Increasing small-scale farmer access to climate services

RICHARD EWBANK

A key part of increasing small-scale farmer resilience to both climate variation and longer term climate change, both now amplified by anthropogenic greenhouse gas emissions derived from the burning of fossil fuels, is to strengthen farmers' adaptive capacity. Implicit in definitions of adaptive capacity is an increased ability to anticipate risk of shocks and stresses through forecasting and knowing how to respond to these forecasts. Understanding forecasts of future weather and climate conditions and applying this understanding, together with other complementary technical knowledge, to a range of decisions about on-farm operations will then build climate resilience. Farmer responses suggest that an initial rationale of a 10–20 per cent increase in output is valid and that increasing forecast effectiveness through combining seasonal and 7-day or 5-day forecasts, together with a focus on agroecological agriculture, may result in an even stronger impact. Long-term forecasts developed through applied climate models that can guide community-based resilience planning and farmer-generated data, e.g. through use of rain gauges, also increase their ability to make resilience-building decisions. Understanding local knowledge and local indicators are important parts of the process, providing a knowledge framework that works for farmers, indicating which decisions are likely to be enhanced by scientific forecasts and adding local context. Increasing access to climate services works particularly well when combined with agroecological advisory services, which deliver greater resilience and productivity compared with conventional, input-intensive methods.

Keywords: climate services, climate-resilient agriculture, agroecology

A KEY PART OF INCREASING small-scale farmer resilience to both climate variation and longer term climate change, both now amplified by anthropogenic greenhouse gas emissions derived from the use of fossil fuels, is to strengthen their adaptive capacity. Implicit in definitions of adaptive capacity is an increased ability to anticipate risk of shocks and stresses through forecasting and knowing how to respond to these forecasts. Understanding forecasts of future weather and climate conditions and applying this understanding, together with other complementary technical knowledge, to a range of decisions about on-farm operations will then build climate resilience. These decisions include choice of crop and crop variety, livestock disease and nutrition management, better timing of planting, soil and water management strategies, protective measures to take in the event of forecast hazards such as drought, frost and flood, timing and type of pest-control measures, and when and how to harvest, store, and market a crop. An increase in adaptive capacity as evident through risk-reducing decision-making would in turn enable

---

Richard Ewbank (rewbank@christian-aid.org) is Global Climate Adviser, Christian Aid, UK.

http://dx.doi.org/10.3362/2046-1887.2016.007, ISSN: 2046-1879 (print) 2046-1887 (online)

improvements in other characteristics of climate resilience: building redundancy into agricultural assets, especially soils, water resources, and agrobiodiversity, that can be mobilized to buffer shocks and stresses; increasing robustness so that an agricultural livelihood can absorb shocks and stresses without losing its essential functions; reducing recovery time after shocks small and large; and being able to thrive when favourable conditions are forecast in order to strengthen resilience to future risk (Christian Aid, 2016).

Considerable experience has been built up with respect to increasing small-scale farmer access to climate services from short-term daily and weekly forecasts to seasonal forecasts. In 1982, as a response to recurrent droughts through the previous decade, the Direction Nationale de la Météorologie (DNM) in Mali began supplying farmers with weather information. As well as receiving rain gauges and associated training to guide decisions such as planting dates, they were provided with daily, 3-day and 10-day forecasts which included agricultural advice (Hellmuth et al., 2010). Since its inception, about 2,500 farmers have been trained. Average yield increases covered a range from 36 per cent (sorghum), and 37 per cent (millet) to 48 per cent (maize) for farmers taking management decisions with agrometeorological information compared with national averages (in the 2010 season). A pilot study in Zimbabwe in 2003–4 (Patt et al., 2005) sought to understand whether farmers receiving seasonal forecast information make different decisions that benefit them and, if they have access to a participatory system of forecast communication, are they more likely to use this information than those receiving forecasts through other, less interactive channels. The study concluded 'that the use of forecasts was associated with an increase in harvests, compared with farmers' typical range of harvests, of 9.4 per cent across the 2 years and 18.7 per cent in the 2003–2004 season'. Although year-to-year variability in yield is larger, this result suggested that forecasts provided through participatory forecast communication do have positive value to users.

