Seasonal climate prediction dissemination to rural farmers in sub-Saharan Africa: a "bottom-up" perspective and the emergence of the mobile phone

Chavas, Daniel R.

Massachusetts Institute of Technology

73 River St., Apt. 2B

Cambridge, MA 02139

drchavas@gmail.com

June 2008

Abstract

Based upon four key assumptions regarding seasonal climate prediction and the rural farmer in sub-Saharan Africa, this paper focuses on increasing information flow efficiency from a "bottom-up" perspective in order to improve the effectiveness of the service. This approach determines the most efficient means of getting forecast information to farmers based upon the individual farmer and his initial set of possible pathways to obtaining the forecast information rather than upon the options for institutions to disseminate the information from the top down. The goal, then, is to maximize both the efficiency of the flow of information from National Meteorological and Hydrological Service to the individual farmer as well as the total number of farmers receiving the information.

This approach highlights the need to account for the rapid emergence of mobile phone use among rural farmers in seasonal forecast dissemination services. Mobile phone networks have the potential to revolutionize this service by significantly improving the efficiency of forecast dissemination, both to the individual farmer and between farmers, and by solving the evaluation problem.

Introduction

Motivation

Climate variability plays a significant role in daily life and development in sub-Saharan Africa (SSA). In particular, much research has been conducted on the Sahelian drought that persisted from the 1970s to the 1990s, including the debate over the primary causes between “endogenous” forcings, such as land use change, and “exogenous” forcings, such as changes in sea surface temperatures, which may imply an anthropogenic component (Hulme 2001; Giannini *et al*. 2003). Either way, such significant climate variability has major impacts on nearly all inhabitants of the region, ranging from health (malaria), energy, access to water, food security, and perhaps political stability (Raleigh and Urdal 2007). One substantial group of people that bears much of the burden of these impacts are rural farmers, whose crops are dependent on proper rains. This paper seeks to address one potentially important means of reducing the impacts of climate variability on this vulnerable population: the seasonal climate forecast. Improving farmer access to this information can help to improve living standards and promote poverty alleviation.

Decision-making among rural farmers in sub-Saharan Africa

It is well established that the prevailing climate regime in sub-Saharan Africa, coupled with the predominance of rain-fed agriculture in food production and income generation in the region, conspire to create a high-risk environment for survival at the household level among marginal populations (Traoré *et al*. 2007). Reliance on complex seasonal rainfall patterns (distribution, frequency, intensity, start of rainy season, length of rainy season) associated with the West African monsoon in choosing crop types, varieties, planting dates, farming practices etc. necessitates intricate and sometimes painful on- and off-farm decision-making by the individual rural farmer in order to attain food security (Roncoli *et al*. 2001; Reardon *et al*. 1988; Binswanger and McIntire 1987).

In most cases, the farmer's general decision-making framework is based upon the ultimate goal to minimize risk (Lyon 2000; Smith 2003; Berry 1989), although information is beneficial for decision-making regardless of the level of risk aversion (LaValle 1978). Decision-making to achieve this goal may be influenced by government policy that promotes certain crops (Pretty and Ward 2001; Reardon and Taylor 1996), traditional indicators of climate conditions (Roncoli *et al*. 2001; WMO 2007(d)), household economic conditions based upon non-farm contributions and the level of success of recent harvests (Roncoli *et al*. 2000), social interaction and observation (Valente 2005), and cultural norms and traditions (Lyon 2000). From among these influences the farmer processes both experiential and analytic information, but typically vivid personal experience is favored (WMO 2008). Thus, how information that contributes to decision-making is communicated often plays a significant role in the farmer's assessment of the value of the information. For example, providing reliable data about a significant threat of locusts is likely to incite a weaker response than would referencing a past year in which locusts destroyed an entire harvest.

In this way, the farmer weighs all available information from a personalized perspective in order to optimize household decision-making and diversify across agricultural, economic, and social domains. Agricultural diversification includes on-farm practices listed above; economic diversification includes migration, non-farm work, and significant contributions from women (Roncoli *et al*. 2001; Reardon and Taylor 1996;

Reardon *et al*. 1988); social diversification aids access to key resources, risk sharing, and reduction of transaction costs via informal contracts (Carter 1997; Roncoli *et al*. 2001; Schechter 2005 (Paraguay); Lyon 2000; Fafchamps 1992; Binswanger and McIntire 1987). All of the above activities must subsequently be localized in order to take into account prevailing socio-cultural norms, rules, traditions, and networks in each village or region (Lyon 2000; Pretty and Ward 2001; Carter 1997).

Linking seasonal climate prediction information to rural farmers

One effort to aid farmers in this intricate decision-making process is through seasonal climate prediction (hereafter “forecast”). Having advance information regarding seasonal precipitation is applicable to decision-making in the agricultural domain, particularly for crop selection, which influences decision-making across all domains. For example, a reliable forecast of high probability of severe drought (conveyed in an appropriate manner) may allow the farmer ample time to migrate elsewhere to live with relatives in order to avoid investing in a poor harvest.

