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Scaling up climate services for farmers: Mission Possible

Learning from good practice in Africa and South Asia

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Front cover photo

A farmer tends to her vegetables in the CCAFS Climate Smart Villages in Lower Nyando, Kenya. Photo credit: K. Trautmann.

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Abbreviations and acronyms

AAS Agrometeorological Advisory Service
AFRRI African Farm Radio Research Initiative
ALC Active Listening Community
AMFU Agro Meteorological Field Unit
CA Conservation Agriculture
CBO Community-Based Organization
CC Control Community
CCAFS CGIAR Research Program on Climate Change, Agriculture and Food Security
CDKN Climate and Development Knowledge Network
CIMMYT International Maize and Wheat Improvement Center
CKW Community Knowledge Worker
CSP Climate Services Partnership
DAAS District-level Agrometeorological Advisory Service
ENSO El Niño-Southern Oscillation
FGD Focus Group Discussion
GFCS Global Framework for Climate Services (GFCS)
GTP *Groupe de Travail Pluridisciplinaire*
ICAR Indian Council of Agricultural Research
ICRISAT International Crops Research Institute for the Semi-Arid Tropics
ICPAD East Africa's IGAD Climate Prediction and Applications Center
ICT Information and Communications Technology
IGAD Intergovernmental Authority on Development
IMD India Meteorological Department
IRI International Research Institute for Climate and Society
ISRA Senegal Agricultural Research Institute
KVK *Krishi Vigyan Kendra*
NARES National Agricultural Research and Extension Systems
NARO National Agricultural Research Organization
NCMRWF National Centre for Medium Range Weather Forecasting
NGO Non-Governmental Organization
NHMS National Hydro-Meteorological Services
NMA National Meteorological Agency
NMS National meteorological services
NWP Numerical Weather Prediction
PAR Participatory Action Research
PLC Passive Listening Community
SAU State Agricultural University
SMS Short Message Service
UDOM Uganda Department of Meteorology
USAID United States Agency for International Development
WMO World Meteorological Organization

Executive summary

This report presents lessons learned from 18 case studies across Africa and South Asia that have developed and delivered weather and climate information and related advisory services for smallholder farmers. The case studies and resulting lessons provide insights on what will be needed to build effective national systems for the production, delivery, communication and evaluation of operational climate services for smallholder farmers across the developing world. The case studies include two national-scale programmes that have been the subject of recent assessments: India's Integrated Agrometeorological Advisory Service (AAS) Program, which provides tailored weather-based agrometeorological advisories to millions of farmers; and Mali's *Projet d'Assistance Agro-meteorologique au Monde Rural*, which provided innovative seasonal agrometeorological advisory services for smallholder farmers and 16 less mature initiatives operating at a pilot scale across Africa and South Asia. The case studies were examined from the standpoint of how they address five key challenges for scaling up effective climate services for farmers: *salience*, *access*, *legitimacy*, *equity* and *integration*.

Three lessons address the *salience* challenge. First, rural climate services are enabled by institutional arrangements and investment in capacity that support sustained interaction between climate forecasters, agricultural organizations and farmers, and enable the passage from climate information to a climate service. Second, climate services must be delivered at a local scale to be relevant to farm decision-making. Third, a seamless suite of forecast, advisory and early warning products at a range of lead times enables farmers to manage evolving risks through the season. Many of the case studies created space for dialogue to bring together climate and agricultural expertise, and to allow the two communities of practice to work together towards translating raw climate information into useful farmer advisories; before later formalizing these forums for dialogue into institutional frameworks, as was the case with Mali's multi-disciplinary working group. This structure emerges as an effective format to convene multiple types of expertise across climate and agricultural research needed to produce a climate service for farmers.

Addressing the *legitimacy* challenge requires giving farmers an effective voice in the design, production, and evaluation of climate services. This includes expanding the boundary of climate science and knowledge production to include agricultural knowledge, as well as the knowledge of farmers themselves, to produce a service they can use. In this area, integration of meteorological information with local indigenous knowledge has been suggested to foster trust, local relevance and use, but rigorous evidence is still lacking. Starting with farmers' knowledge base on climate and their existing predictors of climate variability, remains an important entry point to engage farmers in a meaningful dialogue on climate prediction and use of climate and weather forecasts.

Regarding the *access* challenge, face-to-face dialogue between farmers and service providers is an effective way to communicate historic and predicted seasonal climate information, as well as associated probabilities. Face-to-face seasonal workshops can be combined with Information and Communications Technologies (ICTs) and rural radio programmes to enhance access to climate services at shorter intervals. Participatory approaches are essential to identify the best combinations of communication channels and information content for a given context.

There is increasing evidence that *equity* is a general challenge when scaling up climate services beyond a pilot scale. Proactive targeting of women and other socially marginalized groups can help ensure gender and social inclusiveness in the design and delivery of climate information services for rural communities. Case studies reviewed also underscore the importance of participatory action-research (PAR) approaches in determining the needs of specific farmers within a community, and giving these farmers a voice in how their needs are satisfied. Because climate service needs are highly location-specific, local participation is needed to identify local needs and ensure appropriate tailoring of climate information to meet them. PAR approaches are found to improve uptake, sustainability and quality of the service.

Although the case studies we reviewed generally did not go far in addressing the integration challenge, we recognize that impact on farmer livelihoods at scale will depend on synergies between climate services and interventions within the broader national agricultural and rural development enterprise.

We conclude with a set of guidelines for climate service design that we recommend should be part of any effort to develop climate services at a national scale that seek to serve smallholder farmers. First, involve farmers in the co-design, co-production and co-evaluation of climate services. Second, establish partnerships that bridge the gap between climate, agricultural research and farmers. Third, exploit scalable communication channels to reach "the last mile." Fourth, continuously assess need to improve service delivery. Finally, proactively engage, and target the needs of the most vulnerable and marginalized, particularly women, from the onset. Opening spaces for co-production of climate services has proven a lengthy process, fraught with the challenges of institutional change; however it is a process that will need to be supported and accompanied as countries move to create their frameworks for climate services at the national level under the Global Framework for Climate Services (GFCS).

1. Introduction

Globally, some 80% of agriculture is rainfed, and this figure may reach up to 95% in some areas of sub-Saharan Africa (Alexandratos and Bruinsma 2012). Smallholder farmers in the developing world are particularly vulnerable to the impacts of weather fluctuations and climate extremes. Although farming communities throughout the world have survived by mastering the ability to adapt to widely varying weather and climatic conditions, increasingly erratic climate variability and the rapid pace of other drivers of change are overwhelming local knowledge and traditional coping mechanisms.

Climate services are receiving increasing attention globally as an important component of the agenda on climate adaptation (Zillman 2009; Hansen et al. 2014). Effective climate information and advisory services offer great potential to inform farmer decision-making in the face of increasing uncertainty, improve management of climate-related agricultural risk, and help farmers adapt to change. Mounting evidence on the added value of climate services in support of improved decision-making in a range of climate-vulnerable sectors, including agriculture and food security, disaster management, health and water management, has played an important role in making the case for climate services (see Hansen et al. 2011; Tall et al. 2012; Hellmuth et al. 2007 for examples).

Across sub-Saharan Africa and South Asia, encouraging experiences on the ground, both at pilot and national scales, have begun to grapple with the complexities of producing, communicating and evaluating climate services that address smallholder farmer decision-making needs under a changing climate (Tall et al. 2013). A few national programmes provide weather and climate information and advisory services to their farming populations on a sustained basis. The two most prominent of these are India's Integrated Agrometeorological Advisory Services (which announced plans to scale up to 10 million farmers in 2012) and Mali's *Projet d'Assistance Agro-meteorologique au Monde Rural* (which has provided innovative services to farmers since 1982). The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), with its partners, conducted studies of both of these programmes in order to provide evidence of use and benefit at the village level, and insights about factors that have contributed to their uptake, impact and sustainability (Moussa et al. 2012; Carr et al. 2014; Venkatasubramanian et al. 2014). Other initiatives in Africa and South Asia that have grappled with these complexities have tended to be pilot-scale and project-based. Despite their experimental nature and limited scale, these pilot cases demonstrate a number of good practices and provide valuable insights. To date, these experiences have not been analysed collectively in terms of the lessons they offer to inform future climate service initiatives that aim to reach large numbers of farmers.

This report reviews eighteen case studies, and synthesizes lessons about good practice in designing, developing and delivering climate services that they illustrate. Each of the case studies reviewed has addressed one or more key challenges to reaching smallholder farmers with decision-relevant climate services. While they employ a wide range of approaches, they collectively offer a set of practical insights on how to successfully design, tailor, communicate and evaluate relevant climate information and advisory services that reach farmers at scale. The report distills a set of lessons about good practices that the case studies demonstrate or illustrate. It further distills the lessons into guidelines towards improving the design, delivery and evaluation of tailored climate services for farmers across the developing world.

2. Climate services for farmers

"Climate services," as we use it, encompass the provision of relevant weather and climate information, and a range of advisory services to enable decision-makers to understand and act on the information – within a suitable enabling institutional environment. Tall 2013 distinguishes between climate information and a climate service. A climate service requires appropriate and sustained engagement with users to understand their needs, to involve them in co-design and co-evaluation of information products and services, and to develop effective communication mechanisms. Most of all, a climate service needs to be responsive to end-user needs.

While "weather" and "climate" represent distinct timescales, our use of "climate services" incorporates and expands on established weather information services that target agriculture. The atmosphere varies on a continuum of timescales, from sub-daily weather events to long-term climate change. These timescales of variability are often defined in terms of the dominant factors that drive them, and by extension, the source of predictability (table 1). "Weather" refers to environmental conditions at a given time, and is predictable at a maximum lead time of about two weeks. "Climate variability", on year-to-year to decadal timescales, is influenced by interactions between the atmosphere and its underlying ocean surface, such as those associated with the El Niño/Southern Oscillation (ENSO) in the tropical Pacific. At the long-term extreme of the continuum is "climate change" associated with natural and anthropogenic changes in the chemical composition and heat balance of the global atmosphere.

Climate-sensitive agricultural decisions also have a range of time horizons (table 2; Meinke and Stone 2005). Farmers typically need a combination of historic observations, monitored information through the growing season, and predictions at a range of timescales. To be useful, the timescale of information should match the planning horizon of particular management decisions. Relevant timescales for farm decision-making range from daily weather forecasts, to seasonal prediction, to climate change; but seldom exceed two decades. The field of agrometeorology has a long track record of research and applied work on delivering information and management advisories to farmers, based on monitoring and forecasting at the weather timescale (Stigter et al. 2013). Understanding of ENSO as a driver of climate variability led to advances in forecasting at a seasonal (i.e. ≥ 3-month) lead time (Glantz 2001; Cane et al. 1986; Zebiak et al. 2014). A study by Cane et al. (1994), who showed that ENSO-related Pacific sea surface temperatures were more strongly correlated with maize yields than with seasonal total rainfall in Zimbabwe, stimulated interest in applying seasonal forecasts to smallholder farming in the developing world. A strong and highly visible El Niño event in 1997/98 prompted a surge of effort around the use of seasonal forecasting for smallholder agriculture in the developing world. The advent of seasonal forecasting expanded the lead time of farmer-relevant information that is routinely available into the climate variability timescale, and contributed to the current global interest in climate services. While the longer timescales associated with climate change may influence some farm decisions, they appear to be more relevant to institutional and policy decisions (e.g. plant breeding programmes, market development, investment in infrastructure) that influence options and incentives for farmers.

Table 1. Timescales of atmospheric prediction

Term	Timescale	Source of predictability	Treatment of uncertainty
Weather	< 2 weeks	Initial atmospheric conditions	Deterministic: hourly-daily weather sequences
Climate variability	2 weeks to about 2 decades	Boundary conditions (ocean and land surfaces)	Probabilistic: shifts in probability distribution of seasonal statistics
Climate change	> about 2 decades	Anthropogenic and natural changes in atmospheric composition and heat balance	Scenarios: projections of plausible future climate statistics with unknown uncertainty

Table 2. Climate-sensitive agricultural decisions at a range of temporal and spatial scales (Meinke and Stone 2005)

Agricultural decision	Frequency (years)
Scheduling (e.g. planting, harvest operations)	Intraseasonal (> 0.2)
Tactical crop management (e.g. fertilizer, pesticide use)	Intraseasonal (0.2 – 0.5)
Crop selection (e.g. wheat or chickpeas) or herd management	Seasonal (0.5 – 1.0)
Crop sequence (e.g. long or short fallows) or stocking rates	Interannual (0.5 – 2.0)
Crop rotations (e.g. winter or summer crops)	Annual/bi-annual (1 – 2)
Crop industry (e.g. grain or cotton; native or improved pastures)	Decadal (~ 10)
Agricultural industry (e.g. crops or pastures)	Interdecadal (10 – 20)
Land use (e.g. agriculture or natural systems)	Multidecadal (20 and)
Land use and adaptation of current systems	Climate change

Farmers are best served by a combination of historic and monitored information, and a seamless suite of prediction that ranges from sub-daily weather to at least seasonal forecasts. Figure 1 illustrates the types of early actions that a farmer is able to take at different points in the agricultural calendar, in response to information at different timescales.

Short-term weather forecasts are experienced frequently enough that farmers can quickly develop an intuitive understanding of their accuracy, and rules of thumb for applying the information to management. As we go from weather to climate timescales, agricultural decisions tend to become more context- and farmer-specific, the information becomes more uncertain and hence more challenging to use, and therefore communication challenges and the scope of services required increase. These services may include translating raw climate information into predictions of agricultural impacts or management advisories, training, assistance with planning and organizing response mechanisms, and evaluation and feedback processes to continually improve information products and services. Although farmers out of necessity have a good intuitive understanding of climate variability, training is needed to enable farmers to understand quantitative and graphical presentations of probabilistic climate information. To be useful, raw climate information such as rainfall and temperature must be translated into impacts and management implications within the system being managed. While this is often done through subjective expertise or intuition, quantitative methods to translate historic, monitored and predicted climate information into predicted impacts on agricultural systems (crops, rangelands, pests, diseases), management advisories or decision-support tools is expected to increase the relevance of complex climate information to agricultural decisions.