Other interventions have reported more substantial results. Farmers across three pilot sites in Nyangi, Kenya, received a downscaled package of climate services from ICPAC, East Africa's IGAD Climate Prediction and Applications Center (Tall et al., 2014). As a result, they reported harvests for sorghum and maize 3–4 times larger than their previous experience, attributing this to forecasts, advisories, and other agrometeorological information used. In Indonesia and the Philippines, the provision of climate services has been more explicitly integrated into the general provision of agricultural support, especially for farmers seeking to make the transition from conventional, chemical to more resilient, agroecological farming methods through climate field schools (CFSs). These CFSs increased farmers' knowledge on climate and their ability to anticipate extreme climate events; assisted farmers in observing climatic parameters and their use in guiding farm activities; and helped farmers to interpret climate information, in particular for planting decisions and cropping strategy (Boer et al., 2003). As a result 78 per cent of Indonesian farmers felt that their ability to integrate climate and forecast information into their cropping strategies had increased significantly (7/10 or better).

Despite these positive results, as recently as 2003 it was noted that 'climate information is not yet widely used by farmers who make routine decisions about production in existing farming systems' (Jones, 2003). By 2009, concern was raised that 'seasonality is routinely ignored in the conceptualisation and design of agricultural projects, with detrimental consequences for project performance and participants' wellbeing' (Devereux and Longhurst, 2009). Reasons included a low level of attention paid to seasonality, unrealistic assumptions about trickle-down effects, and lack of livelihoods analysis. With respect to the use of climate services in sub-Saharan Africa, Hansen et al. (2011) confirmed that climate services offer farmers the potential to improve their livelihoods and protect their families and farms against the impacts of longer term climate change. Demand for climate services was seen as widespread but constrained by communication failures and services poorly designed to address farmer priorities. This practice paper highlights three examples of climate service provision based on intervention evaluation and impact assessment, and using these experiences makes a number of recommendations to practitioners for future scaling-up and use.

Developing climate services in Kenya, India, and Nicaragua

Over the past five years, Christian Aid has supported partners in a number of countries to better integrate climate services into their broader resilience-building work (Christian Aid, 2015). In Kenya, activities focused on supporting Christian Community Services Mount Kenya East's (CCSMKE) work improving small-scale farmers' access to the seasonal and 7-day forecasts, whereas in India, a tailored 5-day forecast developed by Gorakhpur Environmental Action Group (GEAG) has been the key information product. In Nicaragua, Centro Humboldt have developed a regional climate model to give longer term agro-climatological scenarios, supplemented with capacity building through farmer-managed rain gauges and general training on climate change.

In Kenya, the basic hypothesis was that through the use of seasonal and short-term (7-day) forecasts, farmers should be able to achieve a 10–20 per cent yield improvement that can be reliably attributed to decisions changed by these forecasts. This reflected the earlier research in Zimbabwe and Mali cited above where farmers using climate services experienced similar or slightly higher productivity responses. The activities (see Figure 1) were designed to match the timing of the seasonal forecast release by the Kenya Meteorological Department, which follows the regional forecast developed by the Greater Horn Regional Climate Outlook Forum (GHARCOF). Farmer group representatives received training after the seasonal forecast was released from climate experts from the Kenya Meteorology Department, the Humanitarian Futures Group, the University of Sussex, and the UK Meteorology Office. This participatory training covered various aspects of forecasting, including how to interpret the information, understand its uncertainty, and how to manage this in making resilience-building agricultural decisions. It also highlighted how forecasts can be related to earlier years when similar conditions occurred, how to combine forecasts with complementary technical advice, and the relationship between scientific and local forecasting information. This was then cascaded to group members through CCSMKE project facilitators, together with government agricultural extension staff to provide complementary advice.

