability in climate has reduced farmers' confidence in traditional knowledge and has led them to seek out both seasonal and short-term weather forecasts. If SCFs can capture the increasingly variable climate, they may be able to provide important information that can create a framework for developing strategies for responding and adapting to climate change.

Because indigenous knowledge has been used for generations and is part of many rural communities' way of life, it makes sense to explore the role of IKFs in relation to SCFs. This is particularly important if SCFs are seen as external knowledge, too general, and of questionable relevance to small-scale farmers and pastoralists. It is a challenge for disseminators to package the two information types; however, those involved in the learning forum supported an approach that does not prioritize either type of information, but rather finds ways to use both.

One of the projects, implemented by ICPAC working with the Nganyi community in western Kenya, has experience in integrating these two domains of climate knowledge (Box 2). Despite the project's achievements, challenges still centre on building trust and acceptance of the SCFs by the community, sourcing and authenticating information based on indigenous knowledge, and acquiring meteorological data within the project area to cross-validate SCFs and IKFs. There is also an urgent need to integrate indigenous risk-reduction strategies with SCFs to provide local communities with new tools for coping with the current climate extremes and adapting for future climate changes and greater impacts.

Integration of IKFs and SCFs in the IK in Western Kenya project

Twice a year, the IGAD Climate Prediction and Applications Centre (ICPAC) convenes a Climate Outlook Forum for the Greater Horn of Africa which produces a consensus seasonal forecast from modern-day climate scientists. The forecast is subsequently downscaled for Kenya by Kenya Meteorological Department (KMD). In September 2008, through a CCAA-supported project focusing on IK in Western Kenya, ICPAC brought meteorologists and Nganyi indigenous knowledge forecasters together to produce a further downscaled consensus forecast for the project area. The Nganyi clan is locally renowned for its forecasting abilities. For generations, family members have handed down their skill and knowledge in interpreting local indicators, including plant and animal behaviour, night sky phenomena and a host of other signs that many consider mystical rather than scientific.

The method for arriving at a consensus began with presentation of the meteorological forecasts for the region and the consensus indigenous forecast (11 groups from within the Nganyi clan met to agree on a common forecast). This was followed by a facilitated discussion of the two forecasts by all. The points of departure were thoroughly considered and reasons for the differences explored. Agreement was then reached on a harmonized forecast. The indigenous knowledge practitioners were very useful in this process, as they are familiar with the local features that would modify the large-scale systems considered by the meteorological methods.

Representatives of government departments (e.g., health, agriculture, education, security, water) were then invited to assume the role of change agent in communicating the risks arising from the forecast. The officials produced advisories for the public regarding activities in their area of responsibility in anticipation of the forecast conditions. The integrated forecast and advisories were then disseminated to the larger community at a meeting at a church compound within the project area. The various advisories were presented by the officer responsible for the subject area.

The meetings were also used to evaluate the previous season's forecast, specifically, whether it was accurate, whether people received it in time, and whether any weather-related impacts were experienced in the region during the season. An evaluation of the first season's forecast, validated by information from the community at the dissemination workshop, revealed surprisingly good results — the community concurred that the forecast was accurate.

Over the life of the project, five seasonal forecasts went through a similar "bridging" process, bringing together meteorologically-based climate outlooks for the region, with the more locally specific forecasts produced by the Nganyi. These took place in September 2008, March 2009, September 2009, March 2010 and September 2010.

A key outcome expected of the project is increased use of climate information by the community in planning their activities, along with increased mutual trust and information exchange between climate scientists and those with indigenous knowledge. In addition, the project will be able to document the history and practices of the Nganyi community and outline the structure of a sustainable disaster risk management curriculum incorporating indigenous knowledge. In July 2010, KMD committed resources to build a new community resource centre which will help to sustain indigenous forecasting practices, and strengthen the harmonization between SCF and IKF begun in this project.

SCF meets IKF: Members of the Nganyi "rainmaker" clan of western Kenya working with meteorologists to develop a harmonized forecast that bridges between their systems of interpretation.

Photo: IDRC and DFID/ T. Omondi

> Meteorological information is usually too "coarse" for crop planning, but integrating indigenous forecasts with those provided by the meteorological departments can bridge this gap.