Providing effective climate services for farmers, beyond the scale of a pilot research project, requires the involvement of a range of institutional stakeholders (Orlove and Tosteson 1999; Hansen 2002; Cash et al. 2006). At a national scale, we conceptualize a chain involving at a minimum national hydro-meteorological services (NHMS), national agricultural research and extension systems (NARES), communication and boundary organizations operating at a local level, institutional and government end users, and the farming communities as the ultimate end users (figure 2). NHMS are the stewards of historic observations; and provide predictions of hydrological and climate variables such temperature, rain, wind and extreme events that can then serve as input to the development of tailored climate services in support of decision-making. Much investment in climate services to date has focused on strengthening the capacity and credibility of NHMS. This investment is essential but not sufficient. As the structure charged with providing research-based knowledge, expert advice and training to farmers, NARES represent a critical second layer in the climate services chain. Where agricultural extension services are effective, they already have the knowledge and trust of farming communities, and have a comparative advantage in translating climate information into management advisories, as one component of the suite of services that they provide. In some countries, NARES have developed quantitative tools to translate climate information into predictions of impacts on agriculture, and to support decision-making by farmers and other agricultural decision-makers. NARES can be thought of as an "intermediary user"

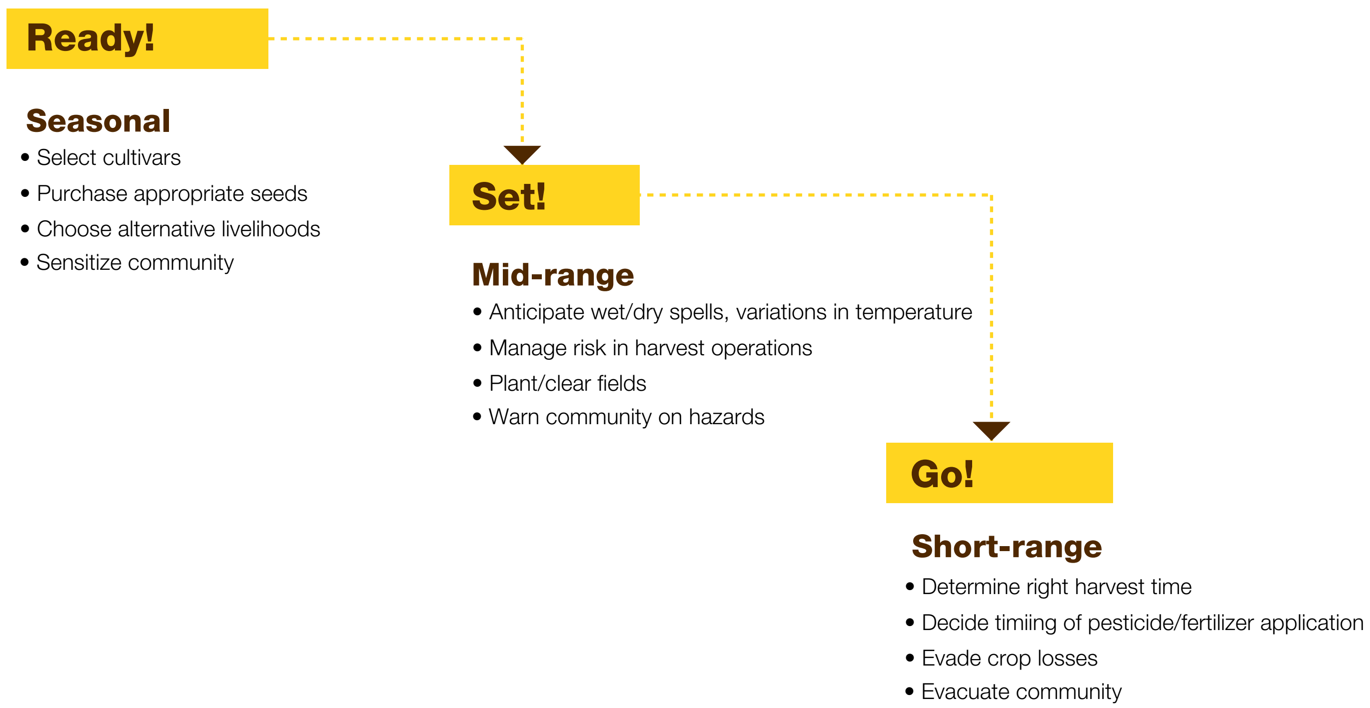


Figure 1. An illustration of possible farmer early actions based on prediction across timescales. Source: Tall (2013).

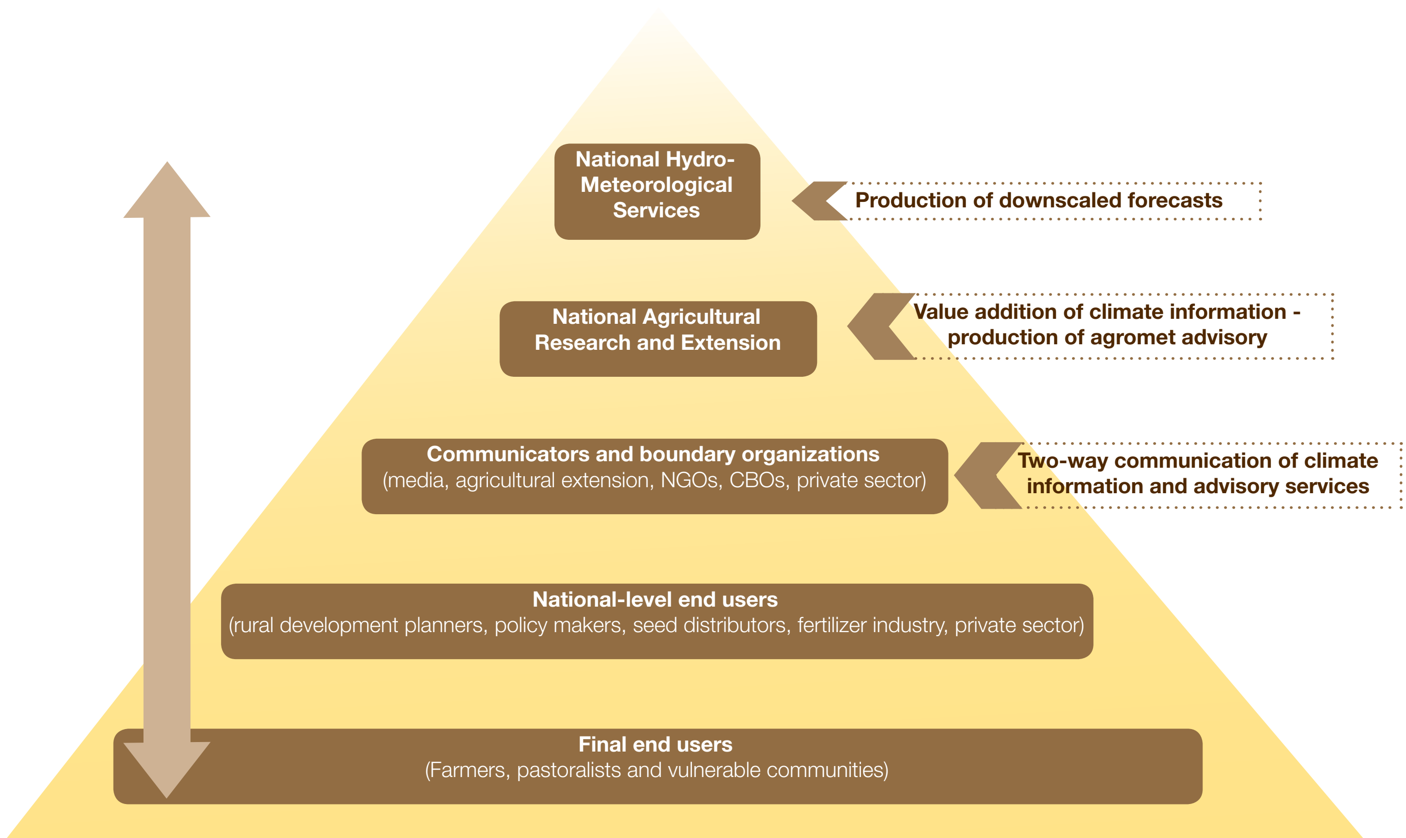


Figure 2. Different levels, roles and users in the chain of climate services at the national level.

or a "co-producer" of climate services, receiving climate information from the NHMS, and translating it into climate-informed advisories tailored to farmers' needs. In developing countries where NARES don't have the capacity to reach large rural populations, other organizations that interact with smallholder farming communities can play a vital role in providing climate services. These include non-governmental organizations (NGOs), community-based organizations (CBOs) such as farmer associations and religious organizations, and the media. End users in the agriculture sector include both vulnerable farming communities (the focus of this report), and a range of institutional and government decision-makers in the agriculture sector. From the available evidence, including case studies presented in this report, we believe that institutional structures/arrangements that provide climate services must involve end users as full partners in the co-design and co-production of climate services.

A substantial body of literature highlights conditions that must be met and challenges that must be overcome in order for climate and weather information to improve the livelihoods of vulnerable farmers (e.g. Stern and Easterly 1999; O'Brien et al. 2000; Hansen 2002; Ingram et al. 2002; Patt and Gwata 2002; Cash et al. 2006; Meinke et al. 2006; Suarez 2009; Tall 2010; Hansen et al. 2011; Stigter et al. 2013). While some of the factors that trap smallholder farmers in poverty also limit their ability to act on advance climate and weather early warning information, the majority of the challenges identified reflect communication and institutional failures, and are therefore arguably amenable to intervention (Hansen et al. 2011). Informed by this literature, a workshop on "*Scaling up Climate Services for Farmers in Africa and South Asia*" (Saly, Senegal, 10-12 December 2012) was held jointly by CCAFS, the United States Agency for International Development (USAID), the World Meteorological Organization (WMO) and the Climate Services Partnership (CSP) (Saly, Senegal, 10-12 December 2012) to identify and prioritize the major challenges, and to identify a way forward to address them. The process concluded that efforts to support smallholder farmers in the developing world through climate services must focus on five key challenges (Tall et al. 2013):

- *Salience*: tailoring content, scale, format and lead time to farm-level decision-making.
- Access: providing timely access to remote rural communities with marginal infrastructure.
- *Legitimacy*: giving farmers an effective voice in the design and delivery of climate services.
- *Equity*: ensuring that women, poor and socially marginalized groups have access to and can use available climate services.
- *Integration*: Providing climate services as part of a larger package of agricultural support and development assistance, enabling farmers to act on received information.

The case studies in this report were reviewed from the standpoint of approaches used to address these five challenges, and how effectively they do so.

3. Case studies of climate services for farmers

The case studies included in this review were selected from a roster of recent and ongoing efforts to provide climate and weather information and advisory services in Africa and South Asia. The cases were initially identified, documented, discussed and debated in the context of the international workshop, "*Scaling Up Climate Services for Farmers in Africa and South Asia*" (Tall et al. 2013). In addition to two national cases (India and Mali) that have been the focus of recent assessments, we surveyed 16 smaller, less mature initiatives that also endeavoured to provide climate services to farmers. These smaller pilot cases were broadly of two types: those that attempted to provide climate information directly to farmers, with no bundled services offering farmers advice on what to do (climate information projects); and those that experimented with providing climate information bundled with agricultural information and advisory services (climate service projects). Both types of pilots offer useful lessons regarding the impediments and enabling conditions to successfully scaling up climate services for farmers. In total, 18 case studies across Africa and South Asia were reviewed, including two national agrometeorological advisory programmes, 11 climate and weather information pilot projects, and five agricultural advisory and extension projects with climate or weather components. Cases were reviewed primarily from the standpoint of the approaches they used to address the key challenges identified. The case studies represent a wide range of approaches. Case studies that focus on information at a weather timescale were included where they appeared to address challenges and offer insights relevant to climate services. The availability of evidence of the degree of success also varied considerably among case studies. We considered available evidence, and the success factors proposed by those who provided the initial case study descriptions. Further information is available in Appendix 1.

Case 1: India's Integrated Agro-meteorological Advisory Service

India's Integrated Agrometeorological Advisory Service (AAS) programme has been operating in its current form since 2008, reaching more than three million farmers. The AAS was created after a series of pilot-level experiments that began in 1988, led by the National Centre for Medium Range Weather Forecasting (NCMRWF).

Agriculture is the mainstay of a majority of people in India and an important contributor to economic growth. Advances in agrometeorological expertise and its application in agricultural planning and production have been a priority of the Indian government as early as the 1930s, when the division of agrometeorology was started. Since then, a number of initiatives have been undertaken to improve and expand on agrometeorological faculties and facilities across the country. Agrometeorological advisories were first initiated in 1976 to provide state level forecast-based advisories to farmers based on short-range weather forecasts issued by the India Meteorological Department (IMD). Made available to farmers one day in advance, these advisories were inadequate for planning weather-based agricultural practices and/or undertaking precautionary measures, which required a much longer lead time.

In agriculture, location-specific weather forecasts in the medium range (3-10 days in advance) hold greater salience for farmers. In addition, forecasts issued need to be fine-tuned to the specific requirements of farmers, particularly in recommending activities and modifications to specific farm-level practices. Keeping these needs in mind, the NCMRWF was established in 1988 by the Government of India as a scientific mission to develop operational Numerical Weather Prediction (NWP) models for forecasting weather in the medium range. To disseminate these forecasts and build forecast-based agricultural advisories, Agro Meteorological Field Units (AMFUs) were created across the country, in all 127 agroclimatic zones.

By 2006, 86 fully functioning AMFUs, primarily located in state agricultural universities (SAUs) and agricultural research stations, were receiving weather forecasts from the NCMRWF twice a week; each forecast was valid for four to five days. Based on these forecasts, and in consultation with a team of agricultural scientists, the AMFUs prepared agricultural advisory bulletins. The advisories, prepared in both English and a local language, were then disseminated to farmers through a variety of communication channels, including radio, television, newspapers, telephone, posters and sometimes meetings. Due to the expansive nature of its production and dissemination, the AAS was soon held as an example of a successful multi-institutional and multi-disciplinary operation (Venkatasubramanian et al. 2014).

In 2007, the AAS was combined with the IMD under the Ministry of Earth Sciences, and as a result the District-level Agrometeorological Advisory Service (DAAS) was launched in June 2008. DAAS aims to generate district-level agro-meteorological advisories based on weather forecasts. DAAS continues to be a multi-institutional project involving a variety of stakeholders including the Indian Council of Agricultural Research (ICAR); SAUs; *Krishi Vigyan Kendras*[1] (KVKs); the Department of Agriculture and Cooperation; State Departments

[1] Krishi Vigyan Kendras (KVKs) are agricultural science extension centers established by the Indian Council of Agricultural Research.

of Agriculture, Horticulture, Animal Husbandry and Forestry; development NGOs and media agencies. DAAS has a four-tiered structure: meteorological (weather forecasting), agricultural (identifying how weather forecasts affect farming), extension (two-way communication with users) and information dissemination (media, IT and others) (see figure 3). In 2011, the DAAS began experimenting with block[2]-level forecasts for a few states and is currently expanding the project (Venkatasubramanian et al. 2014).

Today, IMD issues quantitative district level 5-day weather forecasts twice a week using a Multi-Model Ensemble technique based on forecast products from models available in India and other countries. Weather forecasts for seven parameters (rainfall, maximum and minimum temperatures, wind speed and direction, relative humidity and cloudiness) as well as weekly cumulative rainfall forecasts are generated. These products are disseminated to Regional Meteorological Centres and Meteorological Centres of IMD located in different states. Experts in these centres add value to IMD forecast products, which are then communicated to 130 AMFUs located within SAUs, ICAR Institutes, and Indian Institutes of Technology.

The AMFUs represent each of the 130 agroclimatic zones in the country, each covering 4-6 districts. Apart from recording agrometeorological observations for their respective zones through manual and automatic weather stations, these units are assisted by an advisory board consisting of agricultural scientists representing a wide spectrum of agricultural disciplines in preparation of district-wide agro-advisories. These advisories contain location and crop-specific farm-level advisories as well as descriptions of prevailing weather, soil and crop conditions, and suggestions for taking appropriate measures to minimize losses and optimize inputs in the form of irrigation, fertilizer or pesticides.

The AMFUs are also responsible for dissemination of advisory bulletins to farmers in their respective zones. This is done through several communication channels including mass media (newspapers, television and radio) and through the involvement of district level agencies (District Agricultural Offices, KVKs, Kisan (farmer) Call Centres, NGOs) to build on existing extension channels. More recently, cellular phones (voice mails and SMS) and the Internet are also becoming popular channels of dissemination. SMS services already reach 2.5 million farmer users across 16 states while voicemails via an Interactive Voice Response System reach 30,000 farmers across five states. In addition to reaching farmers to communicate agro-advisory bulletins, a feedback mechanism has been developed to receive inputs from farmers on quality of forecasts, relevance of advisories, and effectiveness of dissemination channels. New initiatives are underway to improve and expand dissemination to reach more farmers in a timely manner.

Web-based services have been greatly improved and expanded to provide agrometeorological information to users at all times through the Internet. Beginning with 25 centres across different agroclimatic zones in the country, the "All India Coordinated Research Project on Agrometeorology" of ICAR has launched a website (Crop Weather Outlook) for easy and immediate access to agrometeorological information and value added services provided by agricultural institutions. In several states, district-wide advisories issued bi-weekly are available online for immediate use. Linkages are also provided to other institutional web-links that can provide further information on agrometeorological operations to users.

The success of India's AAS programme rests on an important pre-requisite: substantial national investment in building a network of strong centres of excellence in meteorological forecasting as well as agricultural research, including human and technical capacity, at both national and state levels. This investment spans over multiple decades, and made possible India's current capacity for downscaling forecasts and value addition of the forecast with agricultural knowledge in order to produce locally salient, usable agromet advisories for farmers.