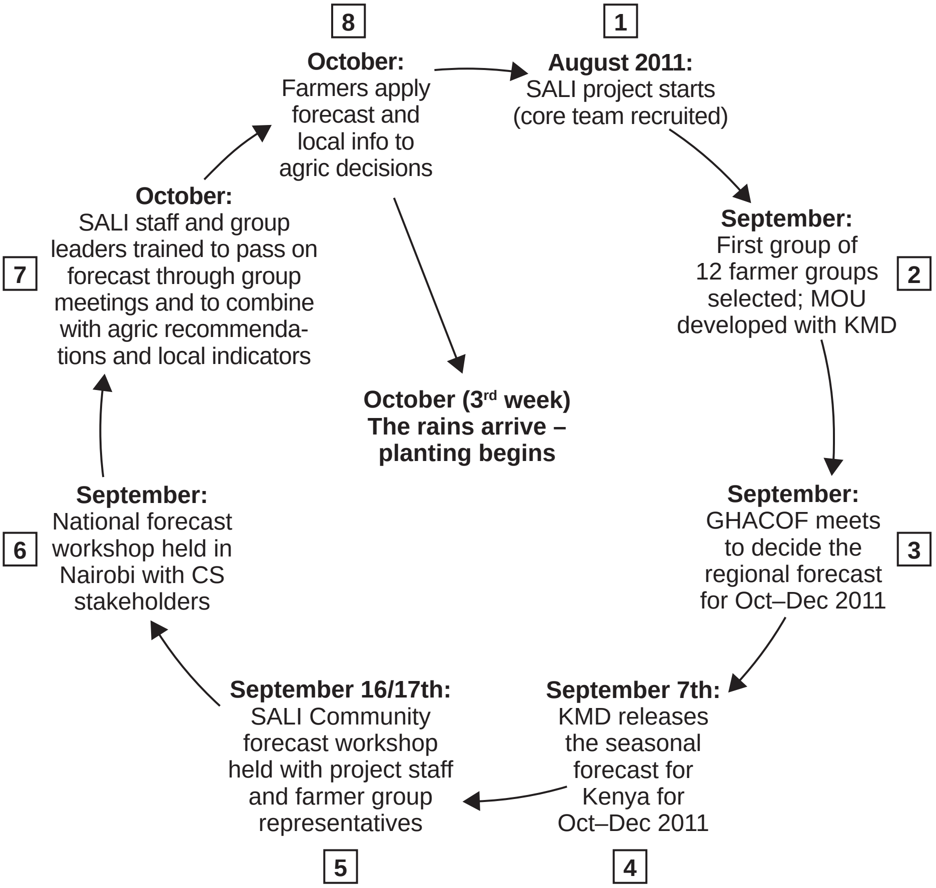

Figure 1 Timeline for seasonal forecasting activities

Seasonal forecasts provide a probabilistic assessment of the likelihood of rainfall being above, below, or normal for the next 3 months. In Kenya, they also contain additional information, such as the likely date of onset and cessation of rains and a summary of impacts on various sectors, including agriculture. Farmers were encouraged to bring their own local knowledge into the process, identifying 18 indicators of varying reliability, from the flowering behaviour of certain tree species to the migration of bees. In general, it was felt that use of these had diminished in recent years, increasing the demand for more scientific forecasts. Reasons for this varied but included environmental change as tree species used for forecasting were cleared for agriculture, increased access to education, and cultural change.

Although there were communication problems (subsequently resolved) with the 7-day forecasts, which were introduced through an SMS-based system for the second season, all farmers reported receiving and using the seasonal forecasts. Decisions changed included (in order of importance) planting closer to the onset of rains; changing variety to increase drought resilience; changing crop to increase drought resilience; changing to conservation agriculture techniques to increase soil moisture; better timing of operations such as fertilizer application and pest control; changing planting regimes, e.g. better plant spacing and rotation; increasing soil moisture through soil erosion control and water diversion; and increased use of manure. Both planting timing and timing of operations were also enhanced by the 7-day forecast. Many of these practical measures to increase resilience led to farmers opting for more agroecological-type interventions as these were perceived to be both better aligned to forecast conditions and more likely to enhance crop productivity.