To integrate the different forecasts, detailed information about both types must be available. This seems to be an emerging challenge in Senegal also, according to the Infoclim (CSE) project, with information based on indigenous knowledge not easily available. The reluctance of those with indigenous knowledge is understandable and should be respected. However, if trust is developed between partners through participatory projects, opportunities for working together are likely to increase.

Combining IKFs and SCFs is one way to deal with the challenges faced in the development, communication, and use of seasonal forecasts. Many farmers already make use of indigenous forecasts in their farm-level decisions. Thus, forecasters should target existing gaps so as to add value to communities working on the ground. Meteorological services could help explain the probability approach for the benefit of indigenous knowledge users. Meteorological information is usually too "coarse" for crop planning, but integrating IKFs with the SCFs provided by the meteorological departments can bridge this gap as demonstrated by the IK in Western Kenya (ICPAC) and Managing Risk in the GHA (SUA) projects.

Climatologists are often uncertain what role indigenous knowledge might play and indigenous knowledge forecasters are suspicious of external people telling them about their environment. For future integration to occur, both groups must be open to working together and building understanding and trust. If this is achieved, imaginative, innovative, and perhaps unexpected responses to climate risk may emerge.

Validation: One way to increase acceptance of IKFs among the scientific community is to validate these forecasts by comparing them with SCFs. The starting point would be to monitor indigenous knowledge indicators to see whether they are linked to known scientific parameters. Tanzania and Benin projects brought farmers and researchers together in the field to observe and reflect on phenological change identified by farmers and linked to other environmental indicators. Another method was to use a core team to monitor indigenous knowledge indicators, then explore how these indicators relate to scientific ones.

Down-scaling and up-scaling climate information: A second step in easing the integration of SCFs and IKFs might be to look at information at the same spatial scale. SCFs are usually given for regions rather than localities. In Benin, for example, the meteorological service was unable to provide rainfall distribution; hence, most farmers relied on local indicators. However, advances have been made that allow for down-scaling to the local level.

Some participants at the learning forum felt that there is a need to scale up some indigenous knowledge indicators, such as certain tree species, so that they could be used more widely. Up-scaling might be a priority if communities identified this need and if relevant indicators could be scaled. Mystical indicators, for example, cannot be up-scaled as people outside a local area have no knowledge of them. But plant indicators may be used over a wide area. Local knowledge about such indicators could be shared with other communities. Up-scaling of tree species as indigenous knowledge indicators has been carried out in the Zambia and Zimbabwe (MSU) and Benin (IDID) projects.

Forecasting is not an end in itself, but should be viewed in a context of decision-making and risk management. Thus, there were conflicting opinions about whether indigenous knowledge should be up-scaled. At the forum, some people felt that indigenous knowledge is only useful locally and should not be up-scaled. Others felt that it could be "out-scaled," where findings in one place (where there are good meteorological data and where relationships between the two approaches can be demonstrated) can be extrapolated to other areas. Exactly how this might be done has not been established. Similarly, some researchers feel that indigenous knowledge should be used in regional consensus forums by integrating it with meteorological science, but how to do this remains a challenge.

Tailoring information to user needs

Tailoring climate information to farmers' and pastoralists' local needs requires a number of steps and a range of stakeholders must be involved. One of the clearest contributions made by the PAR projects has been the establishment of multistakeholder platforms to interpret meteorological, climate, agronomic, and indigenous information, develop advice about how farmers and pastoralists might change their farming practices in light of this information, and disseminate the tailored information to

Farmers and researchers discussing drought tolerant maize varieties near Vumari village of Tanzania's Same district.

Photo courtesy of SUA

In Benin, pre-alert committees such as the one shown here bring together national and local stakeholders to interpret data and develop agro-meteorological advisories useful to rural producers.

Photo courtesy of IDID-ONG

make it more accessible to users than the national level seasonal forecast.

The project in Benin, for example, has established pre-alert committees in 35 communes and it works with a national agro-meteorological pre-alert committee. The national committee includes members from the national meteorological services, the national farmers committee, the Ministry of Agriculture, the Ministry of Environment, researchers from national research institutes and the two national universities, project members, NGOs, and farmers. They receive the national agro-meteorological information from the meteorological services in bulletin form. The various members provide input, based on their interpretation of the national information as well as their own experience and disciplinary background to develop a package of holistic and locally relevant information they think will be suited to farmer use.