Currently in Africa, the World Meteorological Organization has helped organize three Regional Climate Outlook Fora to facilitate collaboration among leading scientists and sector representatives in the creation of a consensus forecast for their respective regions (WMO 2007(d)). Each participating country’s National Meteorological and Hydrological Service (NMHS) creates a national seasonal forecast product that is brought to the forum for synthesis of all national contributions into a self-consistent consensus regional product. Finally, each NMHS downscales this updated regional forecast to create a national forecast for dissemination to relevant sectors and stakeholders (health, energy, water, etc.) in their country (Tarakidzwa 2007; WMO 2007). The forecast information can then be integrated into decision-making, primarily at the national level, to reduce the risk of vulnerable populations. For example, a government may decide, based upon a prediction of increased likelihood of drought and thus food insecurity, to stockpile additional food for either market or aid purposes.

While significant progress has been made in promoting the generation of forecast information in sub-Saharan Africa (Tarakidzwa 2007; Traoré *et al*. 2007), the majority of African countries continue to suffer the full impacts of climate variability (Tarhule 2005). This may be due in part to the fact that the largest demographic—the rural farmer—remains largely cut off from the benefits of forecast information despite the designation of illiterate rural farmers as among the "key targets" of the Regional Climate Outlook Forum process (Ogallo 2007). Considerable barriers exist that segregate rural farmers from access to these benefits, including illiteracy (Tarhule and Lamb 2003), inter-village complexity, lack of communication infrastructure (Ziervogel *et al*. 2005; Mokssit 2007), misunderstanding of forecast information (Roncoli *et al*. 2003; WMO 2007(d); Mokssit 2007), lack of trust in source/messenger, lack of resources for program sustainability (Roncoli *et al*. 2000; WMO 2002(b)), and geographic isolation (Tarakidzwa 2007). Overcoming some of these barriers can help to improve aggregate decision-making and, in turn, alleviate poverty and aid in development. Furthermore, forecast information may be increasingly valuable given that reliability of local forecasting knowledge is diminished in the context of the rapidly changing global climate (Roncoli *et al*. 2000).

Recent efforts

Several projects and measures have been implemented in an effort to target forecast information dissemination to the rural farmer in sub-Saharan Africa. Non-governmental organizations focused on supporting local farming practices are common in some countries (Tarhule and Lamb 2003; Roncoli *et al*. 2001). Furthermore, several projects, including the Climate Forecasting and Agricultural Resources (CFAR) project in Burkina Faso (Tarhule and Lamb 2003; Roncoli *et al*. 2003), the Climate Prediction and Agriculture (CLIMAG) programme, and extension efforts of Société Burkinabe de Fibres et Textiles (SOFITEX) (Tarhule 2005), have taken a village-level focus to forecast dissemination.

At a larger scale, the RANET project employs durable satellite-based radios in villages in order to disseminate agricultural information including forecast products. Many countries also disseminate via agrometeorological bulletins, national radio and television broadcasts and newspaper articles, and some offer agricultural meetings led by journalists or employees of either the NMHS or the Agricultural Ministry. (Tarakidzwa 2007)

Overall, there is a lack of conclusive evidence of the positive effects of current efforts to link forecast information to the rural farmer in sub-Saharan Africa in a large scale, sustainable manner (Jagtap *et al*. 2005; Traoré *et al*. 2007). One potential reason explored here is the lack of focus on how the individual rural farmer accesses information for use in decision-making.

Focusing on forecast information flow

The information perspective

A critical distinction must be made between the *information* and the *message* within which the information is "packaged". In the context of seasonal climate prediction, the message is a categorical-probabilistic forecast (3 categories: "above normal," "normal," and "below normal" growing-season rainfall each with a percent probability attached) rather than deterministic to account for significant underlying uncertainty. However farmers (and most non-scientists) generally do not fully understand probabilistic information[1], although they are used to uncertainty in markets (WMO 2007(d)), and are not adept at interpreting scientific terminologies (Mokssit 2007; Tarakidzwa 2007). Thus, the message must be "unpackaged" into a form that the farmer can understand in order to apply it to his particular situation; otherwise, the farmer ignores the message and does not benefit.

The result is two primary barriers to forecast information access for farmers: how to most efficiently get the information within the message to the farmer, and how to package the message so that the information within is most easily accessible and thus applicable. This paper deals only with the former, but the latter is also a recognized barrier to forecast implementation and is the subject of ongoing research.

Assumptions

Four key assumptions are made about the nature of the forecast message and the rural sub-Saharan farmer as end user:

---

[1] This issue is currently being analyzed by the WMO Commission for Climatology (CCl) Open Programme Area Group (OPAG) 3 Expert Team 1 on Research Needs for Intraseasonal, Seasonal and Interannual Prediction, including Application of these Predictions.