About 94 per cent of farmers attributed increases in crop output of greater than 5 per cent to decisions they had made differently as a result of improved access to forecast information. Two-thirds felt that the impact on their crop production was greater than 15 per cent, which tends to confirm the range proposed in the original hypothesis. A small number of farmers did estimate yield reductions – in one case, a farmer planted more green grams based on the forecast and an army worm outbreak had a negative impact. Another referred to waterlogged fields as a result of heavy April rainfall. Farmers assessed the forecasts as being 80–90 per cent correct, so the review did not include a season where the forecast was significantly different from the actual seasonal performance. Use of the forecast was associated with strong demand for complementary resilience-building agricultural support on issues such as conservation agriculture, soil testing, integrated pest management, and small-scale irrigation. Farmers also emphasized the importance of receiving seasonal forecasts early enough to inform pre-season management decisions such as seed purchase and land management. In Mbeere, this meant at least 4–6 weeks before planting, which proved a challenge in the long rainy season when the interval between the forecast release and the onset of rains is usually shorter.

In Uttar Pradesh, India, GEAG developed an SMS-based 5-day forecast together with relevant agricultural information that is provided to farmers across four districts. The number of farmers receiving information both directly and indirectly has expanded rapidly – in 2012 just 227 received the forecast either directly or indirectly with 40 per cent using the associated advisories. By 2015, 1,323 received the forecast; about 40 per cent of these were women farmers, and 85 per cent were following the advisory. Every direct recipient disseminates the information to at least four other farmers, expanding the indirect reach to about 4,000.

Farmers highlighted a number of changes in climate experienced over the previous decade, including a delayed monsoon onset, a shorter winter season for wheat cultivation, and more intense rainfall interspersed with longer, hotter dry spells. As these climate changes increasingly affect production and the costs of inputs rise, farmers are caught in a vice of incremental stress on their livelihoods that can progressively reduce their ability to develop resilience. GEAG promotes an alternative to conventional chemical agriculture that addresses both sides of this equation by reducing chemical input use, and therefore cost, and increasing resilience, productivity, and profitability through sustainable, agroecological farming methods. Increasing access to climate forecasts fits particularly well within this knowledge-intensive, rather than input-intensive, approach. Farmers emphasized the importance of climate services and associated agroecological advice in achieving greater resilience and efficiency of production. While climate services tailored to sustainable, agroecological approaches can also be used by conventional farmers, climate services designed simply for chemical fertilizer and pesticide use do not have significant utility for agroecological farmers.

Farmer groups described their perceptions of the usefulness of 5-day forecasts, with a variety of impacts and an emphasis on cost savings through better management of inputs, pests and diseases, irrigation, and risk mitigation measures (see Figure 2). Although not all of these could be quantified in all groups, especially damage avoided, specific examples of cost savings were cited. Perceptions of yield increase were less readily estimated but nevertheless, farmers were able to give conservative values of 10–25 per cent, agreeing with the hypothesis proposed for Kenya. There was also value expressed in terms of improving household resilience, something women's group members emphasized, for both household food security and health.

Elements highlighted by the participating communities as contributing to the success of the approach include the use of appropriate communication methods (SMS, village notice boards) to ensure access by all to forecast information, not just those directly receiving the SMS. Other elements were the usefulness of the agro-meteorological information included with the forecast information and the feedback mechanism that ensures farmer groups have the opportunity to review the system monthly and feed back to GEAG. The skilled capacity of GEAG to design and deliver the system in partnership with the Indian Meteorological Department and local universities is also crucial, but this in itself raised issues as to the long-term sustainability of the service. Climate services are provided through the participatory and vulnerability assessment (PVCA) process. Given the importance of climate-related shocks and stresses to the risk profiles generated, it is not unsurprising that climate services have generated the interest and usefulness that they have, but this also ensures that they are integrated into wider community-based adaptation processes.