They prepare a bulletin in French and send it to the local pre-alert committees, which are composed of representatives of farmers' organizations, local leaders, extension service members, and local radio stations. The local committees adapt the information to their area by considering recent weather and the stage of agricultural production farmers are engaged in. The information is also translated into the local language. A communication plan is then developed targeting farmer meetings in the villages and local radio.

In Same District, Tanzania, the Managing Risk in the GHA (SUA) project has established a core team that includes staff from the meteorological services, NGO representatives, extension officers from district to village levels, researchers, input suppliers, and indigenous weather forecasting groups. Once the national SCF is released by the TMA, the core team meets and compares it with the indigenous knowledge-based weather forecast. Since the project began 3 years ago, the two types of forecasts have not contradicted each other. The comparison has made it easier to make recommendations to farmers on which crops to plant and when, whether they should consider diversifying, and whether pastoralists might consider selling their livestock. This advice is disseminated via brochures that extension officers and district officials distribute or use as reference material when talking to farmers. The project

These platforms have increased farmer confidence and capacity to use data while helping scientists understand IKFs and better tailor their forecasts for local adaptation.

team also prints posters that are put up in district offices and given to villages. To ensure that this work is sustainable, the project team has asked the district authorities to set aside a budget for team meetings in the future and to extend the practice to other areas.

These learning platforms have served two main functions. First, they have brought together actors who might not usually spend time together, thus strengthening communication channels among those in the information chain. Second, the interactions have built confidence among both farmers and extension officers in terms of understanding and using the data. The multi-stakeholder platforms have not only been effective in increasing farmer confidence and building farmer capacity to understand and use data, but have also increased scientists' capacity to understand IKFs and better tailor their forecasts for local adaptation.

The platforms also served another function in projects in Malawi and Zimbabwe. They provided an opportunity to raise awareness among farmers about both climate change and seasonal climate information. Building such awareness seemed to create increased demand for climate information (from the meteorological services, from IKFs, and from the consensus forecast where available). It also increased awareness among suppliers of climate data and those disseminating the data about the needs of farmers.

In eastern Zimbabwe (MSU), an innovative method of role-playing was used to help the various stakeholders understand the needs and constraints of the others. For example, farmers assumed the roles of meteorological service scientists and vice versa and acted out their response to the forecasts. This proved to be a powerful way to help people see the nature of the problem and think through various decisions as well as develop a basic understanding of some of the uncertainties associated with the forecasts.

Although establishing these new platforms serves many good purposes, existing information dissemination channels can also be strengthened as a way of improving information flow and contributing to the sustainability of information dissemination. This was clear in the project which aimed at enhancing adaptation to climate change among pastoralists in northern Kenya. By exploring existing formal and informal information channels, which were not immediately evident, the project was able to build on these channels before attempting to develop new ones.

For example, they found that key sources of information for herders were the shops and houses selling goods to them. Women, on the other hand, share information at the wells where they collect water; they discuss weather, range conditions, and where herders have moved. It was clear that settled pastoralists receive information at regular meetings convened by the local chief. The chief, who is in contact with the district steering group that convenes to examine climate information relevant to the district, passes on that information at the monthly village meetings. Project and extension staff members occasionally attend these meetings as well to disseminate climate and non-climate information.

One of the key challenges that emerged around establishing platforms for information use is the danger of creating expectations and dependency. In some projects, such as in the African Smallholders (U. of Zimbabwe) research in Zimbabwe, free inputs, such as seeds, are being given to farmers to help them put into practice the advice they receive through the platforms. The seeds must be used on the learning plots. However, because many of the communities in the area are vulnerable, they are receiving a lot of assistance from NGOs and the government, which can determine the type of crop or variety they plant. Thus, it is imperative that policymakers are included in the system for disseminating climate information to ensure that the right seeds or crop varieties are distributed to the right place. Although this might make sense during these participatory projects, there was a concern that this might create farmer dependency and reward failure in some cases.