Other key circumstances for success in the India case include the multiplicity of dissemination outlets used by the AAS programme: e.g. its link with KVKs (national extension service), research institutes, public media, Internet, and private sector-operated cell phone companies (Vodacom, the GREEN SIM) to ensure that farmers in the most remote rural communities are reached with agrometeorological advisory messages; the inclusion of locally-trusted NGOs and CBOs in the programme (farmer cooperatives, village farmer associations, etc.) into training and communication activities to ensure appropriate communication; and finally in more recent years, IMD's targeted efforts to capture farmers' feedback on the programme through post-seasonal evaluation, and address gaps and service needs identified. These farmer feedback platforms have led to progressive improvements to the programme.

In 2012, CCAFS and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) partnered with IMD in conducting a village level assessment of the communication and use of AAS information, from the farmers' perspective. Researchers conducted focus groups with 490 farmers (45% female, 55% male) and interviewed 132 farmers (54% female, 46% male) in eighteen villages across six states, asking them directly how they receive and use AAS advisories, perceived gaps, and their suggestions for improvement (Venkatasubramanian et al 2014).

A key source of success identified by farmers in the study is the use of diverse communications channels to reach them, including SMS and voice messaging, media (newspapers, radio and television), Internet, meetings and trainings with agricultural

[2] A block is an administrative division in India. It is a sub-division of a district.

extension officers, local knowledge centres, local NGOs, farmers clubs, farmer fairs, bulletins, and announcements over the microphone in villages. In villages where farmers reported receiving AAS information through a larger number of communications channels, awareness and use of AAS information was found to be higher.

The assessment identified key areas of good practice in the AAS programme that are transferable to the scaling up of climate services programmes in other areas. Trainings and discussions in villages were identified as a superior dissemination channel; however, wide community mobilization and inclusion of all farmers within the community is critical to avoid excluding women and less socio-economically advantaged members of the community. Outreach to women, lower-caste and other disadvantaged farmers was identified as one large area for improvement of the programme. Identifying and operating through representative social networks (such as women's savings clubs) and the involvement of a trusted local NGO as a relay of agrometeorological advisories were seen as an important way forward to ensure greater inclusiveness. The presence of a local agrometeorological knowledge centre was also found to improve access to and usability of advisories. Sustained interaction between farmers, agrometeorologists and agricultural scientists, promoted by the presence of a local centre, was found to result in high use of advisories.

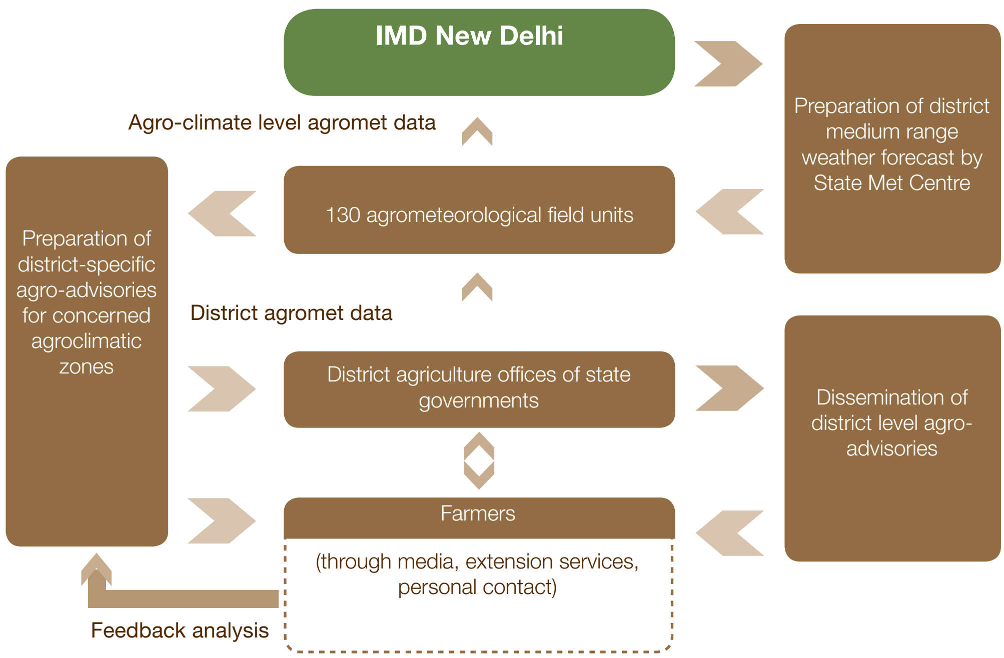


Figure 3. AAS institutional mechanism to reach farmers.
(source: IMD, New Delhi)

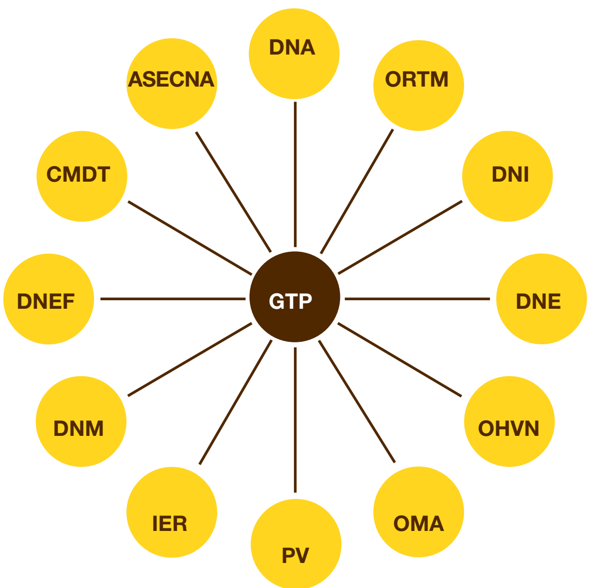
Case 2: Mali's Projet d'Assistance Agro-meteorologique au Monde Rural

In 1982, in response to the 1974 drought that wreaked havoc through the Sahel, Mali's National Meteorological Directorate launched a project to provide climate information to rural communities, especially farmers. Thus Mali's *Projet d'Assistance Agro-meteorologique au Monde Rural* was born. The aim was to provide weather and climate information that would help farmers make decisions about their crops, ultimately giving them long-term food security. The project was highly innovative from the outset. It was the first example of a national hydrological and meteorological service in Africa supplying weather and climate-related advice and recommendations directly to local communities, with an ambition to scale out to the national level (Diarra and Stigter 2008).

The goal of the project was to identify how rural farmers could use weather and climate information to make informed decisions in their farming activities to alleviate the impacts of drought. The project also sought to get rural communities directly involved in agrometeorological activities with extension workers, agricultural officials and policy makers. During the Mali project, local farmers were supplied with rain gauges to measure rainfall in their fields, and were trained in how to collect data and then use that data to inform their agricultural decisions.

The Mali project is significant because several public services and institutions were involved. The project activities were organized by a multidisciplinary working group, or *Groupe de Travail Pluridisciplinaire* (GTP) (figure 4). The group met every ten days and included people with technical, development and research backgrounds, including members of the national hydrological and meteorological service (NHMS), the Ministry of Agriculture, research institutes, rural development agencies, farmers and the media. The GTP was the centre of two-way information flow between climate service providers and the users. The national GTP was replicated with multidisciplinary working groups at a local level (Moussa et al. 2012).

The groups that participated in the Mali project had different, but well-integrated roles. The users defined the weather and climate-related data and products they needed. Farmers collected local rainfall data and then sent that information to the multidisciplinary working group. The Meteorological Service analysed the data. The extension services, and research groups, and Ministry of Agriculture worked on issues related to food production, crop health/protection, and choice of crop varieties. The rural development agencies focused on capacity building and information. And finally, the media disseminated the agrometeorological information.



DNA	National Agricultural Directorate
IER	Institute of Rural Economy
PV	Crop Protection Service
DNE	Livestock National Directorate
DNEF	National Water and Forestry Directorate
OHVN	High Niger Valley Organization
CMDT	Malian Cotton Development Company
DNM	National Meteorological Directorate
ASECNA	Agency for the Safety of Aerial Navigation in Africa
DNI	National Internal Affairs Directorate
OMA	Agricultural Markets Observatory
ORTM	National Radio and Television

Figure 4. Mali's multidisciplinary working group. Source: Moussa et al. 2012

In the Mali case, the GTP was responsible for processing data quickly and converting it into appropriate and useful advice for farmers. Most of that processing happened during their meetings. These meetings were also when the GTP formulated its agrometeorological warnings and advisories and prepared them for circulation to local communities via national radio and television.

The advice given to rural communities dealt with a wide range of agricultural topics. It included reference tables that helped farmers prepare their fields and sow their seeds. Using daily rainfall figures, hydrological reports, and daily weather forecasts, the advice also noted the best time to begin the planting season, as well as when to clear fields, use pesticides, and plant different varieties of seeds. Using information about rainfall, temperature, and humidity, the GTP warned farmers about outbreaks of crop diseases, especially mildew, based on information about rainfall, temperature, and humidity.

Although several national institutions took part, the GTP at the outset worked informally without formal legal status. The objective was to promote participation among the different stakeholders and actors involved in the project, while limiting the cumbersome administrative process. Following its inception, though, the GTP was later formalized by presidential decree. This, according to the artisans of the Mali project, was an important success factor allowing the GTP the flexibility and space to define its mandate and pool relevant expertise across ministries to address information service needs expressed by farmers. Only when the GTP reached a functioning equilibrium was it codified into a decree in 1996 that set its mandate and constitution (Moussa et al. 2012).

The Mali programme has come a long way since its beginnings in 1982. It started with sixteen volunteer farmers in the southern part of the country, and by 1990 had expanded to include eighty farmers in neighbouring communities. After the first year of promising results experienced by the sixteen volunteer farmers, there was an increasing demand from neighbouring communities for rain gauges, agrometeorological information, and training. The project expanded and by 1990, some 80 representative farmers had been trained.

Not long after – in 1993 – the project ballooned to include over 2500 farmers. The rapid increase followed a large multi-stakeholder workshop in 1993 that evaluated the project's performance over the previous four years. The findings were based on information gathered during the project's experimental phase. The evaluation data, which was promising, examined the crop yields from various plots of land, and summarized the opinions of farmers who had used the data (figure 5; Hellmuth et al. 2007). The workshop provided the motivation to extend the programme activities to other regions, increasing the number of participating farmers. From 1993 to 2005, evaluation workshops were held every two years in each of the six districts where the programme was implemented.

Today, thousands of farmers across Mali take part in reading rain gauges and interpreting information to produce their own local forecasts. Mali Meteo claims that today, 700 villages participate in the programme, but a list of these villages and their total inhabitants is not available (Carr et al. 2014).

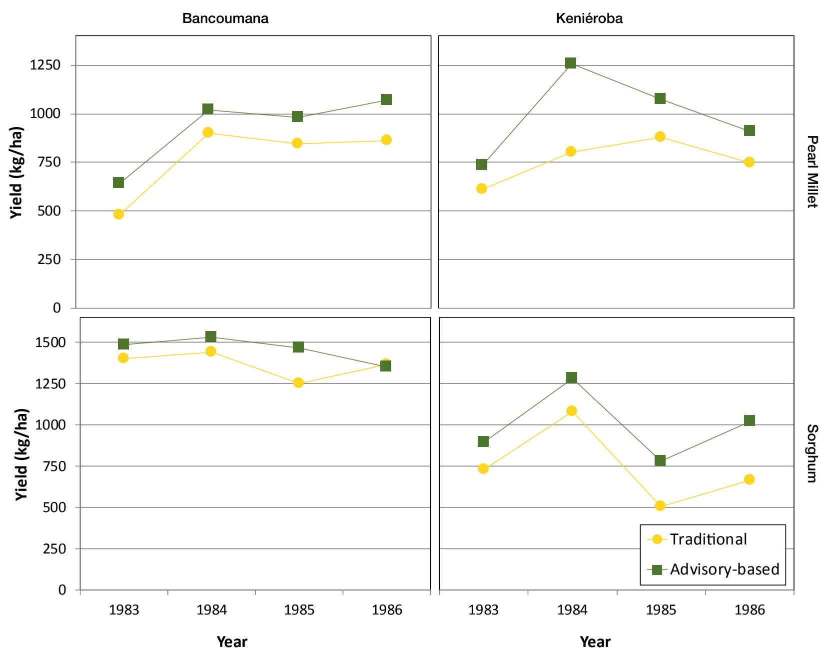


Figure 5: Sorghum and pearl millet yields in advisory-based and traditional plots (1982-1986). Data source: Hellmuth et al. 2007.

A CCAFS-USAID institutional assessment of the Mali case study highlighted several enabling factors that contributed to the programme's success (Moussa et al. 2012). First, the multidisciplinary GTP established at the onset of the project to bring together the relevant climate and agricultural-related public services, served as an effective platform for the production of relevant climate services for farmers, over the course of time opening a space for meaningful co-production of knowledge among different public departments and farmers themselves. Second, the programme supported sustained relationships among diverse groups of stakeholders through innovation, creativity and realism in the implementation of the project. Third, the translation of the information into multiple local languages and user-friendly formats to ensure effective use and sustain the agricultural sector. The fourth factor was solicitation of user feedback – in fact, the entire programme started with local farmers submitting their data to the NHMS. This two-way communication between climate service providers and farmers, and valuation of farmers' input into the production of the advisory service provided, gave farmers a legitimate voice in the process of climate service production and a stake in taking part in the programme. Fifth, the Mali government's commitment from 2001 to strengthen the meteorological service, and take over budgetary ownership from the Swiss Development Corporation and other donor funding gave a life-long lease to the programme, turning it from an outside-driven project to a nationally-appropriated programme and priority. This national buy-in of the programme and political support by the government was critical for the Mali NHMS to continue its operations. Sixth, was the fact that the programme received long-term financial support from the Swiss Development Corporation in its initial years, and some technical backstopping from WMO and AGRHYMET, which enabled the programme space and time to experiment and demonstrate results, before scaling out. Seventh, effective communication channels, especially via the GTP, facilitated information flow between representative farmers, agricultural extension staff and the climate information providers at the national and regional level. The final two factors were that the programme built on existing national systems, and effectively used radio as a medium for information dissemination.

A noteworthy limitation however is that neither the Mali nor the India climate service cases systematically collected feedback from farmers (their clients) on the usefulness of provided climate services, as a way to improve programme and service delivery during the initial years of the programme.

Case 3: Gender-specific weather and climate Information service needs in Kaffrine

This project, targeting Senegal's Kaffrine region, investigated whether men and women had different weather and climate information service needs. Working with three farmer communities (Dioly Mandakh, Malem Thierign and Fass Thiekeen) the project delivered short-range weather advisories (ranging from 3 to 72 hours) and subsequently seasonal forecasts to farmers and followed the information flow within the communities over three years. The focus of the research, conducted in 2011 and 2012 as part of a CCAFS Research grant on Gender, was on understanding the specific climate service needs of women and other socially marginalized groups; all research and questionnaire protocols were gender-disaggregated. The research was complemented by logbooks distributed in June 2011 that captured community feedback on the forecasts provided and their usefulness.

A pre-season, three-day workshop conducted ahead of the season's start trained target farmers on how to use requested forecast products and opened space for a two-way dialogue to take place between forecasters and farmers on forecasting probabilities on the one hand, and farmer needs in terms of packaging and tailoring of information on the other hand. This was a major success factor, enabling farmers to gain familiarity with seasonal forecasts and shorter-term weather advisories they had never accessed before. Such interaction ahead of the season—mediated by a set of innovative methods, including participatory games—was needed to build trust and understanding between providers and users of climate services (Tall 2011).

The Kaffrine gender research project communicated climate and weather forecasts to rural communities using several methods. Most noteworthy was the project's use of the Red Cross to relay information to communities. Early warning alerts were also communicated to community leaders during the first season using SMS. The rural communities proposed some ideas to help future communications: send out SMS messages not only in French, but also in Wolof and Arabic; write the forecasts on blackboards placed in strategic outposts; and, during village forums, publicly designate people to serve as community relays of climate information and weather alerts.