1. The forecast message contains information that improves decision-making

Despite the primitive nature of current forecast capacity due to the inability to downscale below the regional spatial and seasonal time scales (Thornton 2006; WMO 2007(d)), integration of forecast information is better for the farmer than no information or reliance on traditional climate indicators alone. Several local demonstration projects support this claim in SSA, including Mali (Maiga 2002), Gambia (Gibba 2002), and Senegal (Ndiaye 2002), all of which exhibited economic benefits when integrating forecast information into decision-making.

2. The rural farmer is a dynamic information seeker

Schultz (1982) asserted that "people in low income countries, although they are poor, tend to be efficient in allocating their meager resources" (p. 23). A key component in deciding how to allocate such resources is information; Geertz (1978) noted that in many rural areas in the developing world "information is poor, scarce, maldistributed, inefficiently communicated, and intensely valued." Asymmetric information on current market prices often determines bargaining power and encourages self-interested opportunism, imposing significant costs on a rural farmer if a trader attempts to exploit the farmer's relative isolation (Fafchamps and Minten 2001; Lyon 2000). Farmers also time market food purchases based upon known information on inter- and intra-seasonal price variability (Reardon *et al.* 1988). Finally, farmers often use information signals, such as consumption patterns and changes in social standing, as a means of evaluating the integrity of information about the wealth (Fafchamps 1992) and loyalty (Schechter 2005;

Lyon 2000) of others. This is evident in the extreme secrecy of individual farmers' grain storage, livestock, and other assets in rural areas (Carter 1997).

Three general modes of innovation adoption among farmers are recognized: "innovators," "early adopters," and "laggers" (Diederen *et al*. 2003; Feder *et al*. 1985). Given this stratification, the characterization presented here of farmers as dynamic indeed may not apply to all farmers, but rather to the innovators and early adopters, who will be followed by laggers due to "network effects" (e.g. the early adopter benefits, so the hesitant neighbor joins as well) and the rate of improvement in access to the valuable service (Valente 2005). The latter implies that slow adoption among laggers does not necessarily suggest a poor service but instead variation in net benefit of the service across farmers.

3. The rural farmer knows how to incorporate new information to improve decision-making

As shown earlier, rural sub-Saharan farmers are far from simple "subsistence" farmers. One case study in Burkina Faso found that 50-75% of household income is earned from interaction with the non-agricultural market (Reardon *et al*. 1988). Moreover, farmers can and do incorporate information concerning rainfall, as understood by them, into decision-making and are willing to experiment with new farming techniques and technologies (Roncoli *et al*. 2003; Tarhule and Lamb 2003; Roncoli *et al*. 2001). West African farmers have conveyed that long-lead climate forecasts are potentially valuable (Jagtap *et al*. 2005; Ziervogel *et al*. 2005; Ingram *et al*. 2002;

Roncoli *et al*. 2000), and in Kenya demand for climate information is increasing due to the rising incidence of significant floods and droughts in recent years (Ogallo 2007).

The complexity and variability of decision-making at the individual level underpins the cautionary words of Mr. Patrick Luganda, chairman of the Network of Climate Journalists in the Greater Horn of Africa: "Do we know how much [the farmers] know about the subject we are seeking to address them about? They may be illiterate but intelligent. Poverty stricken but happy" (Luganda 2002: 121). The evidence suggests that a) many farmers—particularly the "innovators" and "early adopters"—are fully capable of integrating new and complex information into their decision-making processes, and b) the best method for maximizing forecast benefit would likely be simply to allow them to utilize the new information in the way that they see fit under their own personal circumstances. The latter point is echoed by Reardon *et al*. (1988), which states that it may be difficult to persuade rural households to alter cropping practices in a seemingly logical manner (to an outsider) based upon new information since these same resources provide an important risk aversion function elsewhere.

4. Better decision-making can help alleviate poverty

Adoption of forecast information has the potential to decrease starvation among marginal household-agents (Ziervogel *et al*. 2005). Furthermore, increasing crop income reduces both income inequality and poverty (Reardon and Taylor 1996). Ultimately, for rural farmers trade-offs are the cornerstone of decision-making, and thus bolstering coping capacity via integration of forecast information can reduce the opportunity costs of such trade-offs and help households promote food security and thus alleviate poverty (Roncoli *et al*. 2000).

Information flow efficiency

Based on the above four assumptions taken in logical order, one key means of increasing the benefits of forecast services in sub-Saharan Africa is to maximize information flow efficiency (hereafter IFE) by ensuring that forecast information reaches as many farmers as possible as efficiently as possible.

Information flow from the "bottom-up"

The author seeks to determine the most efficient means of forecast dissemination from the "bottom-up" perspective of the dynamic, information-seeking farmer. A significant consequence of this approach is the condition that any dissemination structure in which the farmer cannot access the information (either the message does not arrive or cannot be properly unpackaged) has an efficiency (IFE) of zero; Chipindu 2002 noted that "forecasts are only useful if the recipients can actually use it to improve their production" (132).

Where can the farmer access information?