Applying tailored climate information

The platforms mentioned above are places where various actors work together to produce new information. In this section, we describe how some of that information and advice is put into practice.

In southern Zambia and southwestern Zimbabwe, the Zambia and Zimbabwe project has developed learning centres, where various options for managing climate variability are demonstrated in test fields. Through the learning centres, training modules are presented by researchers, meteorological officers, and extension officers, who provide climate forecasts and adaptation strategies to sensitize farmers. Those doing the training get IKFs from farmers and integrate this information with SCFs from meteorological officers before preparing and disseminating advisories to farmers.

Using this information, villages then decide what strategies to follow and what technology to employ. These decisions then become the basis for what the project participants refer to as "baby trials" that address the concerns of a particular village and are managed by farmers within that village. "Mother trials" then combine the various "baby trials" and represent the concerns of a ward — about 600 households in the Zimbabwean context.

Both mother and baby trials are monitored by the researchers and the farmers throughout the season, and a field day is held at harvest to demonstrate the effect of various crop management practices on yield, based on the given forecast. An interesting outcome of this approach is that the farmers have taken it upon themselves to pass on this information and have developed dramas and songs related to the lessons they learn. Evidence of use has been demonstrated in reapplication and scaling up of practices that were taught. In addition, there has been a rise in demand for early dissemination of the SCF and the training modules, as a result of the perceived increase in yield among farmers who had attended the training.

In Malawi, farmers involved in "learning plots" have begun to adopt these strategies in their own fields. This seems to be attributable to the demonstration technique and learning by doing of farmers participating in the Tanzania and Malawi (IRA) project. In addition to uptake of adaptation strategies, there has also been a change in attitude toward adaptation to climate change. Before the project, farmers associated change in weather with natural causes and thought they could not do anything about it; now they realize that they can initiate adaptive strategies on their own. Instead of accepting dry spells as evil or natural calamities, farmers are now demanding more information from extension service providers on weather conditions and how they might plan. They are finding that some kinds of IKFs are not working as they used to. Previously, when the temperature rose, the rains would begin; now it gets hot for two weeks and the rains don't come.

Instead of accepting dry spells as evil or natural calamities, farmers are now demanding more information on weather conditions and how they might plan.

In central Tanzania, climate information is paired with technical advice, such as promotion of in situ rainwater harvesting technologies and improved early-maturing and drought-tolerant varieties, and this has led to an increase in yield of farmers who adopted the innovations.

As part of the Tanzania and Malawi (IRA) project, they have also used learning plots, but they differ from those used in Zimbabwe. The plots linked to the learning centre are "mother plots," where all sets of treatments are applied, including different fertilizers and seeds. The farmers then choose one or two of the strategies demonstrated in the mother plots to try on their "baby plots."

The farmers involved in the project help harvest the mother plots and can judge the results for themselves. In the 2009 cropping season, for example, it was evident that the use of new tillage methods increased yields. These methods included ripping (using the *Magoye* ripper implement that creates deeper furrows), tie-ridging (using an ox-drawn ridger and ties between furrows to increase water retention), and deep ploughing using a "spring jembe" (a long, narrow implement attached to a hoe supported on a used motor vehicle suspension spring that has the ability to make deep furrows on hard soils). Using these methods increased sorghum yields 30.5–66% over those using traditional tillage methods (slash and burn, locally called kuberega).

The InfoClim (CSE) project in Senegal also supports a process of learning among partners. A regional committee and a number of local committees work with farmers to gather information on practices in the previous season. Each local committee holds a forum once a year; most local people attend and talk about past experiences, challenges, and what they might do in the coming season. During the season, the local committee meets twice with the regional committee for updates.

Evidence of change can be seen in the increased uptake of climate information by farmers. Although they said they appreciated the information they received from the meteorological office before the project started, they weren't

Research leader Henry Mahoo of Sokoine University of Agriculture discusses the use of rain gauges with farmers in Mhezi village, Tanzania.

Photo courtesy of SUA

Information that is tailored to user needs is more likely to be used.

sure how to use it. Now, because the climate information is more specific to their local area, farmers are seeing and discussing the benefits of using it. For example, after the local committee evaluated information from all partners, they suggested that it was too early to start planting. Those who planted early lost their crops. Similarly, at the end of the season the committee suggested that farmers might wait to harvest as they were expecting more rain. Those who did not wait lost out on better yields. The sharing of information and experience has strengthened farmers' capacity and built a collective understanding, supported by growing trust between the various actors.