In Nicaragua, by contrast, Centro-Humboldt have developed a regional climate model (RCM) using PRECIS software developed by the UK Meteorology Office and applied it to scenarios from 2014–19 to 2034–39 for the main staple crops of maize, beans, and rice. The main implications are:

- A contraction in the area suitable for maize and beans, in particular the areas considered optimal but also a fragmentation of areas considered suitable. The suitable area in the central highlands will contract and shift eastwards. This then encounters geographical constraints as the agroecology changes to the lowland rainforest of the western half of the country, which is unsuitable for these two crops. The net effect of climate change is therefore a crop area that is being squeezed between increasing drought pressures (reduced rainfall, increased temperatures) and the restrictions of geography in migrating east.
- These impacts on crop production are related not only to the total rainfall amount but also the way it is spread across the rainy season (e.g. ideally maize needs 5 mm/day). The models show that the first phase of the rainy season – the *primera* – is likely to become much less reliable in future, merging into the

Village	Impact
Chikaniadech	Increased crop yields – 70% of farmers agree the effect is positive
	Use forecast to decide whether to work on own farm or go for manual labour
	Avoiding loss e.g. protecting crop from extreme rainfall
	Reducing irrigation, labour, and biopesticide costs by 50%
	Saving on fertilizer costs for wheat of IR2, 400 (US$40) per acre (about 25%)
Sarhar	Increased crop yields of 5–10%
	Avoiding depressed yields through water logging e.g. if irrigation is then followed by heavy rain
	Reducing irrigation, labour, and biopesticide costs by 25%
	Reduced labour by women especially
Sanghia	Increased crop yields by 10%
	Better fodder conservation improves livestock performance
	Reduced water and labour costs by 15%
	Reduced and/or more efficient use of other inputs also
Rakhukhur	Increased yield through more accurate use of inputs and better timing of planting
	Reduced input costs (mainly labour, irrigation, and biopesticides)
	Reduced losses related to damage avoided