This study found that, in order to receive information, women and other socially marginalized groups within the target villages need specific communication channels that are relevant to them. These include sharing information at water boreholes and petty sale trade points, and receiving information by SMS on their or their children's cell phones. The study also revealed that *kinds* of weather and climate information needed also differed along gender lines. For example, in Dioly Mandakh, women emphasized that men planted for themselves first in early June before planting women's plots a month later, limiting women farmers' ability to plant at the start of the rainy season, due to their lack of ownership of the means of production (cart, donkey or horse mainly owned by men as heads of the households). As a result, surveyed women farmers in Dioly expressed that knowing when rains would end (a forecast of rainfall cessation) was more important to them than the forecast of seasonal rainfall onset, since their planting season began a month later and risks of early season cessation during the critical period of millet flowering (early September) was the most significant stressor to their yield and seasonal outcome.

In addition to information products initially delivered to the community when the project began, systematic re-assessment through Participatory Action Research (PAR) at the end of season 1 in order to collect farmer feedback revealed that farmers in targeted communities needed the following additional products: a) prediction of seasonal rainfall onset; b) prediction of seasonal rainfall cessation; c) tailored seasonal outlook with rural advisory; d) and updated seasonal forecast probabilities as the season progresses.

In the project's second year, the expanded set of weather and climate information mentioned above was delivered through a partnership between the UK Met Office and the Senegal NHMS, in a bid to improve delivery on farmer-requested information services. During this second season, the local Kaffrine extension service was also brought into the project, as providers of essential rural advisories to accompany seasonal forecast information. Finally, because the community's proposed innovations in communication channels were adopted (i.e. the meteo bulletin board, dissemination at water boreholes for women, etc.), from season 1 to season 2 access to weather and climate information went from a handful of community members in the first project year (in one of the communities only three members had received information), to 100% of sampled respondents in the second year (across all three villages).

The project underscores the importance of PAR approaches in determining specific farmer needs and giving farmers a voice in how their needs are satisfied. Because climate service needs proved to be highly location-specific, local participation is needed to identify local needs and ensure appropriate tailoring of climate information to meet those needs. Even from one community to another, within a radius of ten kilometres, both climate information and information delivery needs differed. For example, one village preferred receiving information through the mosque, whereas another preferred bulletin boards posted across the village). Climate service needs are thus highly locally specific, and PAR research will have to elicit local needs and ensure appropriate tailoring of climate information.

The lead organization in this project was the Agence Nationale de l'Aviation Civile et de la Meteorologie du Senegal (ANACIM). Other partners included Red Cross Senegal, UK Met Office, Humanitarian Futures Programme at King's College London, University of Liverpool, and the University of Reading. The project was supported by CCAFS, Humanitarian Futures Programme at King's College London, and the Climate and Development Knowledge Network (CDKN).

Case 4: Climate Forecasting for Agricultural Resources (CFAR)

The CFAR project in Burkina Faso spanned about ten years (1998-2007). Its development coincided with the establishment of the Climate Outlook Forum, known in West Africa as PRESAO (*Prévisions Saisonnières pour l'Afrique de l'Ouest*), a multi-stakeholder consultation process that brings producers and users of seasonal climate forecasts together at the onset of the rainy season. The project was conducted in three of Burkina Faso's agroecological zones. It reached 160 farmers directly and 900 farmers indirectly. The study addressed two main questions: 1) What prevents farmers from using seasonal climate forecasts? 2) What are the best strategies for communicating seasonal climate forecasts to them? (Roncoli et al. 2009).

The experimental phase centred on workshops involving extension agents, government officials, and traditional authorities, and a dozen farmers from each village. First, farmers were asked about traditional predictions. The seasonal climate forecast for the upcoming season was then presented, followed by explanations about how it was produced and its limitations in terms of scale, timeframe, and various climate parameters. Interactive exercises were conducted to help participants understand the probabilistic nature of the seasonal climate forecast. During the second part of the workshop, farmers worked in small groups to discuss potential responses to the forecasts and to devise dissemination strategies for their villages. In addition to the workshops, summaries of the seasonal climate forecast were broadcast on FM radio stations in local languages and printed on flyers, which were distributed in the villages. In each village, the project established 6-7 "farmer leaders" who managed a rain gauge to provide rainfall data that was fed back to the national meteorological service.

At the end of the farming season, interviews were conducted with 160 farmers in 9 villages (3 per zone)—divided between those who had participated in the workshops and those who had not participated —to determine how participation influenced differences in knowledge and practices. Farmers were asked whether they received a seasonal climate forecast (either at the workshop or by other means) and, if they had, what they understood; whether they shared the forecast with others; whether and how they used seasonal climate forecasts in decision-making; and how they felt about the outcome.

The interviews uncovered interesting findings. First, workshop participants were more likely than non-participants to share the information with others, to understand the probabilistic aspect of seasonal climate forecasts and their limitations, to use forecasts in making management decisions by a wider range of responses, and to evaluate the information more positively. Second, communicating the probabilistic nature of a seasonal climate forecast requires some level of face-to-face interaction; those aspects cannot be easily conveyed by short announcements through radio or mobile phones. Also, during workshops, stories that related to everyday life were more successful than games and visuals at helping participants understand probabilistic forecasts. Third, radio announcements by local FM stations are an effective way of reaching rural communities. Where broadcasting coverage was good they reached up to two thirds of farmers who did not participate in the workshops. However, social networks and informal exchanges at markets, shops, mosques, water fountains, group meetings, and social occasions were also found to be important forms of communication. Fourth, although a climate forecast delivered before the rains began was ideal, the fact that planting continues for several weeks meant that even late forecasts were better than none. These benefits are noteworthy, particularly because the onset of the rainy season is a time when farmers must work hard in harsh conditions, investing energies and resources towards uncertain production outcomes. Some farmers suggested that ways of enhancing the utility of the forecasts, namely by delivering them earlier, and by complementing them with technical advice and provision of inputs, would enhance the utility of the forecasts. Pastoralists also recommended producing forecasts that were tailored to livestock management decisions.

Though the end of project funding and limited uptake of the project's activities by national institutions precluded continuation of this project, CFAR remains one of the best research projects to date on what it will take to make seasonal forecasts useful for farmers.

The project's lead organizations were the University of Georgia and Tufts University. The implementation partners were the Direction Générale de la Météorologie (DGM), Institut de l'Environnement et de Recherches Agricoles, and Plan Burkina. Funding was provided by NOAA.

Case 5: Indigenous Knowledge Bank (Senegal)

The Indigenous Knowledge Bank (IKB) project aimed to identify and document indigenous knowledge about adaptation and vulnerability. Spanning two years, the IKB project encouraged the integration of local knowledge into plans to deal with climate change, as well as strategies for sustainable development. The project created a catalogue of traditional indicators for seasonal forecasts. Working with communities in Kaffrine, Senegal, the project identified indicators of seasonal trends, including the quality and quantity of rain available for sowing, ("*thiebo*" in the local language) and predictions of the end of the season.

The study found that rural communities predict the weather, and seasonal climate trends, by observing natural phenomena. For example, the communities predict when the rainy season will begin by noting when particular trees (e.g. the tamarind, *dimb*, *néré* and *baobab*) start to flower. Various kinds of animal activity are also indicators, including birdsong that calls men to the fields and women to stay at home, the appearance of butterflies, the reproduction of grey lizards, and certain structures built by ants. Certain kinds of physical phenomena, too, have agricultural significance, including wind that changes direction, wind that brings rain, temperature increases, clouds and constellations in the shape of an elephant, and black clouds that turn white.

The project's main lesson was that indigenous knowledge plays a major role in local livelihoods and is crucial to supporting local efforts to forecast and make sense of seasonal climate variability. The project also found that a progressive loss of indigenous knowledge threatens the ability of farmers to adapt to climate change.

The lead organization for this project was Energy, Environment, Development (ENDA– Tiers Monde). Partners included UNITAR. Funding was provided by the European Commission, the Austrian Development Cooperation, and the government of Switzerland.

Case 6: Training of Trainers for Agricultural Extension Services in Ethiopia

This project focuses on training people in agricultural extension services how to use weather and climate information provided by Ethiopia's National Meteorological Agency (NMA) to support farmers' climate risk management. The project began in January 2010, and continues today. It investigates more participatory, cross-disciplinary approaches to bring together research and development institutions, relevant disciplines, and farmers as equal partners to reap the benefits from weather and climate knowledge. So far, the project has directly reached 780 farmers.

Because of the large number of agricultural development agents (DAs) – 26,000 in Ethiopia – it became clear that training all DAs would be impossible. Hence the researchers adopted a cascading "training of trainers" approach and trained 30 extension agents in each of Ethiopia's ten regions. These seminars also increased the interaction between the local agricultural extension services and the local staff of NMA. This link is crucial for enabling NMA to provide better services for the agricultural community.

So far, this project has achieved several results. It has created a national forum – the Weather, Climate and Food Security Working Group – that brings together the NMA and the Ministry of Agriculture for regular meetings. It has trained many extension service workers, agrometeorologists, and meteorological observers, and has organized many "training of trainers" events that have reached almost 1700 participants. It has produced 7000 plastic rain gauges and distributed 3000 of them, primarily to farmers and NGOs. It has trained farmers how to use the gauges, record the data, and apply the data to their agricultural needs. The project produces dekadal (10-day) weather forecasts, and distributes them to agricultural extension agents via SMS.

The lead organization for this project is NMA. Implementation partners include the Ministry of Agriculture and Rural Extension Service, the World Food Programme, AGRA, Oxfam America, and other government and civil stakeholders. Funding is provided by the Rockefeller Foundation.

Case 7: Dissemination of Weather and Climate Information in Local Languages

This project, which runs from 2013 to 2015, involves the Farmers Media Link Centre and the Uganda Department of Meteorology. Along with other partners, these two organizations translated seasonal climate forecasts into local languages for Ugandan farmers. The climate information is distributed to farming communities in the six districts mainly through the sub-county focal point persons for the village banks, faith-based organizations, farming groups and selected CBOs.

The project confirmed that the dissemination of weather and climate information in local languages enhances the understanding and timely delivery of that information to rural farming communities. However the project was noteworthy not only because it communicated the forecast information in local languages, but also because it used innovative mediums. For instance, in some areas climate alerts were conveyed to farmers by their children, who received the climate information at school and then later brought the family (including mothers) together at home to discuss. The alerts were also communicated by religious organizations and women's savings groups.

The Uganda project has had several results. It has translated seasonal forecasts into two local languages (Lusoga and Luganda). It has reached all the districts, targeting one sub-county in each district to receive the information. It helped schools plant orange-fleshed sweet potatoes, in the process teaching schoolchildren how using climate information can improve farming outcomes. To supplement the forecasts as the season progressed, the project produced regular updates and radio broadcasts, and has made plans to start delivering forecasts using SMS.

The lead organization for this project was the Farmers Media Link Centre. Implementation partners included the National Agriculture Research Organization, District Local Governments, NGOs, Media Houses, Makerere University, local and international partners, farming groups, schools, village savings and credit groups (village banks), and faith-based organizations.

Case 8: Climate Knowledge for Community Based Adaptation in Nyangi, Kenya

This project, organized in 2008 by East Africa's IGAD Climate Prediction and Applications Center (ICPAC), focused on three pilot sites in Nyangi, Kenya. Since 2011, ICPAC has invested in improving its capacity for interpreting, downscaling and packaging climate information services for local-level farmers. Investment by the Rockefeller Foundation helped ICPAC provide forecast information, and advisories based on the forecasts, to smallholder farmers in three targeted villages. The information, requested by farmers, included the dates of rainfall onset, expected rainfall intensity and distribution, the expected length of the season, and expected climatic hazards like floods and hail storms. The investment was also intended to help ICPAC develop agricultural advisories based on the forecasts. Not all of the needs expressed by farmers could be addressed. For example, it is not possible to predict rainfall intensity or statistics throughout the season with any degree of skill, though although climate research is currently working to address this challenge.

The project found that climate information significantly benefitted the farmer's harvests. For example, farmers reported harvesting 3-4 times as much maize and sorghum as they used to harvest. They attributed the increase to the weather forecasts, advisories, and other agrometeorological information that they received from ICPAC, which helped them know when during the year they should plant, when to apply fertilizer, and which seeds to sow. One of the farmers – Mary Ogello, from Western Kenya's Reru Community – noted that this was the first time in 35 years that she had harvested crops from all of her gardens. Pastoralists reportedly responded to the advisories by reseeding their overgrazed, highly degraded pasture reserves, and starting a nearby market where they could sell their culls (they used to sell their animals more than 25 km away). The case study notes that the pastoralists "responded to our advisories by planting the recommended crops and varieties (maize, onions, tomatoes, beans, and other vegetables) and followed good agronomic practices."

The lead organizations were ICPAC and the Kenya Meteorological Department. Funding was provided by the IDRC-CCAA project.

Case 9: Integrating Indigenous Knowledge with Seasonal Forecasts in Lushoto

The objective of this project was to reduce the vulnerability of smallholder farmers in the Lushoto District, Tanzania, to climate variability and change by promoting the integration of indigenous knowledge and scientific weather and climate forecasting.

Initiated by CCAFS East Africa, researchers gathered data over the three months that this project lasted by interviewing key informants and undertaking questionnaire surveys. Interviews and Focus Group Discussions (FGDs) were conducted, and questionnaires administered. Both the interviews and FGDs were conducted in three selected villages. Indigenous knowledge weather forecasting groups were formed. A core team was created to coordinate the flow of weather forecast information, the functions of which were integrated into district development planning. In all, the project reached 70 villagers in seven villages.

The project found that farmers use a combination of local indicators to predict weather and climate. Indicators commonly used to predict a good rainfall season and early onset of rain include insects, the flowering of peaches and plums, and the appearance of swarms of butterflies, frogs, ants and grasshoppers. The 2012 March-April-May (MAM) seasonal forecasts using indigenous knowledge and Tanzania Meteorological Agency scientific forecasting were identical. The two approaches predicted that the MAM seasonal rains would be normal. The study suggests that farmers' trust and willingness to pay for scientific forecasts is increased when local, traditional methods of forecasting are combined with modern scientific methods. As such, scientific forecasting may be able to complement indigenous forecasting to help mitigate the loss of traditional weather and climate indicators from climate change.

The lead organization for this project was Sokoine University of Agriculture, which worked alongside the Tanzania Meteorological Agency, the Lushoto District Council and the Selian Agricultural Research Institute. Technical and financial assistance was provided by CCAFS.

Case 10: Identifying farmers' information needs in the Indo-Gangetic Plains

The main objective of this study was to identify the information needs of farmers in the five states of India's Indo-Gangetic Plain (IGP) that would enable them to manage risk in wheat, maize and rice cropping systems. Data was collected at the International Maize and Wheat Improvement Center (CIMMYT) in 2011 and 2012 through a survey of 1200 farming households in five Indo-Gangetic states (Bihar, Haryana, Punjab, Uttar Pradesh and West Bengal) of India, during January-March 2011. Researchers randomly selected six villages in each district and ten households in each village. They collected information on each household's socioeconomic characteristics, assets, and access to different types and sources of information. A multivariate probit specification was used to examine how different socio-economic factors influence the decision of farmers to adopt different sources of information. As a follow up to this study, CIMMYT piloted an ICT-based system for communicating climate information and advisories with farmers in CCAFS benchmark sites of India. Participating farmers receive daily voice and SMS messages covering weather predictions, information about pests and remedies, details of climate smart technologies, and general awareness about climate change and solutions.

The study concluded with key findings about what kind of information farmers want and how they want to receive it. The information that was most requested was availability of inputs such seeds, fertilizer, machinery, pesticides, herbicides, and labour. Which inputs should the farmers use, and when? How much? Where should they purchase the inputs? Though not all dependent on climate information, many of these decisions could be improved through use of climate services as input; and researchers found that information needs are growing as climatic conditions and rainfall timing change.

