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BRIEFING PAPER

USING ICT TO PROVIDE WEATHER INFORMATION FOR AGRICULTURE

INTRODUCTION

This is one of a series of briefing papers to help USAID missions and their implementing partners in sub-Saharan Africa use information and communications technologies (ICT) more successfully to improve the impact of their agriculture projects, including Feed the Future (FTF) initiatives. The focus of this paper is specifically on weather information. While farmers need multiple types of information to help them improve agricultural output and access markets, weather is one of the most highly requested services.

Accurate weather forecasts not only help farmers protect themselves against natural factors but they can also benefit significantly as long as they are aware of the actions they can take to leverage good weather patterns. Weather information is also an input for developing risk mitigation tools such as index insurance products for farmers.

Spotlight: Impact in Mali
A comparison of yields of farmers involved in a weather information project in Mali showed that yields were higher in fields using agro-meteorological information; farmers using agro-met info also earned 80% more income.

Source: "Climate Risk management in Africa: Learning from practice" published by IRI, (2007).

Access to regular and reliable weather information is very poor in most developing countries, but especially sub-Saharan Africa. With limited external information, farmers rely on historical weather patterns for farming but the growing unpredictability in weather systems due to climate change has increased the risk for farmers. Short-term weather patterns can also be significantly different within small geographic areas, especially in tropical zones. Providing granular information for these micro-climate systems is an important element of effective weather information.

The development sector can play a significant role in facilitating models that address the lack of access to quality information for farmers. Improvements in availability of weather data through satellite data collection and the science of weather forecasting using increasingly sophisticated models has provided an opportunity to make a quantum leap in improving both the access and quality of information to farmers in almost any part of the world. The challenge is to develop cost effective models that are able to deliver the information in a timely and understandable form at the level of granularity that is needed to make it actionable. A multi-stakeholder approach including public-private partnerships and civil society to coordinate efforts in facilitating efficient weather information systems may help support effectiveness.

WHO USES WEATHER INFORMATION AND HOW?

Multiple stakeholders in the agriculture ecosystem use weather information. Climatic conditions and seasonal forecasts help ***farmers*** in planning for the upcoming season to maximize productivity based on expected weather patterns.

The most important decisions made by smallholders are based on the seasonal forecast when they decide which mix of crops and seed varieties they will be planting, purchase seed and inputs, and prepare their land accordingly.

Shorter real-time meteorological information of less than ten days and daily forecasts further help determine timing of various activities such as sowing, weeding, spraying, and harvesting. Weather information can be especially impactful if combined with specific advice or tips on the actions that need to be taken by the farmers to address weather patterns.

Example of potential benefit
The citrus crop is vulnerable to the premature fruit drop disease that develops when the temperature is low, the weather is cloudy or lightly rainy, and the leaves of the citrus plant are wet. Specific weather forecasts that enable properly timed fungicide applications can prevent a loss of more than 50% of citrus yield.

Source: "Significance of weather and climate for agriculture" Finnish Meteorological Institute.

Real-time daily or 2-3 day forecasts can also help farmers make very practical decisions that can save them time and money or protect them from weather related damage. For example, with the knowledge that rain is expected farmers can cover or move indoors crops that have been left outdoors for drying; or postpone spraying pesticide on their crops to another day and possibly save both the cost of washed off pesticide as well as the time and labor costs associated with the activity.

Input suppliers can use weather forecasts to plan for the upcoming

season while ***commodity buyers and other actors at market level*** use weather information to make pricing decisions based on expected crop yield forecasts, anticipating harvesting time and availability of supply from different agro-climatic zones or determining other quality parameters.

Insurance providers use historical weather information as an input for developing weather index products and actual weather data to determine whether triggers for pay out on policies have been reached. One such example is Kilimo Salama in Kenya.[1]

Finally, ***policy makers and administrators*** use climate information to guide decisions on supporting long-term adaptation to mitigate the effects of climate change as well as in preparing for extreme weather events.

CHALLENGES OF PROVIDING WEATHER INFORMATION

The accuracy of seasonal and long-term weather forecasts still remains quite low despite access to satellite data and improved forecasting models; the longer the time frame, the higher the possibility of deviance from the forecast. The challenge is to use such probabilistic forecasts to aid decision making for farmers.

Weather information needs to be granular and specific to the micro-environment of the farmer and is also particularly time sensitive as compared to other information needs of small-holder farmers, especially the short term forecasts that help farmers make day-to-day decisions.