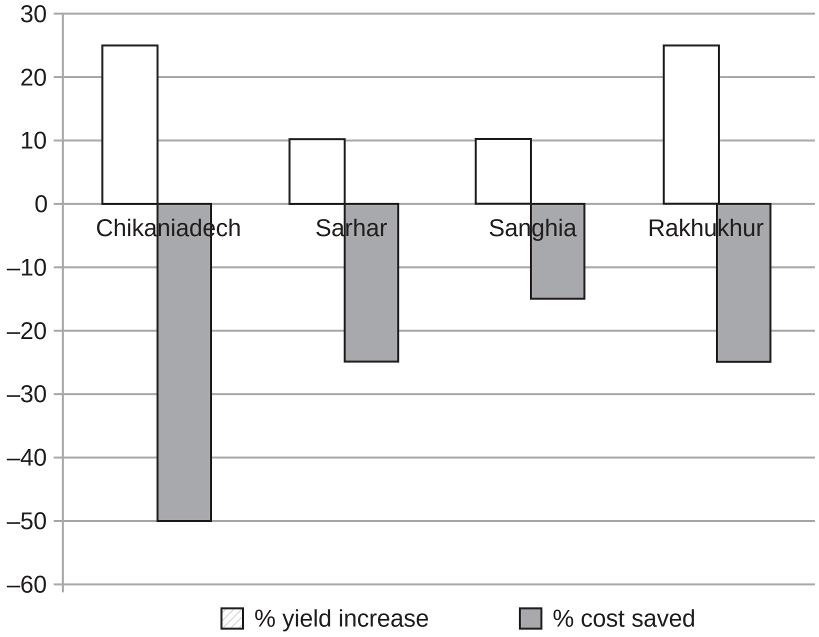

Figure 2 Summary and level of impacts described by farmer groups

second phase – the *postrera* – with a consequential need for farmers to switch to shorter season varieties and refine their techniques for planting timing (so highlighting the need for better access to reliable seasonal and short-term forecasting).
- The trend for rice shows some variation from maize and beans with both fragmentation and expansion. Suitable areas in the western side of the country decline but the potential area expands into the eastern lowland rainforest areas. This has implications for rainforest conservation, given its important role in climate regulation and as a source of valuable genetic biodiversity.

The RCM has also been informed by a network of 27 community-managed rain gauges. The rain gauge records are used by farmer groups to make yield-enhancing decisions that include: matching rainfall to the phenological characteristics of crops to guide crop management measures; using the data to determine the type and variety of crops to plant; better estimating of planting dates; early warning of drought conditions to guide planting and irrigation decisions; early warning of flood risks; and reviewing harvest prospects based on rainfall records to give an early indication of harvest expectations. Yield data from Nochari, another Christian Aid partner involved in the project, indicated a 75 per cent yield improvement that was partly attributed by farmers to use of improved climate and rain gauge information but also to adoption of agroecological methods such as use of organic fertilizers and pesticides, better access to seed through seed banks, and training provided on what to plant when.

Rain gauge data has not just guided crop management but also crossed over into flood and drought early warning. In 2013, in El Dante, farmers knew that 80 per cent of the crop would be affected by drought based on their rain gauge data. In the absence of a climate station producing official data, this acted as an evidence base on which to approach the Municipality COMUSAN (food security committee) to raise the issue of food supplies and lobby for drought relief. Future priorities are to extend the results of the climate model to the communities involved so that they can use it to inform longer term planning as part of the development or renewal of their PVCA-based development plans. As the rain gauge network has further expanded, the scope of climate services has increased to include short-term and seasonal forecasts through a monthly forecast bulletin which has proved essential to increased management of climate risks, such as the 2015/16 El Niño drought.

Conclusions and recommendations to practitioners for future scale-up

For small-scale farmers in Kenya and India, short-term and seasonal forecasts have demonstrated their utility to climate-resilient decision-making that has in turn resulted in increased crop yields, reduced costs, and avoided damage. In India, the emphasis was on reduced costs, which may reflect the value of the 5-day forecast in making continuous decisions throughout the season to fine-tune operations. The priority given to getting the planting date right in Kenya also suggests a preoccupation with avoiding the costs associated with erratic rainy season start-up, such as having to replant a crop, but also ensuring that crops make the most of the available growing season and yield well. Farmer responses in all three interventions suggest that the initial rationale of a 10–20 per cent increase in output is valid and that increasing forecast effectiveness through combining seasonal and 7-day or 5-day forecasts with agroecological support results in even stronger impact.

Local or traditional knowledge on climate forecasting was still seen as important in all three projects, although an increased familiarity with and successful application of scientific forecasts suggests that this diminishes as initial scepticism about their relevance and reliability declines. Traditional forecasting methods, even when their scientific basis is thought to be tenuous, are important in several ways: they highlight the climate risks that farmers are preoccupied with; they illustrate how farmers in any particular context understand the climate around them; and they offer an existing and culturally appropriate mechanism for introducing scientific forecast information that climate scientists and intermediaries can use effectively. Respecting local knowledge also breaks down barriers of reserve that may well exist, given the scepticism farmers expressed about scientific forecasts at the start of all three interventions. Lastly, some local indicators may well have a scientifically plausible basis to them, as has been demonstrated for the movement and migration patterns of certain bird species.