To build an information flow structure from the bottom up, one begins at the household level by noting that if the dynamic farmer is aware of the availability of useful information, he is likely to actively seek out the most efficient means of obtaining it within his modest means.

There are three main types of well-established information sources for the farmer: technology, print media, and direct contact. Technology includes personal radio, television, ground-based telephone, fax, internet, and RANET (satellite based radio project; discussed below); print media includes newspapers and bulletins; direct contact includes community meetings (including farmer groups/schools, interest group and NGO meetings), extension agents, intra-village personal contact (family/community), inter-village personal contact (family/friends), and public schools. (WMO 2002(b); WMO 2006; Jagtap *et al*. 2005; Tarhule and Lamb 2003; Roncoli *et al*. 2000) Mobile phones, relatively new among rural farmers, will be included in a later section.

Feasibility at the farmer level

Out of the initial set of options, a significant subset can be immediately eliminated[2] due to infeasibility for most rural farmers in SSA. First, the print media options can be eliminated because many farmers are illiterate (Tarhule and Lamb 2003). Among available technologies, infrastructure for telephone services, the internet, and fax machines are very limited, particularly in rural areas, and even with internet access the illiteracy hurdle remains. Finally, among options for direct contact, public schools have been suggested as a means for agro-climatic education for children as a part of longer-term planning (WMO 2002(a)) but for short-term applications the teachers may be equally isolated from forecast information access as the farmers themselves.

Unpackaging the message

[2] Options are eliminated uniquely at the given step; they may still be useful for information flow at a later step. For example, while internet is a poor choice for the rural farmer to obtain information, it may be feasible for communication between NMHS and an extension agent higher up in a given IFS.

Can the message be properly unpackaged in order to extract the information in a form that the farmer can use? It is widely acknowledged that a participatory interactive process is essential for the farmer to use the information successfully (Jagtap *et al*. 2005; Mokssit 2007; Tarhule 2005). Stigter (2002) notes that one of the primary bottlenecks to proper unpackaging is the vital importance of interaction to deal with farmer-to-farmer variability and the need for an appropriate support system that accounts for actual conditions in the livelihood of farmers. Furthermore, the context of information delivery is very important, in particular the credibility of the source delivering the information and the opportunity for farmers to discuss, ask questions, and learn by doing, a need cited explicitly in farmer feedback in a Burkina Faso case study (Roncoli *et al*. 2000).

Thus, to unpackage the forecast message, it is critical for the farmer to interact with a "consultant" —simply anyone capable of answer the farmer's questions in order to understand the forecast—who is very familiar with the forecast message and the information that it does and does not contain (e.g. forecast products do *not* contain information on daily rainfall variability). The consultant may be from government, private sector, media, etc. With access to this mechanism, farmers can determine for themselves or discuss with each other or the consultant (if possible) on how best to adapt individual decision-making strategies.

Given this need, several of the remaining options for access to forecast information by the farmer may be eliminated due to the lack of capacity for interactive participation. First, the options that are purely one-way conduits of information may be eliminated—personal radio and television. While ambitious, the RANET project, which employs durable satellite-based radios to transmit forecast and other relevant information to rural African communities, unfortunately has had difficulty taking hold in villages without the existence of someone to unpackage the message interactively with the farmers (Tarakidzwa 2007; M. Kadi personal communication). Furthermore, it is difficult to ensure proper use of the radio, leading villagers to use them for unrelated social ends. Finally, many lack access to batteries (H. Kontongomde personal communcation; M. Kadi personal communcation). In this way, RANET radios do not differ substantially from simple personal radios other than perhaps extended range; as a one-way conduit of information, they too provide little value on their own to the farmer.

Thus, the remaining viable options are community meetings, extension agents, intra-village personal contact, and inter-village personal contact. Community meetings and intra- and inter-village personal contact are intermediary conduits that spread information horizontally but do not reliably move information vertically downwards from the top. In this way, then, these forms of communication can increase the number of farmers with access to information but cannot perpetuate the flow itself. Therefore, while these mechanisms are purely supplemental (although potentially highly beneficial), the creation of an external consultant as a point of information access is a necessary condition to useful forecast information dissemination.

Who is the consultant?

The consultant may come from private business, the government, or an external agency.

Although they may provide utility in local settings, consultants from external interest groups and NGOs (Tarhule and Lamb 2003) often have significant contact with farmers but are not reliable as a sustainable, large-scale means of disseminating seasonal forecasts (Roncoli *et al*. 2001) due to the nature of funding and the whims of the leaders of such intermediaries. Furthermore, local farmers may be less inclined to accept new information due to a lack of trust in a foreigner as the source (Roncoli *et al*. 2000). However, neither of these arguments categorically excludes their potential utility, but their inclusion should be evaluated on a case by case basis to determine regions where such groups are capable of creating long-term trusting relationships with farmers and indeed can adequately fill the information flow gap in a sustainable manner.