It is clear that these multi-stakeholder platforms are helping to clarify how farmers interpret and apply climate information. As seen from the examples above, they can also be a good forum for disseminating successful farming practices and, because multiple stakeholders are involved, they help create ownership which appears to be increasing the use of climate information.

The way forward

Lessons for national meteorological services and regional climate centres: These projects provide numerous lessons for meteorological services in terms of strengthening the type of information provided and how it is disseminated, as well as interactions with users.

Information that is tailored to user needs is more likely to be used. Clearly, farmers want more than just information about the overall rainfall expected in a season. They need to know how the upcoming season will differ from normal seasons in terms of the onset of the rainy season, cessation, and lengths of dry spells, as well as the seasonal total. More important, there is a desire for agro-meteorological information rather than just meteorological information. For example, although farmers want to hear about rainfall, they are more interested in suggestions about how they might change their activities in response to changes in rainfall total and timing.

Some meteorological services include agro-meteorologists who can develop this advice. Where this is not the case, partnerships are required to provide the needed information. As was clearly seen from the projects, agro-meteorological information becomes more useful if it is interpreted in relation to local conditions and local activities. Meteorological services cannot be expected to provide locally relevant information in all areas, which again supports the need for partnerships. Agricultural extension

When meteorologists engage with indigenous knowledge forecasters, value is added to the information from both sources.

officers, in particular, are important allies because of their experience with agriculture strategies, climate variability, and local communities' needs. In many cases, although extension officers have been trained in agricultural science, they grew up in local communities and are sensitive to the local signs and beliefs of their elders. Thus, they are in a key position to bridge the two types of information.

When meteorological staff engage with indigenous knowledge forecasters, value is added to the information from both sources. In projects where IKFs and SCFs were integrated (e.g., IK in Western Kenya and Managing Risk in the GHA), there was agreement on the expected forecast, highlighting the fact that the two types of knowledge can complement each other rather than being seen as separate. A significant challenge will be to get buy-in from meteorologists regarding the value of indigenous knowledge as well as getting indigenous knowledge forecasters to learn more about SCFs and potential synergies. It is evident from KMD and TMA experiences that the participatory process of engaging indigenous knowledge forecasters from the beginning is key to this, as well as feedback from users who can articulate how indigenous forecasts are able to meet some of their requirements where SCFs may fall short.

In addition to tailoring SCFs to users' needs, there are challenges related to the current spatial and temporal scale of the information. Farmers working in their fields not only want to know how the projections for the region are relevant to their own activities, they also need the information in time. Farmers start preparing for planting weeks or months before the season starts. If they receive the seasonal forecast two weeks before the season, it is often too late for them to change their plans. Through the projects, it became clear that providing indigenous forecasts earlier than the SCFs can help farmers start thinking and planning for changes. But there should also be more emphasis on helping meteorological services disseminate their information as quickly as possible, which can depend on the actors in the communications chain.

Support for integrating IKFs and SCFs: Among the eight projects represented at the learning forum, there was consensus that IKFs should be used more widely in conjunction with meteorological SCFs to increase reliability and acceptability of overall forecasts. For this reason, there were calls to promote the integration of these two types of climate information.

To improve current forecasting practices, more emphasis could be placed on identifying local predictors — both what they predict and their equivalent in meteorological terms. This should be explored in relation to climate change to help indigenous knowledge practitioners determine whether these indicators are affected by climate change. Meteorological services could start integrating local indigenous knowledge, such as phenological data, into their advisories to provide users with holistic information, as in the IK project in western Kenya and the IDID project in Benin. This alignment between SCFs and IKFs could help users see that the two approaches are not in opposition.

There was consensus that IKFs should be used more widely alongside meteorological SCFs to increase reliability and acceptability of overall forecasts.