A number of key lessons for sustainability emerge from these experiences:

- Developing a full range of forecasting information from daily forecasts to scenarios for the next 30 or 40 years. A common misconception is that farmers are only interested in the next season but as the experience in Nicaragua shows, the longer term scenario is also considered important. It can inform a range of farm management decisions, from perennial crop investments, such as which coffee variety to plant, to land-use decisions such as irrigation infrastructure and reforestation, both issues raised by participants in Kenya.
- Clarity on the uncertainty of forecasts. These are probabilistic information resources that cannot eliminate uncertainty, but can reduce it. This makes transparency from forecast generators of the uncertainty and the skill of the forecast over previous seasons important. For example, if a seasonal forecast has a reliability track record of 80 per cent and farmers know this, they will not be surprised when for one season out of five, a low probability event occurs. They will also know that by using forecasts consistently, they will come out ahead in the other four seasons.
- Choosing the right mixture of communication methods to ensure that forecasts are received not only by directly registered farmers (such as those with mobile phones) but those less easily reached and often more vulnerable households. With much attention given to new information and communication technologies, it is easy to forget that the most vulnerable may not have the resources or literacy skills to use these successfully. Often more traditional methods that can easily incorporate local languages are more effective and should remain in the mix.

- Feedback mechanisms that enable forecast users to ask questions, raise issues, and obtain clarification have proved important in enabling the effective application of climate services. This allows forecast users to understand what can initially appear to be complex issues, understand the uncertainty in forecasting and how to manage it, and enable forecast generators to gain invaluable feedback to improve formats, communication channels, and which complementary information to include.
- Complementary agricultural advice that responds to climate-service users' resilience priorities is clearly seen as an integral part of effective forecast application. In all three examples above, these involved supporting forecast users in the transition from conventional, chemical to more resilient, agroecological methods. This transition from input-intensive to knowledge-intensive agriculture is both enhanced by and enhances climate-service use and shows improved yields, reduced costs, and avoided damage over previous unsustainable conventional chemical practices. This also has implications for the way agricultural extension is provided, implying a change in function for climate stations from just measuring points to more integrated centres for community climate-resilience advice and support. In some areas, such as through climate field schools in the Philippines, this process has already started with positive results.
- Building climate services into community-based resilience-building planning processes, such as PVCA, demonstrates that these are complementary and not contrasting processes. It can also ensure that climate information informs and enhances the action plans developed, so improving their value in reducing climate risk, responding flexibly to future shocks and stresses as they emerge, including in sectors beyond agriculture to more general risk reduction.
- Farmers and farmer groups can generate their own information through rain gauges, etc. As the Nicaraguan experience shows, this local data can advise agricultural and disaster risk-related decision-making and fill gaps in the official network of climate stations. They can also support their local climate stations as well as potentially receive services from them, improving their access to and understanding of climate services. Peer linkages, such as farmer-to-farmer extension and experience sharing, are also effective, so facilitating these generates more sustainable impact, promotes the scale-out of information, and reduces the cost of this process. As the World Economic Forum (2016) highlights, 'citizen science gives participants a sense of belonging to an effort that creates positive, lasting change – it combines advancing scientific knowledge with educating citizens, raising awareness of issues, and encouraging wider participation'.

Other issues in the wider meteorological sector also need to be addressed to increase access to climate services. As Hansen et al. (2011) highlight, structural adjustment policies implemented by multilateral development banks have reduced the resources available to National Hydro-Meteorological Agencies (NHMAs) and encouraged them to seek revenue from commercializing forecast provision. These need to be reversed and climate data and forecasts seen as public goods and open-source information for development, not least to avoid the moral hazard implied by rendering climate services and the protection they can provide unaffordable for poorer and more vulnerable people. In addition, four other essential recommendations are suggested:

- to mainstream climate information into agricultural research and development strategy;
- to develop capacity to use and effectively demand climate information;
- to give a degree of ownership and an effective voice to the agricultural sector and particularly farmers in climate information products and services;
- in many cases, to realign, resource, and train NHMAs as providers of services for development and participants in the development process.