All surveyed farmers reported using multiple sources to access information about agriculture and, more specifically, climate change and risk management. There was no single source providing all that the farmers needed, and the farmers didn't trust any particular source more than others. The primary source of information was other farmers living in their neighbourhood or nearby villages (91%), followed by input dealers (68%), television (55%), mobile phones (36%) and newspapers (33%). Based on three criteria – timeliness, accuracy, and reliability of information – 41% farmers ranked other farmers as the best most important source of information, followed by input dealers (21%), and mobile phones (10%).

The study also showed that the source of information a farmer uses depends on his or her education and income. Resource-poor and smallholder farmers usually depend on face-to-face sources of information, like other farmers and input dealers. Younger farmers and large-scale farmers, who have more education and better networks, tend to use modern sources of information like the Internet, telecentres and mobile-phone-based services. In general, better-educated farmers prefer to use modern ICTs rather than traditional sources like newspapers, radio or television. While progressive farmers represent a minority, the proportion of farmers who are proficient with ICT is expanding rapidly.

In the surveyed sample almost all the farmers had access to mobile phones, but only 41% of those farmers used mobile phones to access information relating to agriculture. Service providers usually deliver information to the farmers on their mobile phones by SMS. But because literacy rates among farmers are low, the ability to read and type messages on mobile phones is also low. Only 51% of farmers in the IGP can read SMS messages, and only 29% can reply in text form.

Although many of them were not using the services, 90% of farmers expressed interest in receiving information on their mobile phones and were also willing to pay (47% of farmers) for such services provided that the content is relevant, services are useful and trustworthy, and bring some impact on their incomes, farm yields, and cost of production. Farmers preferred voice messages over text messaging (Mittal 2012).

The lead organization for this project was CIMMYT, with funding and technical support provided by CCAFS.

Case 11: CCAFS Climate Services Kaffrine Pilot, Senegal

This pilot project was started by CCAFS in the Kaffrine District, located in the peanut basin of central Senegal where agriculture is the primary source of income and employs nearly 90% of the population. It has run from 2011 to the present day. After a year of success in training and communicating the seasonal rainfall outlook forecast in 2011 to a group of 33 farmers from six villages, the project was extended to the entire Kaffrine region, following increased funding. Farmer demand for prediction services of the onset of the rainy season was strong, as was the demand for weather forecasts from 1 to 5 days ahead, and for nowcasting up to 1 hour ahead. Beginning with 33 farmers in six villages in 2011, training workshops reached 123 farmers located in various locations spanning the whole region in 2012, today reaching up to 5000 farmers through relay farmers, SMS, local radio, community meetings and TV.

In 2013, the Kaffrine project was widened through a partnership with the *Union des Radios Associatives et Communautaires du Sénégal* (URAC), an association of 73 community-based radio stations promoting economic development through communication and local information exchange. The union's reach extends across all of Senegal's 14 administrative regions and it operates in all local languages, giving it significant potential to transform lives through reliable information. The interactive nature of the radio programme allows listeners to revert with their feedback including additional information, views, and requests for information, clarification, and feedback. From 2014, *l'Agence Nationale de l'Aviation Civile et de la Meteorologie du Sénégal* (ANACIM) plans to communicate downscaled seasonal forecasts and 10 day forecasts across the rainy season as a special radio programme in the four administrative regions of Kaffrine, Thies, Diourbel and Louga. Through this partnership, the project is expected to reach more than 2 million farmers, providing hope that delivery of climate services at scale is mission possible in Senegal (CCAFS 2014).

The main success of the Kaffrine case rests on strong partnerships between the NHMS (ANACIM), the Senegal Agricultural Research Institute (ISRA), the Ministry of Agriculture and Extension Services, as well as a host of local partners in Kaffrine with clearly defined roles in the chain to produce, add value and communicate climate services for farmers. Inspired by Mali's GTP model, the project built on a multidisciplinary team in Kaffrine implemented by a previous government funded project to foster dialogue between producers and users of climate services at two levels: national (mainly national institutions located in Dakar) and local (extension services in Kaffrine). Partners at the local level included farmers' groups (women producers, farmer cooperatives, etc.), seed producers and extension services. Unlike the Mali GTP however, the local Kaffrine GTP serves solely as the main conduit to communicate the seasonal forecast and related agricultural advisory with other local authorities of Kaffrine, spanning various government agencies and local NGOs; the brunt of value-addition of the seasonal climate forecast with agricultural know-how is still conducted by the agricultural extension officer of Kaffrine, Mr Seck. Activities as part of this project include farmer training workshops using participatory methods (similar to the ones employed by the CFAR project in Burkina Faso) to communicate the seasonal probability distribution function with farmers, engaging farmers in a discussion around local predictions of change, what farm practices to adopt/change given seasonal probabilities. Other activities include community training workshops, field visits and evaluation. Initial evaluation during the first year showed strong demand for climate information, and evidence that farmers rely on climate information for decisions about planting dates, crop choices, and investment in inputs.

The lead organization for this project is ANACIM. Partner organizations include the Department of Agriculture, the National Agricultural Extension Service and World Vision. Funding and technical support were provided by CCAFS.

Case 12: CCAFS Climate Services Wote Pilot, Kenya

Led by ICRISAT as a CCAFS research pilot, this study initiated a structured evaluation of alternative approaches to communicating seasonal climate information with farmers in Wote Division, Makuene County, Kenya during the 2011 short rain season. The study was extended to Kaiti Division in the same county during the 2012 short rain season. It considered two different methods of presenting climate forecast information to smallholder farmers against a control with no intervention. The first was a two-day training workshop that shared a downscaled seasonal forecast with farmers, taught them to interpret the forecast as a probability distribution (using same method as that used in Case 11) and its implications for decision-making. The second approach was a forecast-based agro-advisory (without training) that included a qualitative discussion of the seasonal forecast, and recommended farm-level practices based on the forecast. In all, the project reached a total of 600 farmers, with further extension training of trainers to scale out project outreach.

The effectiveness of treatments was assessed by collecting data on crops, varieties and management practices initially planned pre-season, those practices that were implemented during the season, and outcome of the practices implemented through three different surveys conducted during the period of experimentation. Initial evaluation results showed that forecast information, delivered in either format (training or agro-advisory without training), significantly changed farm management decisions. The evidence suggests that farmers understood and utilized the agromet advisory, used it to make adjustments to their farm plans, generally increased the intensity of their management, and ultimately benefitted through more efficient input use and improved yields.

The study produced several important findings. First, farmers are generally optimistic about the coming season but tend to be conservative when making actual investments, due to higher risk perceptions. Second, in the absence of forecasts farmers tend to adopt conservative management strategies such as cropping more area and using drought-tolerant crops, rather than investing in improved management of crops as evidenced by differences in the way farmers in control and treatment villages managed their farms. Third, improved understanding of climate variability and seasonal climate forecast information provided a basis for farmers to plan and implement strategies that can contribute to increased productivity and profitability. Fourth, the training and support received by farmers during this study helped them to better understand the potential value of this information and make use of it. Though farmers in the target area have access to climate information, their lack of understanding of the forecast information and uncertainties associated with them led to low levels of utilization of that information. Fifth, and a major finding from the study, was that farmers who underwent the training (treatment group 1) were found to be more realistic in their assessment of the performance of the season and more satisfied with the outcome and their management decisions. As such, a certain change in attitude of farmers about climate is evident, once empowered to plan for the season through climate forecast information and related advisories. Finally, farmers have shown keen interest in receiving climate information and have understood the value of this information in planning farm operations. The willingness of all surveyed farmers at the end of the project to pay for the continued agromet service is an indication of the perceived value.

In June, the project conducted a training of intermediaries that trained 30 extension officers representing 12 divisions from the county as well as representatives of local FM radio stations – Mbaitu and Syokimau scaled - to reach up to 500,000 smallholder farmers in the county of Makuene. This provides hope that scaling up workshop-based approaches to training farmers on seasonal forecast applications is possible, working through a “training of trainers” approach training extension officers and existing boundary organizations such as media, rural radios and NGOs to serve as the missing link between climate service providers and farmers (ICRISAT 2013).

This project’s lead organization is ICRISAT, working in collaboration with Kenya’s Agricultural Institution (KARI) and extension service as primary implementation partners. Funding and technical support were provided by CCAFS.

Case 13: Uganda SMS-based Farmer Advisory Delivery

The Grameen Foundation set up a village-based network of Community Knowledge Workers (CKWs) in the Kasese District of Uganda (from November 2011 to December 2012), and equipped them with low-priced smart phones (on loan to them) with a locally built app that contains agricultural information related to crops, livestock, market prices, regional weather, and water harvesting techniques, which the CKWs could query to provide information to interested farmers in their communities. With technical support from WMO, Uganda’s Department of Meteorology (UDOM) began providing agricultural advisories to the Grameen Foundation. This information is then relayed to the CKWs via mobile phones, which is in turn accessed by farmers through SMS in their local language, as they need it. The phone-based system connects hard-to-reach farmers in villages with experienced agriculturalists at the National Agricultural Research Organization (NARO), who provide the agricultural information that is loaded onto the app.

Through this partnership, four specific mobile applications were developed for farmers to access a range of information services, including agricultural and climate information: 1) *The Farmer’s Friend*, a searchable database with agricultural advice and targeted weather forecasts; 2) Health Tips for sexual and reproductive health; 3) *Clinic Directory* for nearby clinics; 4) and finally, the *Google Trader* application, which matches agriculture buyers and sellers. MTN’s cell phone-based platform integrates, and allows CKWs to query, several types of relevant information: real-time local weather from UDOM, market prices from local price collectors, and photographic data sheets on major pests and plant diseases from NARO. An innovative business model that pays CKWs according to how many queries they answered from fellow farmers, enables them to make a living from brokering information services for farmers, potentially allowing the work to be sustained after the project ends.

At the time the information was provided, UDOM provided 32 ten-day weather forecasts and advisories, which were sent to the mobile phones of 12,596 farmers in the Kasese District. The project has sent farmers two seasonal forecasts. The CKWs have given farmers more than 16,000 weather forecasts. Analysis shows that, on average, farmers used weather information 3.4 times and relied on the information more and more. Peaks of queries from farmers (live monitored) for weather and agricultural information occurred during times of rainy season onset/planting period, harvest time, and at various times during the season when dry/wet spells are experienced. In a mid-term evaluation conducted in August 2012, 87% of the farmers interviewed reported having used information about when to plant crops and manage them, 78% said the 10-day weather forecasts were mostly accurate. During an August 2012 field seminar, a farmer showed a demonstration farm where he used one part of his garden to practice agriculture based on the weather advisories, and another part where he didn’t adhere to the advisories. He reported good yields from the agricultural advisory part, including a bumper harvest and market during lean years.

The lead organization for this project was the Grameen Foundation Uganda Lab. Partner organizations included the Grameen Foundation; the Ugandan Department of Meteorology; the Ministry of Water, Lands and Environment (Department of Meteorology); and the National Agriculture Research Organization. Funded was provided by the WMO and the Bill and Melinda Gates Foundation.

Case 14: Supporting Smallholder Decision Making in Zimbabwe and Tanzania

Rooted in an approach that helps farmers use historical data analysis to identify local climate trends and plan their resource allocations for the season, this project was innovative in its use of analyses of historical climate data to support farmer decisions in sites in Tanzania and Zimbabwe. This study was conducted in Zimbabwe from November 2011 to January 2013, and will be conducted in Tanzania from October 2012 to December 2014. At the time information was provided, it had reached 250 farmers in Tanzania and 2,300 in Zimbabwe.

Participating farmers estimated probabilities of variables such as total rainfall amounts and onset dates for the upcoming season. In Zimbabwe, participatory activities included community and household vulnerability assessments and action planning. Evidence indicates that farmers found participatory planning methods useful for identifying and comparing different crop management techniques they could use for the next season, and have modified strategies on their farms as a result.

The lead organization for this project was the University of Reading. Implementation partners include Practical Action, AGRITEX (in Zimbabwe), the Tanzania Met Authority, and the Agricultural Research Institute (in Tanzania). Funding was provided by the Nuffield Foundation (in Zimbabwe) and funding and technical support by CCAFS (in Tanzania).

Case 15: METAGRI: Roving Seminars in West Africa

The METAGRI project was developed in 2008 by WMO based on previous experience in the provision of weather and climate information to smallholder farmers, including more than 25 years of technical support operating in Mali. It has lasted from 2008 until the present day. The project covers over 15 West African countries.

One day workshops for farmers on weather and climate known as ‘roving seminars’ focused on five main topics: climate variability and climate change, specific climate risk for agriculture in the host region, agrometeorology (products and tools), agronomic research and adaptation to climate change, and, finally, use of the so-called farmer’s rain gauge and methodology of rainfall and phenological observations.

At every seminar, a limited number of simple plastic rain gauges were provided to the most skilful farmers, allowing them to measure rainfall in their plots. Training teams were multidisciplinary, including meteorologists, agricultural extension agents and agriculture experts. The teams met previously with regional authorities, and during the seminars brought the farmers to a convenient meeting room in the agricultural area, providing them transportation costs, coffee and tea, and lunch.

A total of 159 one-day seminars were held in Western Africa and 3325 rain gauges were distributed. About 7300 farmers, including 1000 women, participated in the seminars. In addition, 800 agricultural extension farmers, local leaders, NGO staff, and local journalists were trained. It is estimated that at least one representative of around 3000 small rural villages has been trained and is able to use weather and climate information to improve the villages’ agriculture decisions. Nevertheless, because of cultural differences, the representation of men and women were not equal. In addition, there were strong differences not only from country to country, but also inside every country.

Though appealing as a model at scale, one limitation of the roving seminar approach is its lack of depth and time spent to build real capacity within targeted farming communities to understand probabilistic climate forecasting and use a suite of climate services in a seamless manner across the season to support their on-farm decisions, beyond the seasonal forecast. No evaluation of the impact of the roving seminar approach exists to draw further inferences from.

The lead organization for this project was WMO. Implementation partners include the national meteorological services (NMS) of Benin, Burkina Faso, Cape Vert, Côte d’Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, and Togo. Funding from 2008-2011 was provided by Agencia Estatal de Meteorologia, Government of Spain (AEMET); funding from 2012-2014 comes from the Norwegian Ministry of Foreign Affairs.

Case 16: National Frameworks for Climate Services, West Africa pilots

From July through September 2012, the Global Framework for Climate Services (GFCS) piloted activities in West Africa to build national frameworks that would begin to build a user interface platform at the national level. Within this project, the meteorological offices of Burkina Faso, Niger and Mali were supported to conduct national stakeholder consultation workshops on climate services, developed maps of relevant stakeholders at the national level, and reached out to key stakeholders across all climate-sensitive sectors in the country (health, agriculture and food security, disaster management, water resources management, infrastructure, transport and energy) that would be potential users of their climate and weather products.

The main innovation of this case study was in the methodology it developed to bring together national forecasters, agricultural research institutions and national decision-makers, boundary organizations and end users (representatives of vulnerable farmer communities). Each workshop consisted of three days of intense interaction between climate scientists and users, where dialogue was mediated through small group discussions between scientists and end users, module-based communication on climate science concepts and probabilistic forecasting (no "PowerPoint" rule), participatory games to simulate early warning > early action in practice, and interactive discussion among participants to develop a shared mandate for building a national chain of climate services with clearly defined roles for each actor. Participants included representatives of the national climate science and agricultural research communities, scientists and researchers with a direct mandate in the production of relevant climate, weather or agromet information, and representatives from the user communities– farmers, as well as government planners and boundary organizations able to serve as relays of meteorological/climate information for farmers.

These interactions resulted in roadmaps to build National Frameworks for Climate Services in each country, and establish effective chains of information that would link climate service providers with policy-makers and farmers, herders and the most vulnerable communities; with built-in channels for feedback and end-user input into climate service development. The main finding from this case is that nationally defined and appropriate institutional frameworks, resting on collaboration across public departments, are needed to enable the delivery of salient climate services for farmers.