The remaining two options are both potentially viable depending on either the availability of sufficient funds for a government program or the existence of a private information service business and access to this service for the farmer. A consultant from the government has direct access to the original source of information (NMHS, Agriculture Ministry etc.), but government funding for such programs is often unreliable. Private business may be able to capitalize on the demand for information and efficiently combine forecast information with other agricultural/market information services, but only if farmer can access the service at low cost.

Initial forecast dissemination from National Meteorological and Hydrological Service

In order to create the consultant (regardless of who it is), training is needed, either at the national or regional level, to teach the critical task of how to unpackage the message. Such a workshop is necessary once at minimum[3], but it is likely that having regular meetings before each season or year (depending on the country's climate regime)

[3] If the structure of the message does not change substantially from year to year, and therefore once trained the consultant retains capacity to unpackage all future messages.

to reinforce training and ensure comprehension of the latest forecast message would be of tremendous value. Given that the NMHS creates the initial forecast message, direct NMHS involvement in consultant training may help ensure proper understanding of the meteorological information within the message.

Summary

A "bottom-up" approach to forecast dissemination in rural sub-Saharan agriculture allows one to delineate the most efficient means available for transmitting this useful information to dynamic, information-seeking farmers under the principle that the forecast dissemination has zero efficiency if the information does not reach the farmer. From the above results, the minimum framework for dissemination can be created with 5 basic steps (Figure 1):

1) Message creation: NMHS
2) Message transfer: NMHS → consultant
3) Message transfer: consultant → farmer
4) Interactive consultant-farmer message unpackaging: message → information
5) Information integration: farmer

Step 1 is already standard and step 5 is assumed to be automatic (assumption 3).

At each remaining step, then, the goal is to maximize *total* IFE, not simply stepwise efficiency. Total IFE can be viewed as "number of farmers who benefit per dollar input." Because all farmers can be assumed to benefit approximately equally from access to forecast information and that this benefit is assumed to be binary (benefits with information, does not benefit without it), IFE can be approximated by:

$$IFE_{tot} = \frac{\text{\# farmers that access information}}{\text{total cost of system of dissemination}} \quad [1]$$

Thus, for example, the radio is a highly efficient means of transferring the message to a large audience (step 3), but without two-way interaction to unpackage the message, the information is not accessible to the farmer (step 4) and the result is zero farmers who access the information (the numerator) and therefore zero total IFE despite low stepwise cost at step 3.

Furthermore, efficiency at step 3 may be improved by exploiting intra-village (inter-village) social networks, which can provide a means for increased information flow volume within (between) villages. Choosing highly visible meeting places for message unpackaging and working with those who have high social standing and are perceived as trustworthy ("centers," Fafchamps 1992) can rapidly expand forecast information use and credibility both within villages and across regions.

Practical application

This analysis suggests that in countries that do not already have some form of an extension service out to rural villages or of privately-owned information services, there is minimal potential for an information flow structure that would allow rural farmers to benefit from forecast information in an efficient, large-scale manner using currently well-established technologies and practices. This is because step 4 requires a resource-intensive step 3 (transportation to village), and for this reason government support of such a service or network is often diminished or abandoned (Roncoli *et al*. 2000; Stigter 2002). It is therefore unwise to expect a government to invest in the long-term development of a new extension program in support of forecast dissemination.

In countries where village extension/consultant services are already in place, though, typically through each country's Agriculture Ministry (Jagtap *et al*. 2005; H. Kontongomde personal communcation), the media (Tarhule and Lamb 2003; Roncoli *et al*. 2003), or private business, the framework to allow rural farmers to access and exploit forecast information is available. In the absence of mobile phone technology, direct personal contact at the nearest village is likely the only feasible approach.

The mobile phone: can it revolutionize forecast dissemination?

Recent proliferation[4]

The emergence and proliferation of mobile phones in rural Africa, only recently recognized by the international community, has the potential to revolutionize forecast dissemination to farmers by streamlining the process and drastically reducing the overall cost of information access for the farmer. Mobile phone use in Africa has increased dramatically (WMO 2006) and dominates land-based telephony (Scott *et al*. 2004; Waverman *et al*. 2005), and the continent was the fastest growing mobile market in the world during 2000-2005 (Coyle 2005). Furthermore, teledensity figures may be underestimated due to the tendency to share mobile phones, especially among the poor

[4] See *Davis and Ochieng 2006*.

(McKemey *et al*. 2003). This explosive growth is due in large part to cost advantages, including lower up-front expenditure, suitability for communal/shared use, lower levels of skills required compared with other technologies (e.g. internet), and innovative business models such as the MTN mobile village pay phones in Uganda and Vodafone community phone shops in South Africa (Davis and Ochieng 2006). The author's personal experience in northern Ghana (2007) noted that some rural people even possessed multiple mobile phones for unknown reasons.