A core multidisciplinary team is needed to carry out the integration. Both human and institutional capacity must be developed to validate indigenous knowledge indicators and find effective ways to link IKFs with SCFs. Local farmer-managed meteorological stations could be key in helping to validate IKFs, as had been shown through ICPAC's work in Kenya, Midlands State University in Zimbabwe, and the SUA team in Same, Tanzania. Achieving this integration is going to require sufficient time for case-study-based projects to pilot the various validation, integration, and dissemination techniques. In addition, it is important that those working with SCFs and students learning about them are more exposed to IKFs and their strengths from early on in the curriculum.

Supporting future uptake of integrated climate forecasts: The PAR projects have shown that even though indigenous knowledge is useful to farmers and can complement SCFs, to make the best use of this rich information, scientists and researchers will need increased capacity to request, analyze, and use the necessary data. Future research must involve specialists in fields, such as botany and zoology, who can study plant and animal behaviour and relate it to conventional forecasts. Indigenous knowledge providers also need to be supported so that they can share their knowledge

Partnerships among relevant institutions, NGOs, and local communities can strengthen capacity and increase use of seasonal and indigenous forecasts, on climate change, and on agricultural production.

without it being compromised.

Zambia and Zimbabwe (MSU) project participants suggested that some indicators are readily available from local communities, whereas others must be approached sensitively. They also found that only elderly people who grew up locally have good indigenous knowledge of their area. At the same time, meteorological agencies need to be engaged in the use of indigenous knowledge indicators to generate seasonal forecasts as evidenced by the ICPAC project. In this way, they can appreciate the value of IKFs in terms of integrating them with seasonal forecasts. In the Zambia and Zimbabwe project, there was evidence that meteorological offices located close to communities could most easily become familiar with local indigenous knowledge and understand how it relates to the seasonal forecast, in order to explore options for "scaling up" that knowledge where appropriate.

Developing partnerships among relevant institutions, NGOs, and local communities will enhance the capacity to cooperate on the use of seasonal and indigenous forecasts, on climate change, and on agricultural production. In Benin, for example, the PAR project influenced the meteorological service to start generating information for sectors other than aviation, because they saw the potential value for agriculture. Such partnerships should incorporate indigenous channels of dissemination — including dancers, artists, and dramatists, for example — beyond the use of conventional methods, such as radio, television, and extension workers.

The IK in Western Kenya (ICPAC), Managing Risk in the GHA (SUA), Zambia and Zimbabwe (MSU), and Benin (IDID) projects all indicated that when the two sources of weather forecasts were integrated, they were most often in agreement and complementary. However, participants suggested that one of the threats hindering the effective use of IKFs is the skepticism of many scientists. If this problem can be overcome, then meteorological science can be used to enrich indigenous knowledge based indicators and vice versa.

It has been clear in these projects that feedback from small-scale farmers to meteorologists helped the latter respond to user needs. Also, the sharing of data through the projects has strengthened trust and understanding among the various user groups. For example, in some countries, agricultural offices have shared rainfall data they collect from their areas of operations with the meteorological department. Such collaboration is expected to significantly improve the coverage as well as accuracy of the SCFs.

Lessons for policymakers: Policy support is needed to improve the nature and availability of information and to strengthen partnerships for sharing and using climate information. Improvements can be achieved by increasing meteorological services' capacity to generate climate information that is rigorous, timely, and relevant to users' needs. This includes providing more information than seasonal totals and improving channels for feedback on information uptake and use.

Researchers suggested that one of the threats hindering the effective use of IKFs is the skepticism of many scientists.

In some of the projects, ongoing engagement with policymakers has increased their attention, uptake, and participation. Involving policymakers allows them to see the benefits for themselves rather than being lobbied after the project results are available.

Another positive outcome of engaging policymakers during the project life cycle is their ability to lobby for mechanisms that contribute to sustainability. For example, in Zambia, policymakers who participated in a local project forum adopted a supporting financial role in the dissemination of information through radio in local languages. In Senegal, local authorities were involved in workshops and activities throughout the project. The self-organized farmer committees supported by the project were recognized

Involving policymakers allows them to see the benefits for themselves; in some cases they identified resources to sustain useful practices identified through research.

by local officials, providing them access to government resources. In Benin, engagement with local authorities has ensured budgetary support for radio communication beyond the life of the project. In addition, the project has been praised as a way to adapt to climate change and has gained sufficient support to be included in local development plans in approximately 35 towns.