The approach and resulting lessons have informed the process for setting up an enabling institutional framework for multi-sector national climate services in Tanzania and Malawi, under the GFCS. Subsequent national workshops were also organized in Belize, Senegal, South Africa and Chad, to broker dialogue on climate services among national stakeholders, following the methodology piloted in West Africa (GFCS 2014).

Though the national consultation workshops achieve much by way of generating user demand for climate services and creating a nationally-driven mandate to deliver climate services for farmers, funding for follow-up support is necessary for countries to be able to act on the recommendations from their national workshops and implement/test a national climate services framework.

Case 17: African Farm Radio Research Initiative

The African Farm Radio Research Initiative (AFRRI) was a multi-stakeholder action research project created to gather solid evidence to show if and how rural radio can improve food security in Africa. Though the initiative did not include any climate service delivery, it displayed the potential of rural radio as a powerful medium to reach millions of farmers with information services. AFRRI was implemented in Tanzania, Malawi, Uganda, Mali and Ghana. It lasted for 42 months and reportedly reached 40 million farmers (Farm Radio International 2011).

A Participatory Radio Campaign (PRC) is a radio-based activity designed by Farm Radio International, an NGO that works with African broadcasters to produce educational radio shows focused on food security challenges, conducted over a specific time period when a broad farming population is encouraged to make informed decisions about adopting a specific agricultural technology. AFRRI tested the PRC's effectiveness through the production and broadcasting of 4 to 6-month series of radio programmes meant to increase farmers' knowledge, and inspire them to analyse, discuss, and make informed decisions. PRCs in this case were based on agricultural knowledge, and did not include weather or climate information services.

From 2008 to 2010, AFRRI worked with 25 radio stations in the five countries to research, plan and produce two PRCs per station. Around each station's area of coverage, three types of communities were selected. Active Listening Communities (ALCs) helped plan the programmes and provided feedback. Passive Listening Communities (PLCs) would listen only if they chanced on the programme by themselves, and did not have other contact with the programme. The PLCs are representative of the majority of people reached by the radio station's broadcasts. Finally, Control Communities (CCs) could not receive broadcasts at all and were not aware of the PRCs. In total, 49 PRCs were broadcast.

In August 2010, AFRRI evaluated 15 PRCs (three per country) to find out whether farmers listened to them (and, if so, how frequently), whether the PRCs resulted in increased knowledge about the improved practice, and whether they resulted in adoption of the improved practice. In total, the survey included 4500 farmers: 300 per PRC, divided evenly among ALCs, PLCs, and CCs.

The key finding is that by listening to the radio, 39% of the farmers in ALCs gained the knowledge promoted and put it into practice, while 21% of listeners in PLCs and 4% people in CCs adopted the practice. Seventy per cent of people in

ALCs and 52% in PLCs demonstrated an increase in detailed knowledge about the technologies, compared to only 18% in CCs. An estimated 40 million farmers in the five countries were served by the 25 AFRRI partner radio stations, indicating that the radio is an effective agent of change, disseminating knowledge quickly at low cost.

The lead organization for this project was Farm Radio International, in collaboration with World University Service of Canada. Implementation partners included farmers, agricultural knowledge partners, radio stations, ministries of agriculture, extension services, and other development actors. Funding was provided by the Bill and Melinda Gates Foundation.

Case 18: Climate Learning for African Agriculture

This innovative learning project investigated the necessary institutional pre-conditions for effective climate services for agriculture and food security. The countries included in this project were Sierra Leone, Benin, Uganda, and Mozambique. The study, which lasted from September 2011 to August 2013, concluded that policy-making on agricultural knowledge management under climate change has largely fallen into the gap between ministries of environment charged with climate policy, and ministries of agriculture charged with questions of agricultural knowledge. National-level stakeholders ascribed relatively little importance to the provision of climate information.

In each country surveyed, there were several interesting local-level projects where farmers were involved in processes intended to help them adapt to climate change. Some explicitly invoked climate change in their rationale and objectives, while others did not. Those that did tended to focus on broad characterizations of current and future climate trends and climate uncertainty rather than specific downscaled projections. Many of these projects, however, remain characterized by a consultative or at best collaborative approach to farmer's participation in research; as such farmers' participation remains limited in the process of producing relevant interventions and information services to address their adaptation needs. Project staff and farmers remain focused on specific solutions rather than building the farmers' own capacity for innovation. These projects tend to confront issues of supply of inputs, including credit, and market opportunities, as they affect farmers. Most of these projects involve the private sector to confront issues such as supply of inputs, credit and market opportunities, which can constrain the ability of farmers to act on information and advisories. However, fully integrating climate services with other local agricultural services remains a challenging issue.

This remains compatible with private sector involvement in, e.g. input supply. The challenging issue however remains integration of different services and actors in local networks.

The lead organization for this project was the Natural Resources Institute at the University of Greenwich. Implementation partners included the Forum for Agricultural Research in Africa and the African Network for Agricultural Advisory Services. Funding was provided by CDKN.

4. Learning from good practice

Together, the cases reviewed in this report offer us a rich repository of insights about how to reach farmers at scale with decision-relevant, timely and salient climate services. To extract lessons about good practices for implementing climate services, we mapped the case studies onto the key challenges (*salience*, *access*, *legitimacy*, *equity*, *integration*) that they attempted to address (table 3); and then examined what approaches were used to address those challenges, and any available evidence of their effectiveness. This process of examining how effectively existing practices address the challenges began in breakout groups at the international workshop on "*Scaling up Climate Services for Farmers in Africa and South Asia*" (Tall et al. 2013). Participants during this conference gave overview presentations on each of the case studies 3-18, which were followed by a discussion of which approaches had been used to address the challenges, and available evidence about their effectiveness. For the national agrometeorology programmes of India and Mali (Cases 1 and 2), plenary discussions were more extensive and were informed by recent evaluations (Carr et al. 2014; Venkatasubramanian et al. 2014). We followed up by examining the case studies in more depth, looking for common elements across case studies that show promise for addressing the five key challenges.

Appendix 1 summarizes the main findings from each case, as well as the success factors that enabled them and key limitations.

Table 3. Challenges to scaling up climate services addressed by case studies, based on good practice themes

Good practice theme	Challenge addressed	Case studies featured under theme
Theme 1: Bridging the gap between climate forecasters, agricultural research and user communities	*Salience:* How to ensure that climate information and advisory services are relevant to the decisions of smallholder farmers?	1. India Integrated Agrometeorological Advisory Service 2. Mali *Projet d'Assistance Agro-meteorologique au Monde Rural* 8. Climate Knowledge for Community Based Adaptation in Nyangi 11. CCAFS Climate Services Kaffrine Pilot (Senegal) 16. National Frameworks for Climate Services West Africa Pilots 14. CCAFS Climate Services Wote Pilot, Kenya
Theme 2: Reaching the "last mile" at scale	*Access:* How to provide timely climate services access to remote rural communities with marginal infrastructure?	7. Dissemination of Weather and Climate Information in Local Languages 13. Uganda SMS-based Farmer Advisory Delivery 17. African Farm Radio Research Initiative
Theme 3: Giving farmers a voice in climate services	*Legitimacy*: How to ensure that farmers own climate services, and shape their design and delivery?	2. Mali *Projet d'Assistance Agro-meteorologique au Monde Rural* 9. Integrating Indigenous Knowledge with Seasonal Forecasts in Lushoto 9. Indigenous Knowledge Bank (Senegal) 10. Identifying farmers' information needs in the Indo-Gangetic Plains
Theme 4: Equitable climate information and advisory services	*Equity:* How to ensure that climate services are accessible by and useful to women and other socially and economically marginalized groups?	3. Gender-Specific Climate Service Needs in Kaffrine 6. Training of Trainers for Agricultural Extension Services in Ethiopia
Theme 5: Is information enough?	*Integration:* How to integrate climate services with other development interventions to enable effective management of climate-related agricultural risk?	1. India Integrated Agrometeorological Advisory Service 4. Climate Forecasting for Agricultural Resources 14. Supporting Smallholder Decision Making in Zimbabwe and Tanzania 15. METAGRI: Roving Seminars in West Africa 18. Climate Learning for African Agriculture

Eight lessons emerge from our review of good practice to address the challenges to scaling up climate services for farmers (Box 1). Lessons 1-3 respond to the challenge of salience, or tailoring the content, scale, format and lead time of climate services to farm-level decision-making. Lessons 4-5 address the challenge of legitimacy, and how to give farmers an effective voice in the design and delivery of climate services due to benefit them. Finally, lessons 6-7 address the challenge of access; while lesson 8 confronts the tenacious challenge of ensuring equity in service delivery, while still scaling up climate services for millions of farmers.

It is noteworthy that the cases reviewed did not provide much insight on the challenge of integration. Case 18 "*Climate Learning for African Agriculture*" notes that the majority of rural programmes do not go far by way of integrating climate information and advisory services; however additional cases will need to be reviewed to have a better understanding in practice on how climate services can be delivered as part of larger packages of support for farmers, and mainstreamed into existing public extension support programmes and rural development plans.

Lesson 1: Bridging gaps through enabling institutional frameworks

Climate services for farmers are enabled by locally appropriate institutional and governance arrangements that support sustained interaction between climate and agricultural organizations, and formalize engagement with end users. While the specific implementation might be different in different contexts, features that seem to be important across successful initiatives include: (a) formal partnerships and sustained processes for coordination between national meteorological and agricultural agencies, (b) mechanisms for collaboration among organizations at a local (e.g. district) level, and (c) formalized engagement of end users in the co-design and evaluation of services.

The India and Mali cases created new institutional arrangements that highlight the critical importance of bringing together cross-disciplinary expertise in the production of tailored climate services relevant for farmers. In each case, climate and agricultural experts worked together in an established institutional framework to transform climate information into a climate service: relevant and timely weather-based agrometeorological advisories and services for farmers. In Mali, a multi-disciplinary working group (GTP) with local level

Box1: Eight Good practice lessons in scaling up climate services for farmers[3]

Addressing the salience challenge:

1. Rural climate services are enabled and sustained by institutional arrangements, and investment in capacity at multiple levels, that support sustained interaction between climate and agricultural organizations and farmers.
2. Climate services must be delivered at a local scale to be relevant to farm decision-making.
3. A seamless suite of forecast, advisory and early warning products, with a range of lead times, enables farmers to manage evolving risks through the season.

Addressing the legitimacy challenge:

4. Giving farmers an effective voice in the design, production and evaluation of climate services increases uptake, legitimacy, and sustainability.
5. Integration of meteorological information with local indigenous knowledge may foster trust, local relevance and use.

Addressing the access challenge:

6. Face-to-face dialogue between farmers and service providers is an effective way to communicate historic and predicted seasonal climate information.
7. ICTs, in combination with other communication channels, offer expanding opportunities to reach farmers with relevant information, at scale.

Addressing the equity challenge:

8. Proactive targeting of women and other socially marginalized groups can help ensure inclusiveness in the design and delivery of climate information services for rural communities

[3] Although the case studies we reviewed did not directly address the integration challenge, we recognize that impact on farmer livelihoods at scale will depend on exploiting synergies between climate services, and the other aspects of advice and support to farmers within national agricultural development strategies.

replicates serves as the platform to bring together relevant expertise from different ministerial departments (climate, water, livestock, plant protection, soils, etc.) with relevant information for farmers. The GTP also identifies farmers' climate service needs, analyses technical aspects of data and products, develops recommendations related to agricultural production, disseminates advisories, and builds capacity. A key characteristic of the GTP institutional model is that it creates a platform for direct engagement across disciplines and with end users. In India, the finished meteorological product is sent by the state meteorological office to the state agricultural research university, where it is interpreted by a multidisciplinary team of agronomists, soil scientists, plant pathologists and entomologists to produce a weather-based farmer advisory relevant at a district scale (in some states) across the entire state. Thus the structure of both programmes allows for co-designing of services across disciplines.

From both cases, we learn that weather and climate information becomes relevant to farmers when it is integrated with agricultural knowledge and research, to produce an integrated agrometeorological advisory service for farmers, underscoring the necessity of institutional partnerships that enable climate and agricultural experts to work together to transform weather and climate information into a weather and climate service that provides relevant and timely weather-based agrometeorological advisories for farmers.

Seven of the 18 case studies employed some structured process for bringing together meteorology and agricultural experts to jointly produce agricultural advisories. For example, the project *CCAFS Climate Services Kaffrine Pilot* (case 11) replicated aspects of Mali's GTP model at a district level, bringing together representatives from the national services of meteorology, agriculture, soil and plant protection to produce a package of seasonal climate information, bundled with agricultural advisories. The case studies demonstrate the replication of cross-disciplinary and cross-agency partnerships at the national and local scale, but they do not provide enough evidence to allow us to draw conclusions about how they should be designed in particular contexts. Though the Kaffrine GTP does not serve the same purpose of integrating different types of expertise to value add climate and weather information, as does the Mali GTP, it still opens a useful platform to communicate the seasonal forecast within different public departments at the national level, and local level, in so doing addressing the challenge of cross-ministerial work which remains a difficult process in many countries. The national GFCS workshops in Mali, Burkina Faso and Niger, piloted in the project *National Frameworks for Climate Services West Africa* (case 16) sought to develop a model for bringing national stakeholders together to define a nationally appropriate enabling institutional environment for integrated climate services that makes cross-disciplinary work across government agencies possible. The process brokered dialogue among national-level stakeholders, using participatory methods to communicate science and didactic games (similar to methodology used in the project *Gender-Specific Climate Service Needs in Kaffrine* (case 3). The approach and resulting lessons have informed the process for setting up an enabling institutional framework for multi-sector national climate services in Tanzania and Malawi, under the GFCS.

One important limitation of the above cases is that many of them failed to meaningfully bring farmers into the process of climate service production. As displayed in figure 6, an enabling institutional framework needs to expand the boundary of climate knowledge and service production to include the voices of farmers themselves. Sustained engagement with farmers in the co-design and evaluation of services – an important component of an enabling institutional framework – is addressed separately in Lesson 4.

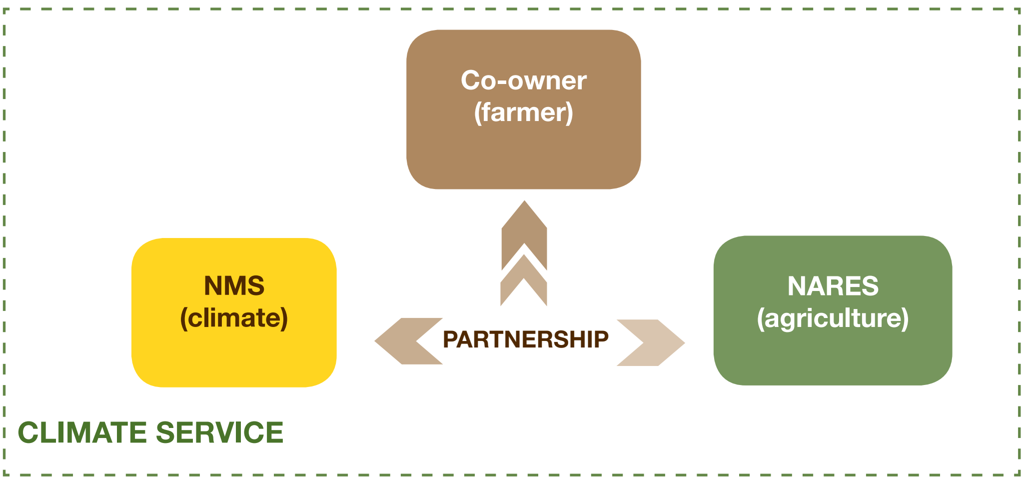


Figure 6. Expanding the boundary of climate service production to include agricultural researchers and farmers, as equal partners in the endeavour to produce relevant climate services for agriculture.