The proliferation of mobile telephony further emphasizes the notion of rural farmers as dynamic information seekers. In Senegal, mobile phones help combat asymmetric information, and thus small farmers have strengthened their bargaining power (Manobi 2006). Despite political and security issues, the Democratic Republic of Congo has 1.1 million subscribers due in part to the entrepreneurial activities of individuals like some villagers in two jungle provinces who were so eager to use mobile phones that "they have built a 50-foot-high tree house to catch signals from distant cell phone towers…one man uses it as a public pay phone…Those who want to climb to his platform and use his phone, pay him for the privilege" (LaFreniere 2005). In Kenya, farmers, especially those who are illiterate or have problems with text messages, can also access market information through voice mail by calling a hotline telephone number. Rural-based market information points (MIP) for farmers have been created to enhance trading with more distant urban centers; the Kenyan Business Development Services programme (KBDS; KBDS 2004: 1) records that between May and October 2004 more than 24,000 farmers accessed commodity information from these points in three districts alone.

Application to forecast dissemination: efficiency and evaluation

In the context of forecast dissemination to rural farmers, mobile phones can potentially offer two significant increases in efficiency. First, they eliminate space as a barrier and thus significantly reduce information access costs by connecting the farmer directly to the consultant and facilitating two-way interaction between them without requiring the consultant to physically visit the farmer's village. As shown in Figure 2, this direct connection combines step 3 and 4 at a highly reduced cost and may allow for the reduction of the number of consultants needed in step 2 to only a handful given that a single consultant is now (technologically) accessible to all farmers.

The second major advantage that should not be overlooked is that the use of mobile phones is inherently a *demand-driven* process. One of the major issues with all current methods of forecast information dissemination to farmers is the complexity and the cost-prohibitive nature of proper evaluation. If information dissemination is driven by demand, however, evaluation is internalized: "innovators" and "early adopters" will seek the service that most efficiently provides access to the information, and "laggers" will follow, particularly in the rural context where social networks (i.e. word of mouth) play such a prominent role. While not yet clear, a potential supply-driven disappointment may turn out to be the RANET project, in which radios are often used for unintended purposes (H. Kontongomde personal communcation) and for which little evaluation/feedback can be extracted to better adapt it to farmer needs without substantial expenditures (M. Kadi personal communcation).

Practical implementation[5]

How can mobile phones be used within the forecast dissemination framework to maximize efficiency? In Kenya, where a large majority of farmers now own one, several demand-driven options have emerged, with strong support from the media. First, radio and television talk shows now exist that take telephone calls to answer questions and obtain feedback directly from farmers. Second, farmers in some villages have self-organized and will use their phones to call a meeting with a journalist in order to explain the climate forecast (i.e. to help unpackage the message) and facilitate discussion. Finally, some villages have organized their own climate fora (Ogallo 2007). This has helped drive the creation of a network of journalists as consultants in dealing with the forecast message to further address the growing farmer demand for forecast information. Meanwhile, extension agent services in Kenya have been disappearing due to a lack of funding. Moreover, RANET is struggling to have an impact due to the problematic need to downscale its service to the village level.

In Cameroon, private businesses offering expert information services for rural farmers have developed given the demand from farmers for a wide range of information, from market prices to knowledge of predator fish (Nyirubugara 2008). Conceivably seasonal forecast information can become one component of these services.

By eliminating geography as a barrier to forecast information access, the key remaining component is on-going two-way interaction. Therefore, a simple "hot line" for farmers, whether in the NMHS, media, private business, etc., to call and ask questions would be the minimum prerequisite for a potentially useful and efficient service. This

[5] This section is largely based on personal discussion with Dr. Ogallo (Kenya Professor, ICPAC) and Mr. Mwadali (Kenya Meteorologist, media outreach), 4 December 2007.

will also permit direct farmer feedback on changes to the service that can allow for quick adaptation to best fit farmer needs and improvement of the skills of the consultants.

Conclusion

Rural farmers in sub-Saharan Africa routinely make complex and difficult decisions, primarily with the goal of risk reduction. One potentially significant means of improving decision-making is seasonal climate prediction (SCP), typically performed at a national scale by the National Meteorological and Hydrological Service (NMHS), upscaled and synthesized at the regional scale, and then downscaled back to the national level for dissemination by the NMHS. However, efforts to disseminate seasonal forecast information to the rural farmer have been problematic due to a variety of reasons related primarily to farmers' geographic isolation and distribution.

Employing a "bottom-up" approach beginning with the individual farmer as a dynamic information seeker better accounts for the farmer's options to access and implement information when determining the optimal means of disseminating seasonal climate forecasts for rural agriculture. Given the geographic isolation of rural farms and the need for two-way interaction to help the farmer understand the forecast and apply it to his individualized situation, the only currently well-established means of dissemination that can reasonably be expected to be efficient on a large scale is one that includes direct personal contact via local extension service agents.

However, the rapid proliferation of mobile phone use among rural farmers to access information has the potential to revolutionize forecast dissemination by eliminating geographic barriers and thus significantly reducing costs while maintaining critical two-way interaction. Furthermore, dissemination via mobile phones would represent the first demand-based system of forecast dissemination, thereby internalizing evaluation of both the means of dissemination and the skills of the consultants themselves. Given the substantial logistical and economic barriers to evaluation of extension agents and their services, mobile phones may provide a cheap, efficient, and adaptable means of forecast dissemination to rural farmers.