In Kenya, the KMD recently allocated funds for the construction of a climate information resource centre (including a new meteorological station) on land purchased by the Nganyi community in western Kenya. KMD has been an active member of this PAR project and is committed to taking over leadership from ICPAC once the latter's role is complete.

Another important way to gain support for strengthening climate information is by using intermediaries or brokers who can influence policy, rather than project partners attempting to lobby directly. Brokers who are well positioned and are already part of the system, such as district officers, can also have a longer-term influence.

Policies to support partnerships that increase the sharing of climate information and its use in a holistic fashion — rather than focusing on the information itself — are central to climate adaptation and good development. Bringing together indigenous forecasters, extension officers, meteorological services, researchers, and farmers creates opportunities to look at agriculture and pastoralism in a holistic manner — recognizing the different actors, the types of information they provide, and how this information might help farmers adjust to more variable climate. This is a development priority and should be supported at the national, district, and local levels. Funding support can help initiate these platforms, but policy support that encourages ongoing engagement of various stakeholders is critical. This is also important in developing a national policy framework for inter-ministerial (multi-sectoral) data sharing. At the learning forum, many participants mentioned the difficulty of accessing and sharing data across sub-Saharan Africa, which may be an impediment to providing the agricultural section with climate information in a holistic way.

Although new platforms and partnerships are needed, in some cases existing institutions or structures can be built on to link the meteorological community and end-users. In some places, government department representatives at the local level can develop and disseminate advisories in local languages. Similarly, among pastoralists in Kenya, there are existing channels of information that can be used to disseminate climate information.

Policy support that encourages ongoing engagement of various stakeholders is critical. Many noted the difficulty of accessing and sharing data across sub-Saharan Africa.

Another component that is relevant for policymakers is the need to build capacity in a number of areas: the capacity to strengthen the scientific products and their dissemination, the capacity to work across disciplines, and the capacity to interpret and apply climate information (both SCFs and IKFs) at the local level. Activities, such as the PAR projects, that include a participatory process with a wide range of actors go a long way toward strengthening many of these capacities. In some instances, targeted support is needed to strengthen them even further. Rather than focusing on adaptation as an end-point, it should be seen that strengthening capacity supports the adaptation process. This is necessary so that local actors determine and implement their own adaptation responses rather than having them imposed from the top down.

The PAR projects have begun to demonstrate the usefulness of integrated forecasts. More examples of better decisions resulting from the use of the forecasts are needed to get broader buy-in. However, it is clear that there has been some success in integrating the two types of knowledge and this provides evidence for supporting those who encourage the integration of SCFs and IKFs.

Conclusion

The challenge of an increasingly variable climate is of particular concern to small-scale farmers and pastoralists in sub-Saharan Africa, as the weather determines the course of their lives. Information about conditions over the rainy season can help them prepare as much as possible and choose strategies to maximize yields and raise healthy livestock — the basis of their livelihood and food security.

Adapting to annual variability is an important start in dealing with long-term climate change. It is particularly important for people whose livelihoods are often fragile and for whom securing food and resources is a struggle. However, because they have lived in a variable environment for a long time, they have developed many ways to deal with variability. One of these ways has been to observe the environment and learn to read what changes mean in terms of coming weather. At the same time, western science has developed ways to predict weather and climate. Both methods can help inform agricultural management, and it is important to find opportunities to integrate them and deliver information in a way that is suited to user needs to ensure maximum benefit.

It is clear from the eight projects represented at the learning forum that the PAR approach has had significant benefits. Grounded in participation by the various stakeholders, it supported engagement from the beginning, which helped create trust and buy-in. Stakeholders were able to understand each other's perspectives and challenges and explore ways to work together over the course of several years. The participatory approach also enabled integrated climate information to inform farm decisions, as when farmers taking part in demonstration plots were able to provide feedback at end of a season and apply lessons they learned in the next season.

Integrating different types of knowledge and different stakeholder groups is not simple. However, because the challenges of adapting to climate change and improving food security in sub-Saharan Africa are significant, groundbreaking work, such as that shared in the PAR projects, must be recognized and supported to increase the resilience of farmers and pastoralists and help them adapt to climate variability and change.

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