Lesson 2: Bringing climate services to the local scale

Climate services must be presented at a local scale to be relevant to farm decision-making. Across India and Mali we learn of the importance of matching the geographic scales of forecasting and decision-making. Farmers make decisions at the level of their fields, whereas climate model outputs are at very coarse scale, downscaled at best to the country, state or provincial levels. The challenge of bridging geographical scales was addressed in both national programmes (cases 1 and 2) by replicating the model of the multidisciplinary expert teams at the local level. After weather and climate information is produced at sub-regional (Mali) and state levels (India), local level agricultural experts add value to the forecasts at the district level from their sector-specific knowledge to provide relevant advisories in support of farm-level decision-making (Carr et al 2014; Venkatasubramanian et al 2014).

The *Kaffrine* (case 11) and *Wote* (case 12) *CCAFS Climate Services Pilots* further demonstrate the added value of downscaled information. In both projects, seasonal forecasts were statistically downscaled using local weather station records and the International Research Institute for Climate and Society's Climate Predictability Tool, before being communicated to farmers in a probabilistic format. The success of this approach underscores the vital importance of downscaled climate information (historical and predicted) overlaid with local agricultural expertise, to support farmer ahead-of-season planning at the scale of decision-making.

Lesson 3: Seamless forecast products put farmers in charge

A seamless suite of forecast, advisory and early warning products, with a range of lead times, enables farmers to manage evolving risks through the season. From the project *Gender-Specific Climate Service Needs in Kaffrine* (case 3), we learn that a suite of seamless forecast products – ranging from the seasonal to monthly forecast updates, 10-day and shorter-range early warning products and advisories (72h, 48h, 24h, 3h down to nowcasts) – can enable farmers to manage climate-related risks as they evolve throughout the season. Responding to farmers' suggestions solicited in a pre-project assessment of community climate information needs, the project delivered a suite of seamless forecast products to three pilot farmer communities in Kaffrine in 2011 and 2012. Communicating climate information in probabilistic terms helped farmers to understand how uncertainty changes as the season evolves; and shifted the onus of decision-making from technical advisors, to the farmers who must ultimately select management that is consistent with the evolving envelope of uncertainty and their tolerance for risk.

Lessons 4-5 respond to the challenge of giving farmers an effective voice in the design and delivery of climate services.

Lesson 4: Giving farmers a voice

Giving farmers an effective voice in the design, production and evaluation of climate services increases uptake, legitimacy, and sustainability. The Mali experience in particular (case 2) highlights the value of co-producing climate services with the targeted farmer communities, via training and involving them in the process of collecting and interpreting weather data, and defining which products they needed to support their decision-making throughout the season. This approach both improves trust and the uptake of agro-meteorological advisories by farmers, as evidenced by the encouraging results of improved yields reported during the project's experimental phase (1982-1990) (figure 5). In the India case, IMD field missions in recent years to collect farmer feedback on the usefulness of information and recommended changes were another key and important source of success, often missing as criteria in evaluations of climate services. The project *Training of Trainers for Agricultural Extension Services in Ethiopia* (case 6), which has directly trained close to 800 farmers, also demonstrates involving farmers in the production of the climate service. Like the Mali case, this project provided farmers with rain gauges and trained them to produce their own locally relevant forecasts. The projects *Climate Forecasting for Agricultural Resources* (case 4) and *Gender-Specific Climate Service Needs in Kaffrine* (case 3) engaged farmers in blending climate information with their own local climate knowledge. Case 13, *Uganda SMS-based Farmer Advisory Delivery*, engaged trained Community Knowledge Workers to interpret climate and other information to their fellow farmers, and facilitate two-way interaction between farmers and information providers. Case 3 in particular highlights the value in beginning with a dialogue with farmers to build common ground on climate forecasting, whether using modern scientific or traditional predictors. The project *Identifying farmers' information needs in the Indo-Gangetic Plains* (case 10) further underscores the importance of assessing farmers' information needs at the outset of a programme, as well as the ease by which such an assessment can be accomplished.

Moving beyond mere engagement, as the project *Gender-Specific Climate Service Needs in Kaffrine* (case 3) demonstrates, PAR approaches engage farmers, from the outset, to identify information needs and communication channels needed by different social groups within the farming community, and co-develop products and services needed for each community. In case 3, this approach rendered improvements in access and salience from a handful at the beginning of the project to 100% of all interviewed farmers by the end of the research project. For participatory approaches to be useful, however, continuous re-assessment of farmer needs (ideally following each season) will be needed to account for farmer learning and capture farmer feedback on provided services. In case 3, farmer needs differed from one of the target villages to another (within a 10 km radius) in terms of information type and communication challenges. However, a key limitation of assessing information needs and tailoring information packages at an individual village level would be challenging within a national scale climate services programme. Regular reassessment of farmers' needs is a way to ensure the quality of services. However, when designing climate services programmes for delivery at scale, a balance will need to be struck between very location-specific participatory needs assessment and feasibility considerations.

Lesson 5: Salience through integrating local and scientific knowledge

Integration of meteorological information with local indigenous knowledge may foster trust, local relevance, and use. One case study reviewed in this publication; *Integrating Indigenous Knowledge with Seasonal Forecasts in Lushoto* (case 9) seems to indicate the added value to the seasonal forecast through integration of local indicators in its production, and suggest that traditional and modern forecasting methods can complement each other. The project sought to downscale forecasts by tapping into the rich reservoir of knowledge of interactions between nature and climate within the farming communities. A second case from West Africa, the *Indigenous Knowledge Bank* project (case 5), documented available traditional indicators used for local climate forecasting, before they disappear altogether.

While there is growing interest in using indigenous knowledge to downscale scientific forecasts, the contribution of this approach to accuracy, salience, and improved use of climate information for farm decision-making will have to be rigorously assessed before this can be recommended as a good practice to replicate. If the benefits are demonstrated, it could alleviate significantly the barrier of local salience and trust by farmers to use outside-derived climate predictions. Study of local predictions provides insight into the aspects of climate that are most salient to farmers, allowing scientists to better tailor scientific forecasting products to their needs. Further, integration of traditional indicators with scientific forecasts can help enhance the relevance of scientific forecasting within the existing decision systems of farmers (Roncoli 2006).

Regardless, the importance of beginning with farmers' knowledge base on climate and starting dialogue from their existing predictors of climate changes, is an important entry point to engage farmers in a meaningful dialogue on climate prediction and use of climate and weather forecasts, as demonstrated by the *Climate Forecasting for Agricultural Resources pilot in Burkina Faso* (case 4) and *CCAFS Kaffrine pilot* (case 11).

Lessons 6-7 respond to the challenge of providing timely access to climate information services to remote rural communities with marginal infrastructure.

Lesson 6: Face-to-face dialogue to communicate seasonal information

Face-to-face dialogue among farmers and experts is an effective way to communicate complex seasonal climate information. The ten-year *Climate Forecasting for Agricultural Resources* (case 4) pilot in Burkina Faso provided evidence that dialogue between farmers and experts, via pre-season participatory workshops, enabled them to understand some of the complexities of seasonal climate forecasts, such as their probabilistic nature, and their usefulness and limitations for a range of management responses; and to communicate this information with others in their communities. Researchers reported that most of the farmers who attended workshops, compared with one third of those who did not, retained some notion of probability (Ingram et al. 2002). The *Kaffrine* (case 11) and *Wote* (case 12) *CCAFS Climate Services Pilots* also found pre-season workshop to be effective for making complex, probabilistic, downscaled seasonal forecast information understandable; and for exploring potential farm management actions consistent with the envelope of uncertainty. Both projects (cases 11 and 12), put considerable emphasis on enabling farmers to understand the complexities of probabilistic information, through interactive exercises, analogies of acting on decisions based on uncertain information, and breakout group discussion. In the project *Gender-Specific Climate Service Needs in Kaffrine* (case 3), pre-season workshops involving appropriate participatory tools and didactic games opened a space to train climate and agricultural scientists about the decision-making challenges of farmers, improving their ability to tailor information to farmers' needs. The project *Uganda SMS-based Farmer Advisory Delivery* (case 13) used an alternative approach, training and using Community Knowledge Workers as communication intermediaries with their fellow farmers. This process mirrors Mali's model of engaging model farmers as instruments of communication.

Other studies have similarly argued that in order to understand the implications of climate variability and change in the context of their fields and management operations, farmers need to be both collaboratively assisted by scholars and scientists, and to have interaction with and training from farmer facilitators or extension intermediaries (Stigter and Winarto 2013).

Recognizing that providing seasonal climate information for farmers is not sufficient to enable them to act, well-designed pre-season training and planning workshops have the potential to provide a space for farmers and climate and agricultural experts to communicate with each other, begin dialogue and co-produce climate services that are relevant to farmers' needs. However, scaling up intensive interactions between farmers and scientists is an obvious challenge. Two of the projects included in this review did reach farmers on a larger scale using Roving Seminars, which are a limited version of the workshop model. The project *Training of Trainers for Agricultural Extension Services in Ethiopia* (case 6) has reached close to 800 farmers in Ethiopia since 2010, and the project *METAGRI Roving Seminars in West Africa* (case 15) has reached over 7000 farmers in West Africa since 2008. The Roving Seminars are shorter (1 day vs. 2-3 days) than the preseason workshops implemented in cases 3, 4, 11 and 12; and do not go into depth in probabilities, or co-learning and co-production of climate services. In this case (15), even a simplified version of the pre-season workshops appeared challenging and costly to implement at a large scale.

Embedding such a process within institutions (e.g. agricultural extension services, development NGOs, agribusiness) that already serve and interact with farming communities on a large scale seems to offer the best prospect for upscaling to large numbers of farmers. Several of the case studies involved development organizations with strong ties to rural communities, using for example local Red Cross volunteers, World Vision staff, or professional media communicators to reach farmers with climate advisories or early warnings. Training national agricultural extension systems and other boundary organizations, such as NGOs, media and rural radio, to serve as the missing link between farmers and climate service providers offers a promising way forward. Scaling this up would require substantial investment in the capacity of these organizations to incorporate climate services into their ongoing interactions with farming communities, for example through staff training programmes on the communication, application and evaluation of climate information with smallholder farming communities.

Lesson 7: Diverse communication channels to reach the last mile

Information and communication technologies (ICT), combined with traditional proven mediums (e.g. rural radio, farmer organizations, social networks and trusted local NGOs), offer expanding opportunities to reach farmers with relevant climate services, at scale. The case studies that reached the largest numbers of farmers, including the national programmes in India and Mali, employed some combination of mobile phones and more traditional media. In India, this was achieved through SMS and voice recordings sent to farmers on their phones in local languages. Partnerships with local NGOs and public agricultural extension services were leveraged to ensure that advisories reached the most remote and vulnerable farmers, capitalizing on existing networks. In Mali, the more traditional vectors of rural radio and public extension service staff were also used to reach farmers, though future plans include farmer outreach through SMS. The project *Africa Farm Radio Research Initiative* (case 17) leveraged participatory rural radio programming. Both cases demonstrate that ICTs offer powerful new tools to reach farmers at scale, quickly, and at low cost. The AFRRI project (case 17) found that 40 million farmers in five countries were served by the 25 AFRRI partner radio stations over 42 months of engagement. The project *Uganda SMS-based Farmer Advisory Delivery* (case 13) utilized ICTs in a revolutionary manner to put agricultural information in the hands of incentivized Community Knowledge Workers with smart phones able to query climate and agricultural information on behalf of marginalized farmers, with support from the Grameen Foundation. Integrating an innovative ICT platform with a network of trained Community Knowledge Workers combined the reach and timeliness of mobile phone technology with the benefits of face-to-face interaction (Lesson 6). We expect that ICT-based communication of climate information will generally be most effective when it incorporates mechanisms that allow two-way interaction, and feedback to the information providers. Examples include radio listening groups, radio call-in programmes, and phone call centres. Examples surveyed by Jost et al. also confirm that dissemination platforms with provisions for farmer feedback on received information are the most effective platforms for climate information communication (Jost 2013).

Lesson 8 responds to the challenge of ensuring that women, poor and socially marginalized groups have access to and can use available climate services.

Lesson 8: Gender and social equity

Proactive targeting of women and other socially marginalized groups can help ensure inclusiveness in the design and delivery of climate information services for rural communities. Growing evidence of the difficulties of providing climate services that benefit various social groups, including women farmers and other socially marginalized groups, equally includes recent evaluations of the national agrometeorological advisory programmes of India and Mali (cases 1 and 2). The project *Climate Forecasting for Agricultural Resources* (case 4) explicitly targeted the most vulnerable sub-groups in the community. Despite the project's commitment to inclusiveness, workshop participant recruitment was influenced by dominant groups who, at times, sought to exclude disadvantaged groups (e.g. women, pastoralists, immigrants).

The only case surveyed that explicitly targeted the most vulnerable sub-groups in the community is the project *Gender-Specific Climate Service Needs in Kaffrine* (case 3), which sought to provide climate information that was salient to women farmers. Because they lacked the means of production, women were found to be the group in the community in Kaffrine who were most vulnerable to climate shocks, even more than children or handicapped men. The Kaffrine experience demonstrated that women farmers can be full participants in the design and evaluation of climate services, but that this necessitates pro-active targeting of women farmers from the design of the project, to continual re-assessment of needs throughout the life of the project. The project achieved this through separate focus group discussions and gender-disaggregated questionnaires to identify specific information products and communication channels that best meet needs of rural women farmers. We anticipate challenges with scaling up, as extrapolation of women's specific climate service needs to a larger range of sites will necessarily lead to loss some of the rich context-specificity gleaned from one village. However such site-specific PAR emerges as an important good practice to guide and inform design of climate services that ensure social inclusiveness, and service the needs of all farmers.

5. Policy implications and recommendations for climate services design

The lessons we presented in this report suggest a few elements that we recommend should generally be part of any effort to develop climate services at a national scale that seek to serve smallholder farmers.

First, involve farmers in the co-design, co-production and co-evaluation of climate services. Evidence from the case studies suggests that needs can be quite context-specific, varying even from one village to the next. What appears as an intuitive initial step—asking end users what they need—is often overlooked. However, giving farmers an effective voice requires more than an initial needs assessment. The informed and sustained engagement of farmers throughout the design, production, delivery and evaluation is needed in order for information products and services to evolve with experience, changing needs and changing capability of climate and other relevant sciences. It means valuing farmers' perspectives; and providing opportunities for engagement with researchers so their requirements can be informed by science, and the provision of services can be informed by their evolving requirements. Working with rural communities to integrate their knowledge into production of climate services is at the heart of the co-production effort. Doing this at scale requires efficient mechanisms to engage legitimate representatives of smallholder farmers, and to capture and map farmers' evolving needs.

Second, establish partnerships that bridge the gap between climate, agricultural research and farmers. The co-production of climate services requires sustained interaction and engagement of all parties (climate, research and end users). It has become clear that new institutional arrangements for salience will be required, expanding the boundary of climate service production to both agricultural research and farmers themselves (figure 6). When end-users' climate service needs are elicited, this often reveals significant gaps between their needs and the information and services that are routinely available. Filling those gaps requires climate expertise for example to: downscale climate information to a scale that is relevant to rural communities, improve prediction skill, or extend prediction to include agriculturally-important variables such as onset or cessation of the rainy season or the distribution of dry and wet spells. However, meeting farmers' needs also involves integrating climate information and agricultural expertise to produce predictions of climate impacts on agriculture, and farm management advisories. While national meteorological services (NMS) have the expertise to produce raw weather and climate information, national agricultural research and extension systems (NARES) are generally in a better position to translate this information into advice and support for farmers. Strong partnerships between national meteorological and hydrological services (repositories of climate knowledge at the national level) and national agricultural research and extension services (repositories of agricultural knowledge and extension support in country) are therefore a pre-requisite to producing information and services that are tailored to farmers' needs. Where such partnerships are not yet formalized, brokering partnership enabling sustained dialogue and is essential to the success of climate services that target farmers. We draw out examples of how case studies attempted to foster these partnerships, but the case studies reviewed do not provide enough evidence about their success, or factors that may limit their success, to address this important issue within the report.