References

Berry S 1989 Social institutions and access to resources *Africa 59 41-55*

Binswanger H P and McIntire J 1987 Behavioral and material determinants of production relations in land-abundant tropical agriculture *Economic Development and Cultural Change 36 75-99*

Carter M 1997 Environment, technology, and the social articulation of risk in West African agriculture *Economic Development and Cultural Change 45 557-590*

Chipindu B 2002 The means of achieving better recognition of the value and benefits of climate forecasts and agrometeorological information disseminated to users *AGM-7/WCAC-1, WMO/TD-No. 1223, 127-133* World Meteorological Organization Geneva, Switzerland

Coyle 2005 Overview in *Africa: the impact of mobile phones* Vodafone policy paper 2

Davis K and Ochieng C 2006 ICTs as appropriate technologies for African development, International Food Policy Research Institute bronze award essay

Diederen P J M, Meijl J C M van, Wolters A M and Bijak K 2003 Innovation adoption in agriculture: innovators, early adopters, and laggards *Cahiers D'économie et Sociologie Rurales 67 30-50*

Fafchamps M 1992 Solidarity networks in preindustrial societies: rational peasants with a moral economy *Economic Development and Cultural Change 41 147-174*

Fafchamps M and Minten B 2001 Social capital and agricultural trade *American Journal of Agricultural Economics 83 680-85*

Feder G, Just R E and Zilberman D 1985 Adoption of agricultural innovations in developing countries: a survey *Economic Development and Cultural Change 33 255-298*

Geertz C 1978 The bazaar economy: information and search in peasant marketing *American Economic Review 68 28-32*

Giannini A, Saravanan R and Chang P 2003 Oceanic forcing of Sahel rainfall on interannual to interdecadal timescales *Science 302 1027-1030*

Gibba P 2002 The impact of accurate and timely issue of climate forecast and agrometeorological warnings on policy and decision-making *AGM-7/WCAC-1, WMO/TD-No. 1223, 153-159* World Meteorological Organization Geneva, Switzerland

Ingram K T, Roncoli M C and Kirshen P H 2002 Opportunities and constraints for farmers of West Africa to use seasonal precipitation forecasts with Burkina Faso as a case study *Agricultural Systems 74 331-349*

Jagtap S S and Jones J W 2005 Decision support system for agricultural applications of climate forecast in West Africa *Progress Report 2004-05 NOAA Office of Global Programs*

Kenya Business Development Services Program *2004 November Monthly Newsletter* Nairobi, Kenya

Hulme M 2001 Climate perspectives on Sahelian desiccation: 1973-1998 *Global Environmental Change 11 19-29*

Kirschen P H and Flitcroft I D 2000 Use of seasonal precipitation forecasting to improve agricultural production in the Sudano-Sahel: an institutional analysis of Burkina Faso *Natural Resource Forum 24 185-195*

LaFreniere S 2005 Cell phones catapult rural Africa to 21st century *New York Times August 25*

LaValle I H ed 1978 Fundamentals of decision analysis Holt, Rinehart and Winston, New York

Luganda P 2002 Effective methods of communicating climate forecasts and agrometeorological advisories to farmers and other end-users *AGM-7/WCAC-1, WMO/TD-No. 1223, 119-122* World Meteorological Organization Geneva, Switzerland

Lyon F 2000 Trust, networks and norms: the creation of social capital in agricultural economies in Ghana *World Development 28 663-681*

Maiga D A 2002 L'application des informations et des avis agrométéorologiques à l'agriculture, à l'élevage et à la foresterie: une etude de cas au Mali *AGM-7/WCAC-1, WMO/TD-No. 1223, 69-74* World Meteorological Organization Geneva, Switzerland.

Manobi 2006 (http://www.manobi.sn) Accessed 23 January

McKemey K, Scott N, Souter D, Afullo T, Kibombo R and Sakyi-Dawson O 2003 Innovative demand models for telecommunications services *Technical report U.K. Department for International Development*

Mokssit A 2007 End-user liaison: role of interfacing mechanisms climate change issues for northern Africa and Mediterranean region *presented at WMO Climate Information and Prediction Services RA I Training Workshop, Tunis 8 November*

Ndiaye M 2002 Avantages des previsions climatiques et des avis agroclimatiques (expérience sénégalaise) *AGM-7/WCAC-1, WMO/TD-No. 1223, 146-152* World Meteorological Organization Geneva, Switzerland

Nyirubugara O 2008 Mobile phone vital for Cameroon farmers (http://www.africanews.com/site/list_messages/18810) Accessed 22 August

Ogallo L 2007 CLIPS: RCOFs, Regional networking and consensus building, and user liaison for targeted climate service delivery *presented at Public Weather Services Symposium, Geneva, Switzerland 4 Dec*