Likewise the lessons for sustainability above strongly echo the eight good practice lessons in scaling up climate services for farmers highlighted by Tall et al. (2014). These also emphasize the importance of addressing gender concerns within climate service provision. As the experiences above show, climate services are important for and in demand from both men and women. In small-scale agriculture, women make up 43 per cent of the workforce but manage up to 90 per cent of staple crop production (FAO, 2011). However only 15 per cent of agricultural extension workers are women and only 5 per cent of extension messages reach women farmers (GFRAS, 2012). This, as with many of the areas highlighted above with regard to support for small-scale farmers, needs a comprehensive transformation for a successful transition to climate-resilient agriculture.

References

Boer, R., Tamkani, K. and Subbiah, A.R. (2003) 'Communicating climate forecast to farmers through climate field school: Indonesian experience', in *Insights and Tools for Adaptation: Learning from Climate Variability, 18–20 November 2003, Washington, DC* [pdf] <www.climateadaptation.net/docs/papers/Rboer-Subbiah%20paper.pdf> [accessed 23 November 2016].

Christian Aid (2015) *Developing Climate Services: Experience in Forecast Use from Kenya, India and Nicaragua* [pdf], Programme Experience Report <http://programme.christianaid.org.uk/programme-policy-practice/sites/default/files/2016-03/developing-climate-services-experience-feb-2015.pdf> [accessed 17 November 2016].

Christian Aid (2016) *Measuring Resilience Impact at Programme and Project Levels* [pdf], Programme Practice Guideline <http://programme.christianaid.org.uk/programme-policy-practice/sites/default/files/2016-08/Measuring-Resilience-Impact-Aug2016.pdf> [accessed 23 November 2016].

Devereux, S. and Longhurst, R. (2009) 'Seasonal neglect? Aseasonality in agricultural project design', in *Seasonality Revisited: International Conference, Institute of Development Studies, UK, 8–10 July 2009* [online] <www.future-agricultures.org/search-documents/seasonality-revisited/background-report-and-papers/997-seasonal-neglect-aseasonality-in-agricultural-project-design/file> [accessed 23 November 2016].

FAO (2011) *The Role of Women in Agriculture* [pdf], ESA Working Paper No. 11-02 <www.fao.org/docrep/013/am307e/am307e00.pdf> [accessed 23 November 2016].

Global Forum for Rural Advisory Services (GFRAS) (2012) *Factsheet on Extension Services*, Position Paper, GFRAS, FAO, Farming First, IFPRI, World Farmers Organisation.

Hansen, J., Masons, S., Sun, L. and Tall, A. (2011) ‘Review of seasonal climate forecasting for agriculture in sub-Saharan Africa’, *Experimental Agriculture* 47(2); 205–40 <https://doi.org/10.1017/S0014479710000876>.

Hellmuth, M., Diarra, D.Z., Vaughan, C. and Cousin, R. (2010) *Increasing Food Security with Agrometeorological Information: Mali’s National Meteorological Service Helps Farmers Manage Climate Risk*, World Resources Report Case Study, Washington, DC: World Resources Report.

Jones, J.W. (2003) *Agricultural Responses to Climate Variability and Climate Change*, Background Paper for NOAA Workshop, *Insights and Tools for Adaptation: Learning from Climate Variability,* Washington, DC.

Patt, A., Suarez, P. and Gwata, C. (2005) ‘Effects of seasonal climate forecasts and participatory workshops among subsistence farmers in Zimbabwe’, *Proceedings of the National Academy of Sciences* 102(35): 12623–8 <http://dx.doi.org/10.1073/pnas.0506125102>.

Tall, A., Hansen, J., Jay, A., Campbell, B., Kinyangi, J., Aggarwal, P.K. and Zougmore, R. (2014) *Scaling Up Climate Services for Farmers: Mission Possible. Learning from Good Practice in Africa and South Asia*, CCAFS Report No.13, Copenhagen: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

World Economic Forum (2016) *The Global Risks Report*, 11th edn, Geneva: World Economic Forum.