The ability of farmers to understand the weather data even when they do receive it, as well as to use the weather information is limited by the lack of technical knowledge or access to the technology needed to minimize the risk or maximize the potential of expected weather patterns.

[1] Learn more at https://vimeo.com/50617347 and http://kilimosalama.wordpress.com/

ROLE OF INFORMATION AND COMMUNICATION TECHNOLOGY

ICT can play multiple roles in strengthening weather information systems from data collection to dissemination.

Data collection: Lack of adequate ground-based weather stations in sub-Saharan Africa has often been cited as one of major challenges for poor weather forecasts. While availability of satellite data has reduced the need for ground-based data for forecasting, it is still a useful input for verifying and validating forecasts. It can be used for greater refinement of models, as well as for specific uses such as tracking the development of extreme weather events and for index insurance products. ICT can facilitate these data collection needs in several different ways. For instance, attaching weather collection instruments onto telecommunication towers can leverage existing mobile infrastructure. Not only does this reduce the cost of establishing independent ground-based weather stations, but it has the additional advantages of enabling real-time transmission of data that is geo-tagged based on tower location.

Another way of collecting micro-level weather data is by providing trained local intermediaries with simple weather measurement tools who can then transfer data via SMS for analysis. This is useful for collecting data from remote and specific micro-climate areas, albeit with the quality limitations of using a human interface to make the actual measurements.

Similar data collection models are being used to collect information on the impact of climate change by monitoring key weather parameters such as rainfall, temperature, and water flows, as well as related impacts on the agriculture ecosystem such as crop species, and vegetation cover[2].

[2] Ospina, A.V. & Heeks, R. "ICT-Enabled Responses to Climate Change in Rural Agricultural Communities" (2012)

ICT tools used for weather

Radio: Is used to disseminate weather forecasts as well as more qualitative information related to planning for weather events for which the long format is more suitable than short text messages. Radio has some limitations as it cannot be as granular and individualized and there is often no direct link with the end user. Some programs have initiated "radio clubs" for farmers to gather to listen to weather forecast and discuss implications in a group.

Mobile Phones: SMS is the most cost effective and simple form to deliver information. Forecasts can be very targeted geographically by linking mobile phone numbers to the telecommunication towers. Interactive voice response (IVR) systems that dynamically render weather conditions into human speech using pre-recorded sentences in native dialects and accents are effective for illiterate users.

Smartphones: Smartphone technology, if accessible, can enhance the type of content that is disseminated. Forecasts and advice can be accompanied by visuals that are easier for some users. They are also a good platform for survey tools to capture farmer needs and feedback.

Call centers: Many programs are also introducing call centers to provide more detailed information and as a feedback mechanism for users.

ICT-based data collection also provides a mechanism to survey farmers to understand localized needs. Text surveys with simple yes/no responses or longer surveys completed through an intermediary on a smartphone platform can then be used to customize information to be relevant for specific micro-climate areas and the challenges farmers are facing based on their crops or farming practices.

Data dissemination: ICT tools can also be used to disseminate weather

information directly to users in a cost effective way that can be customized by geography, language and specific needs of the users. With weather information particularly, the granularity of the information and the timing is very important; this is a key strength of ICT over the traditional dissemination strategies. For example, farmers prefer to receive daily forecasts of weather information early in the morning so that they can plan accordingly. No other traditional channel can be as precise as an automated weather feed sent out via SMS or voice message to the farmer at a specific time and for his particular geographic area down to village level.

Some of the most common uses of ICT for disseminating agro-meteorological information include:

- Transmitting simple weather forecasts including seasonal, ten day, or short-term forecasts that are daily or every few days.
- Reminders or tips that are related to the actions that farmers can take in response to the expected weather conditions (e.g. sunshine tomorrow, spray fertilizer or pesticide for a given crop).
- Warnings or alerts for disasters or extreme weather events. Extreme weather events such as storms and lightning are particularly prevalent in tropical climates and especially so in coastal areas where low-lying land is susceptible to frequent flooding due to inclement weather. Flood warnings are also important for farmers situated along major river systems.

SECTOR TRENDS

There have been significant advances in climate sciences over the last decade both in the science of predicting weather patterns and the ecosystem for providing weather information to farmers. Some key trends are described below.