Third, exploit scalable communication channels to reach "the last mile." Once tailored products are developed, the next challenge is to communicate widely to ensure the products reach the majority of farmers in the country or target region. As the case studies reviewed in this report illustrate, a wide range of communication channels can be used to deliver climate-related information and advisories, and to collect farmer feedback. Our experience, and assessment of the literature and case studies, suggest that expanding access to climate services for smallholder farmers is best accomplished through a combination of leveraging the reach and cost-effectiveness of ICTs (e.g. SMS, rural radio, voice recordings, call services); and working through trained staff of boundary organizations (agricultural extension, NGOs, Community Based Organizations, agri-business) and farmer facilitators who can facilitate the face-to-face dialogue that is needed to deal with the complexities of seasonal climate information. Evidence indicates that two-way communication between farmers and climate service providers is essential, regardless of the communication channels used (Jost 2013; Stigter and Winarto 2013).

Fourth, continuously assess to improve quality of service delivery. To ensure that climate services respond to evolving end-user needs and reflect the changing nature of the sciences involved, projects and programmes need to keep assessing adherence of provided products to local needs throughout the lifespan of the climate services project or programme. Assessment and reassessment should be part of the initial design and be integrated throughout the process of climate services development, particularly including giving farmers an effective voice, and communication approaches to reach more remote farmers. Assessing climate services fulfils at least three purposes. First, it can foster legitimacy and accountability by providing a formal mechanism to capture users' needs and feedback. Second, it informs the iterative process of improving and tailoring climate services to evolving local needs. Third, the resulting evidence of the costs and benefits of climate services can be used to build a case to governments and donors for continued and perhaps increased investment.

Finally, proactively engage, and target the needs of, the most vulnerable and marginalized, particularly women, from the onset. The vulnerability of smallholder farmers to climate risk is a major motivation for much of the recent interest and investment in climate services. Yet the challenges that lead some segments of rural populations to be more vulnerable also tend to make it more difficult to benefit from institutional services, including climate services. In the cases included in this study, the most vulnerable tended to be resource-poor, female and lower caste farmers, marginalized by the boundaries of their own community's sociocultural norms, and invisible to many outsiders. In order to build the resilience of farmers equitably, it is important to proactively target women and other marginalized farmers in the various steps of the design and delivery of climate services programmes, and ensure that they are represented in institutional and governance arrangements.

These five guidelines map out an integrated approach for designing, producing, communicating and evaluating climate services for smallholder farmers.

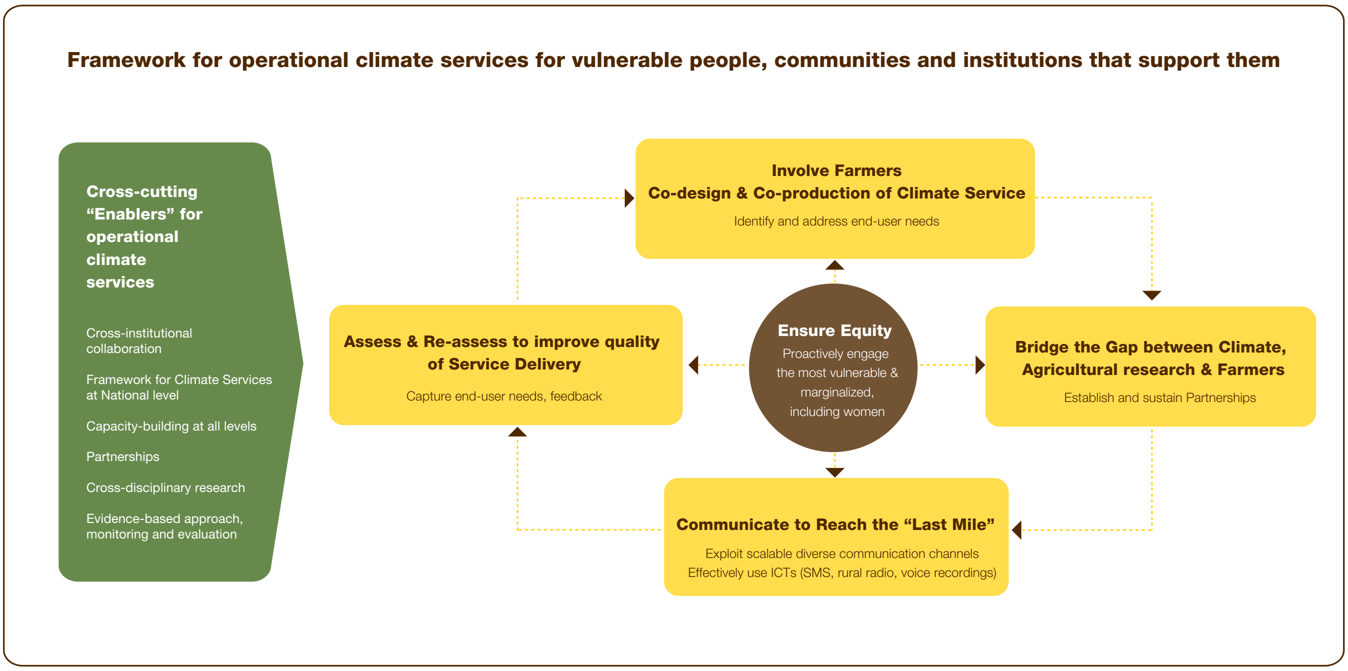


Figure 7. Proposed integrated framework for designing, producing, communicating and evaluating climate services for farmers.

6. Conclusion

As the cases reviewed in this report detail, reaching large numbers of farmers with climate services that are relevant, usable, credible and valued by end users is "Mission Possible" – but not without challenges. The eight good practice lessons (Box 1) summarize some of the ways in which experiences on the ground are addressing the tenacious challenges to providing climate services that are useful for smallholder farmers in the developing world. The case studies that support these lessons also provide evidence that this endeavour is possible, although challenging. Overcoming the challenges will require collaboration across communities and across disciplines, as well as enabling institutional frameworks within which such collaboration can take place at the national and sub-national levels, towards the production and delivery of end-user relevant climate services. Helping countries establish frameworks for climate services, which enable such collaboration across institutions and their associated ministries, is an urgent priority and perhaps the most difficult challenge.

This report has offered five potent guidelines gleaned from good practice across Africa and South Asia to address the challenges to scaling up climate services for farmers, and guide the efforts of future programmes aiming to support agricultural decision-making through climate information services (see figure 7). These guidelines map out an integrated approach for designing, producing, communicating and evaluating climate services for smallholder farmers.

In a world of exacerbated climate variability and uncertainty, with the greatest impacts anticipated in areas of Africa, Asia and the developing world, equipping and the most vulnerable communities with climate information and advisory services to anticipate climate-related shocks and changes becomes an urgent priority.

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Appendix 1 - Case study summaries

Cases	Success Factors	Main Findings	Limitations
Case 1: India AAS	-Strong network of Centres of Excellence: meteorological forecasting and agricultural research -Substantial national investment -Human and technical capacity (National and State levels) -Multiplicity of dissemination outlets -Inclusion of locally-trusted NGOs and CBOs -Farmers' feedback: post-seasonal evaluation -Diverse communications channels	-Higher number of farmers with awareness and use of AAS in villages where multiple communication channels used (including social groups and networks) -Training and Discussions: superior dissemination channel -High use of advisory: sustained interaction between farmers, agrometeorological services and agricultural scientists through local centres	-Limited reach to women, low-caste and disadvantaged farmers -Unsystematic collection of feedback from farmers
Case 2: Mali Meteo	-Establishment of multidisciplinary GTP: centre of two-way information flow b/w climate service providers and users -National GTP replicated with multidisciplinary working groups at local level -Different but well-integrated roles of participating groups -Multi-language translation of information -Mali government's commitment to strengthen met-services -Long-term financial support from Swiss Development Corporation	-Two-way communication and valuation of farmers' input gave farmers a legitimate voice and stake in the programme -National buy-in of the programme and government's political support was critical for Mali NHMS to continue its operations	-Unsystematic collection of feedback from farmers on the usefulness of provided climate services during the initial years of the programme
Case 3: Kaffrine Gender Research Project	-Pre-season, 3-day workshop : enabled farmers to gain familiarity with seasonal forecasts and short-term weather advisories	-Highlights the importance of PAR approaches to address different needs of farmers	-Lack of replicability at scale -Detailed village-by-village participatory research required
Case 4: Climate Forecasting for Agricultural Resources (CFAR)	-Experimental phase during workshops involved extension agents, government officials, and traditional authorities, and a dozen farmers from each village -Interactive exercises conducted to help participants understand the probabilistic nature of the seasonal climate forecast -Summaries of the seasonal climate forecast broadcasted on FM radio stations in local languages -6-7 'Farmer Leaders' were appointed to manage rain gauge for providing rainfall data, fed back to the national-met service	-Likelihood of workshop participants to use forecasts in making management decisions and understand probabilistic aspect of seasonal climate forecasts is more than non-participants - Face-to-face interaction is required to communicate probabilistic nature of a seasonal climate forecast -Radio announcements: effective way of reaching rural communities -Late forecasts were better than none	-Insufficient project funding - Limited uptake of the project's activities by national institutions
Case 5: Indigenous Knowledge Bank (Senegal)	Indigenous knowledge played vital role in local livelihoods -To support local efforts to forecast -To understand seasonal climate fluctuations	-Rural communities predict weather and seasonal climate trends by observing natural phenomena -Progressive loss of indigenous knowledge threatens the ability of farmers to adapt to climate change	

Appendix 1 continued

Cases	Success Factors	Main Findings	Limitations
Case 6: Training of Trainers for Agricultural Extension Services in Ethiopia	-Weather, Climate and Food Security Working Group: brings together NMA and Ministry of Agriculture -Organized 'training of trainers': 1700 participants -Trained many extension service workers, agromets and meteorological observers	-Project produced dekadal (10-day) weather forecast and distributed it to agricultural extension agents via SMS	
Case 7: Dissemination of Weather and Climate Information in Local Languages	- Communicated the forecast information in local languages -Used innovative mediums (children, religious organizations and women's savings groups) -Produced regular updates and radio broadcasts	-Dissemination of weather and climate information in local languages enhances understanding and timely delivery of information to rural farming communities	
Case 8: Climate Knowledge for Community Based Adaptation in Nyangi, Kenya	-Investment from ICPAC to improve capacity for interpreting, downscaling and packaging climate information services for local-level farmers -Pastoralists "responded to our advisories by planting the recommended crops and varieties (maize, onions, tomatoes, beans, and other vegetables) and followed good agronomic practices	-Climate information significantly benefitted the farmer's harvests -Agromet information farmers received from ICPAC helped them know when during the year they should plant, when to apply fertilizer and which seeds to sow	
Case 9: Integrating Indigenous Knowledge with Seasonal Forecasts in Lushoto, Tanzania	-Interviews and (FGDs) conducted in selected villages -Formation of indigenous knowledge weather forecasting -Creation of a core team to coordinate the flow of weather forecast information	-Farmers use a combination of local indicators to predict the weatherandclimate (insects, flowering of peaches, frogs, ants) -Scientific forecasting may be able to complement indigenous forecasting to help mitigate the loss of traditional weather and climate	
Case 10 : Identifying farmers' information needs in the Indo-Gangetic Plains	-Participatory research approach and quantitative rigor to understand farmers' information and service needs	-Farmers use multiple sources to access information about agriculture, climate change and risk management (Input dealers, Television, Mobile Phones, Newspapers)-Sources of information used by a farmer depends on his/her education and income - Farmers preferred voice messages over text messages	-Due to illiteracy, information could not be delivered by SMS
Case 11: CCAFS Climate Services Kaffrine Pilot, Senegal	-Strong partnerships between NHMS, National Agricultural Research Institute (ISRA), Ministry of Agriculture and Extension Services -Clear roles in the chain to produce, value-add and communicate climate services for farmers -2-level dialogue b/w producers and users of climate services: national and local and farmer training workshops using PAR	-Strong demand for climate information and evidence that farmers rely on climate information for decisions about planting dates, crop choices and investment in inputs	
Case 12: CCAFS Climate Services Wote Pilot, Kenya	-Strong evaluation protocol with scientific rigor to evaluate the effectiveness of two different methods of presenting climate forecast information to smallholder farmers against a control with no intervention -*Method 1*: Two-day training workshop to share seasonal forecast and teach probabilistic distribution function with decision making implications -*Method 2*: Direct communication of agro-advisory, which includes seasonal forecast implications for agricultural management and recommended farm-level practices to adopt	-Forecast information is useful: significant changes in farm practices -Face-to-face training workshops: essential medium to communicate and provide context to the seasonal forecast -Scaling up workshop-based approaches to train farmers on seasonal forecast applications is possible	

Appendix 1 continued

Cases	Success Factors	Main Findings	Limitations
Case 13: Uganda SMS-based Farmer Advisory Delivery	-Establishment of village-based network of Community Knowledge Workers (CKWs) equipped with low-priced smart phones with a locally built app that contains agricultural information that could be queried to provide information to interested farmers in their communities -Business incentive for CKWs	-Peaks of queries from farmers occurred during times of rainy season onset/planting period, harvest time and during the season when dry/wet spells are experienced	
Case 14: Supporting Smallholder Decision Making in Zimbabwe and Tanzania	-Farmers utilized historical data analysis to identify local climate trends and plan their resource allocations for the season -Participating farmers estimated probabilities of variables (total rainfall amounts, onset dates for the upcoming season)	-Farmers found participatory planning methods useful for identifying and comparing different crop management techniques for the next season and have modified strategies on their farms as a result	
Case 15: METAGRI: Roving Seminars in West Africa.	-159 one day workshops for farmers on weather and climate: 'Roving Seminars' on 5 topics:- Climate variability and climate change Specific climate risks for agriculture Agrometeorology (products and tools) Agronomic research and adaptation to climate change Use of farmer's rain gauge (distributed 3325 rain gauges) -Multidisciplinary training teams (met-scientists, extension agents, agriculture experts)	-Around 1000 women receiving training -3325 rain gauges were distributed	-Lack of depth and time to build real capacity within targeted farming communities -No evaluation done on the impact of roving seminar approach -Because of cultural differences, representations of men and women were not equal
Case 16: National Frameworks for Climate Services, West Africa pilots	-Brought together National forecasters, agricultural research institutions and national decision-makers, boundary organizations and end users -Three-day intense interaction workshop -Participatory games to simulate early warning	-Nationally-defined and appropriate institutional frameworks are needed to enable the delivery of salient agromet advisories for farmers	-Insufficient funding for follow-up
Case 17: African Farm Radio Research Initiative	-Multi-stakeholder action research project: by Farm Radio International, shows if and how rural radio can improve food security in Africa -Rigorous evaluation protocol to measure project impact -AFRRI worked with 25 radio stations (over 3 yrs) in 5 countries to research, plan and produce 2 PRCs per station	-Radio: an effective agent of change, disseminating knowledge quickly at low cost	-No actual delivery of climate services as part of this project
Case 18: Climate Learning for African Agriculture	-Implementation of interesting local-level projects: ensuring farmers involvement in processes intended to help them adapt to climate change -Projects tend to confront issues of supply of inputs, including credit and market opportunities	-There exists necessary institutional pre-conditions for effective climate services for agriculture and food security -Gap between ministries of environment charged with climate policy, and ministries of agriculture charged with questions of agricultural knowledge	-National-level stakeholders ascribe relatively less importance to provision of climate information -Limited farmers' participation -Focused on specific solutions rather than building the farmers' own capacity for innovation

This report presents lessons learned from eighteen case studies across Africa and South Asia that have developed and delivered weather and climate information and related advisory services for smallholder farmers. The case studies and resulting lessons provide insights on what will be needed to build effective national systems for the production, delivery, communication and evaluation of operational climate services for smallholder farmers across the developing world.

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