Forecasting trends: The use of satellites has had a transformative impact on weather information. It has made weather information globally available at low-cost to regional and national meteorological institutions, as well as the private sector. The need for ground based, conventional Automatic Weather Stations (AWS) is less critical now, thereby reducing the burden on national governments to create extensive infrastructure, although still relevant to a lesser degree for validating and refining the models.

The science of forecasting weather and climate change has improved significantly with the development of more complex models and the use of powerful computers enabling much greater accuracy and relevance at the micro-climate level.

There is also some recognition of traditional knowledge that uses alternative indicators to make predictions relevant to local geographies. Efforts are being made to capture this traditional knowledge and incorporate into the weather information systems.

> "Indigenous weather forecasting techniques, practiced by traditional rainmakers in the Banyore community in western Kenya, are helping scientists to develop more reliable systems for predicting the weather. By noting the migration and behavior of certain birds, insects and reptiles, and the flowering of certain trees and other plants, the Nganyi predict rain or drought. In addition, by gauging the strength and direction of winds, they are able to forecast whether rain from Lake Victoria is likely or not."
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> **Source:** New Agriculturist, (2012).

The ecosystem for providing weather and climate services in Africa is changing as well with the entry of private sector weather forecasting and dissemination services supplementing the traditional publicly-funded National Meteorological services in some African countries. Although at a very nascent stage, over time, it is possible that dissemination of weather information for smallholder farmers will be increasingly led by private sector organizations with incentive to deliver such services. These include companies specializing in providing weather information to multiple sectors. There are also opportunities for the telecom sector as it expands value-added services, and companies that service the agriculture sector, such as insurance companies through index insurance products.

SUSTAINABILITY

Delivery of information to smallholder farmers is often subsidized by grants or cross-subsidized by other products. Some subscription based services have also been introduced and in limited cases have been successful in generating revenue.[3] Each of these expects to become sustainable once they have achieved adequate volume. Several emerging business models follow below.

Bundled approach: Weather information is not provided as a standalone service, but bundled along with other information being provided to farmers. Fees for service can then include multiple types of information.

Customer diversification: A diversified customer base for weather products that includes small and commercial farmer subscriptions, NGOs, private sector agribusinesses, farmer associations, and cooperatives.

Sector diversification: An alternative to bundling services is to be an exclusive provider of weather information to organizations in multiple sectors, such as aviation, energy, hospitality or agriculture, that can use weather to improve productivity or have other commercial uses for weather information.

Another model is providing weather information as a ***value-added service*** because it helps drive the ability of the customer to pay for the primary product such as index insurance or inputs. For example, index insurance companies have an incentive to provide weather information to farmers in order to improve their productivity and ability to pay premiums.

[3] Ignitia, a private weather information provider in Ghana, has a direct subscription base of 50,000 farmers in Ghana who are paying about US$5/ year for weekly forecasts.

SELECT CASES OF WEATHER INFORMATION PLATFORMS	
Regional Initiative	
Toto Agriculture **Partners:** INSEAD Gates Foundation GSMA Farmers Voice Radio Grameen Foundation Others	This project has developed a content automation platform to provide access to localized agricultural knowledge in the world's poorest areas. Weather information is a key component that is delivered through SMS, MMS, video and radio. Highlights: • Uses satellite and weather station data from FORECA to create weather feeds. • Provides applications in data, video and voice (IVR) format in over 124 languages. • Highly scalable platform that can handle millions of SMS messages on a daily basis. • Geo-tagging by telecom tower location allows delivery of granular information within a 13km grid.
Private sector service providers	
FORECA	A Finnish weather forecasting company that provides digitized weather services to companies across the globe. Highlights: • It offers raw weather data feeds that provide weather forecasts, current conditions, and optional weather animations for any location worldwide. • Weather feeds can be accessed by coordinates or by location name (over 140,000 locations), and available in 25 languages. • The interface is suitable for mobile applications, web applications, and any other application that can receive and visualize online data.
Ignitia Ltd.	A technology company from Sweden that has developed an advanced forecasting model especially for tropical climates, which includes most of West and Central Africa. Currently operating in Ghana and aims to expand across West Africa. Highlights: • Serves multiple customer segment including small-scale farmers, advanced farmers, and organizations with customized products. • Products include short term forecasts of up to 30 hours, rain forecasting, harvest forecasting and early warning alerts.
Delivery models for weather information	
Esoko	Esoko is a technology platform and consulting company that helps organizations manage information flows. It currently works with partners in 15 countries across sub-Saharan Africa. It offers a package of information services for farmers that includes weather. The weather information comes from content providers such as Toto Agriculture. Highlights: • ICT products include bulk SMS messages, automated alerts and field alerts. • Clients include individual farmers, businesses, NGOs, and governments.
Mobile Weather Alert **Partners:** Uganda Department of Meteorology World Meteorological Organization Grameen Foundation National Lake Rescue Institute	A pilot project to support the decision-making processes of Ugandan farmers in the Kasese region and fishermen on Lake Victoria. The project involves two-way communication between Community Knowledge Workers and end-users. Advisory information is informed by 10-day, monthly, and seasonal forecasts, and shaped by farmers, who give input on the type of information that would be most helpful. Highlights: • Two-way information flows. • Weather information combined with specific advisory information. • Awareness and training for farmers & other stakeholders.
Bangladesh Friendship Education Society - Community Climate Care Centers (CCC)	This project proposes a network of local sources of information for farmers, both through mobile technology and at the centers themselves. In an effort to help farmers in vulnerable communities adapt to climate change, the centers will be equipped with internet-accessible computers, video conferencing, and other low-cost ICT systems to connect local farmers to national and localized weather information.
Noula	Noula is an interactive crisis and needs-mapping platform developed by the Haitian ICT company Solutions in response to the 2010 earthquake in Haiti. Noula provides a channel for two-way communication between remote communities and service providers, using a call center where extreme weather information is simultaneously received, analyzed and geo-located, then provided to vulnerable Haitian communities.

TIPS FOR PRACTITIONERS

Provided below are tips for practitioners to consider in the design of effective and scalable programs to deliver weather information to farmers using an ICT platform.

Any program providing weather information should also match the information with customized guidance or decision making tools that are crop specific and localized in nature. Unlike other content provided to farmers, weather information in itself is not a self-sufficient advisory. Farmers need to know what actions to take in response to the weather advisory as well. The advice needs to be demand driven and both location and time specific. For example, seasonal weather forecasts can be accompanied by crop reports that estimate potential yields of different crops and seed varieties based on the expected weather patterns and local soil conditions.

Secondly, the communication tools being used should be based on demand and targeted to the nature of the information and the needs of the users. A multichannel approach is often required that includes mass media, targeted mobile based messaging, and face-to-face contact with trusted local intermediaries.

It is also important to develop platforms that facilitate two-way flows of information. These should include the collection of localized data and feedback from farmers, as well as disseminating information to farmers. All of these are important design elements that help improve the accuracy of the weather forecast and make them more relevant to farmers needs.

Finally, given the multiple potential sources of content and stakeholders involved in the process of creating localized information, consider the interoperability of the system across different actors.

LOOKING FORWARD

ICT has the potential to become a strategic enabler of climate and weather information systems by not only providing a platform to scale the dissemination of information to farmers at unprecedented levels, but also do so at the level of localization and temporal specificity that is an important element of effective and actionable weather information. One such promising approach has been piloted in The Netherlands to gauge localized precipitation data by measuring its impact on radio signals transmitted between cellular towers.[4] That said, while there are multiple examples of innovative projects using ICT for weather information, we have not yet seen any achieve the scale needed to have a significant impact.

In developed countries, weather information systems include multiple agencies that are publicly funded as well as private sector and member organizations. In the US, for example, the National Weather Service that is part of the US National Oceanic and Atmospheric Administration (NOAA) is a key actor in the weather information eco-system. However, farmers have multiple sources of information including more customized weather forecasts and weather-based analysis and decision tools that are available through farmer associations as well as private sector providers that provide value added services. Planalytics is an example of a weather intelligence consultancy service that provides sophisticated monitoring and modeling techniques to help agricultural firms to improve yield, seed selection and crop development. Similarly, in developing countries, there is a growing understanding that there needs to be a multi-stakeholder approach involving the national meteorological agencies, extension services, international and local research agencies, and the private sector. This is likely to result in a change in traditional roles and leverage the inherent strengths of the different actors to achieve both sustainable models and quality outcomes.

[4] Overeem, A., Leijnse, H., and Uijlenhoet, R. Country-wide rainfall maps from cellular communication networks. PNAS, *Vol 110, No. 8* (19 Feb 2013).

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