Pretty J and Ward H 2001 Social capital and the environment *World Development 29 209-227*

Raleigh C and Urdal H 2007 Climate change, environmental degradation and armed conflict *Political Geography 26 674-694*

Reardon T and Taylor J E 1996 Agroclimatic shock, income inequality, and poverty: evidence from Burkina Faso *World Development 24 901-914*

Reardon T, Matlon P and Delgado C 1988 Coping with household-level food insecurity in drought-affected areas of Burkina Faso *World Development 16 1065-1074*

Roncoli M C, Ingram K and Flitcroft I 2000 Opportunities and constraints to using seasonal precipitation forecasting to improve agricultural production systems and livelihood security in the Sahel-Sudan region: a case study of Burkina Faso *CFAR—Phase I. NOAA Office of Global Programs*

Roncoli M C, Ingram K and Kirshen P 2001 The costs and risks of coping with drought: livelihood impacts and farmers' responses in Burkina Faso *Climate Research 19 119-132*

Roncoli M C, Ingram K T, Jost C C, Kirschen P H and Yaka P 2003 Farmers' behavioral responses to seasonal rainfall forecasts in the Sahel-Sudan *presented at 17th Symposium of the International Farming Systems Association, Orlando, Florida, November 17th -20th*

Schechter L 2005 Trust, trustworthiness, and risk in rural paraguay *Ph.D. dissertation University of California-Berkeley*

Scott N, Batchelor S, Ridley J and Jorgensen B 2004 The impact of mobile phones in Africa, *prepared for the Commission for Africa, London*

Schultz T W ed 1982 Investing in people University of California Press, Berkeley

Smith R E 2003 Land tenure reform in Africa: a shift to the defensive *Progress in Development Studies 3 210-222*

Stigter C J 2002 The establishment of needs for climate forecasts and other agromet information for agriculture by local, national and regional decision-makers and users communities *AGM-7/WCAC-1, WMO/TD-No. 1223, 76-83* World Meteorological Organization Geneva, Switzerland

Tarakidzwa I 2007 Use and dissemination of seasonal climate forecasts in agricultural production in Africa *CagM Report No. 102, WMO/TD No. 1344, 29-40* World Meteorological Organization Geneva, Switzerland

Tarhule A 2005 Climate information for development: an integrated dissemination model *11th General Assembly of the Council for the Development of Social Science Research in Africa (CODESRIA) in Maputo, Mozambique, 6-10 December*

Tarhule A and Lamb P J 2003 Climate research and seasonal forecasting for West Africans: perceptions, dissemination, and use? *Bulletin of the American Meteorological Society 84 1741-1759*

Thornton P K 2006 Ex ante impact assessment and seasonal climate forecasts: status and issues *Climate Research 33 55-65*

Traoré P C S, Kouressy M, Vaskmann M, Tabo R, Maikano I, Traoré S B and Cooper P 2007 Climate prediction and agriculture: what is different about Sudano-Sahelian West Africa? in **Sivakumar M V K and Hansen J** eds *Climate prediction and agriculture: advances and challenges* World Meteorological Organization 189-203

Valente T W 2005 Network models and methods for studying the diffusion of innovation in **Carrington P J** ed *Models and methods in social network analysis* Cambridge University Press 98-116

Waverman L, Meschi M and Melvyn F 2005 The impact of telecoms on economic growth in developing countries in *Africa: The Impact of Mobile Phones* Vodafone policy paper 2

WMO 2002(a) RA I expert group meeting on the application of climate forecast for agriculture: conclusions and recommendations of the meeting *AGM-7/WCAC-1, WMO/TD-No. 1223, 172-175* World Meteorological Organization Geneva, Switzerland

WMO 2002(b) RA I expert group meeting on the application of climate forecast for agriculture: working group C report *AGM-7/WCAC-1, WMO/TD-No. 1223, 168-171* World Meteorological Organization Geneva, Switzerland

WMO 2003 RA VI CLIPS NMHS questionnaire analysis World Meteorological Organization Geneva, Switzerland

WMO 2006 Commission for agricultural meteorology: the first fifty years *WMO No. 999* World Meteorological Organization Geneva, Switzerland

WMO 2007(a) WMO contributing to regional climate forecasting worldwide *WCP Feature Article* October 2007 World Meteorological Organization Geneva, Switzerland

WMO 2007(b) Report of the president of the vommission for agricultural meteorology *WMO Cg-XV/Doc. 3.4.2* World Meteorological Organization Geneva, Switzerland

WMO 2007(c) Review of performance of the CLIPS project (1995-2007) World Meteorological Organization Geneva, Switzerland

WMO 2008 Living with climate variability and change: understanding the uncertainties and managing the risks *Report of WMO Conference at Espoo* World Meteorological Organization Geneva, Switzerland (in press)

Ziervogel G, Bithell M, Washington R and Downing T 2005 Agent-based social simulation: a method for assessing the impact of seasonal climate forecast applications among smallholder farmers *Agricultural Systems 83 1-26*

Figures

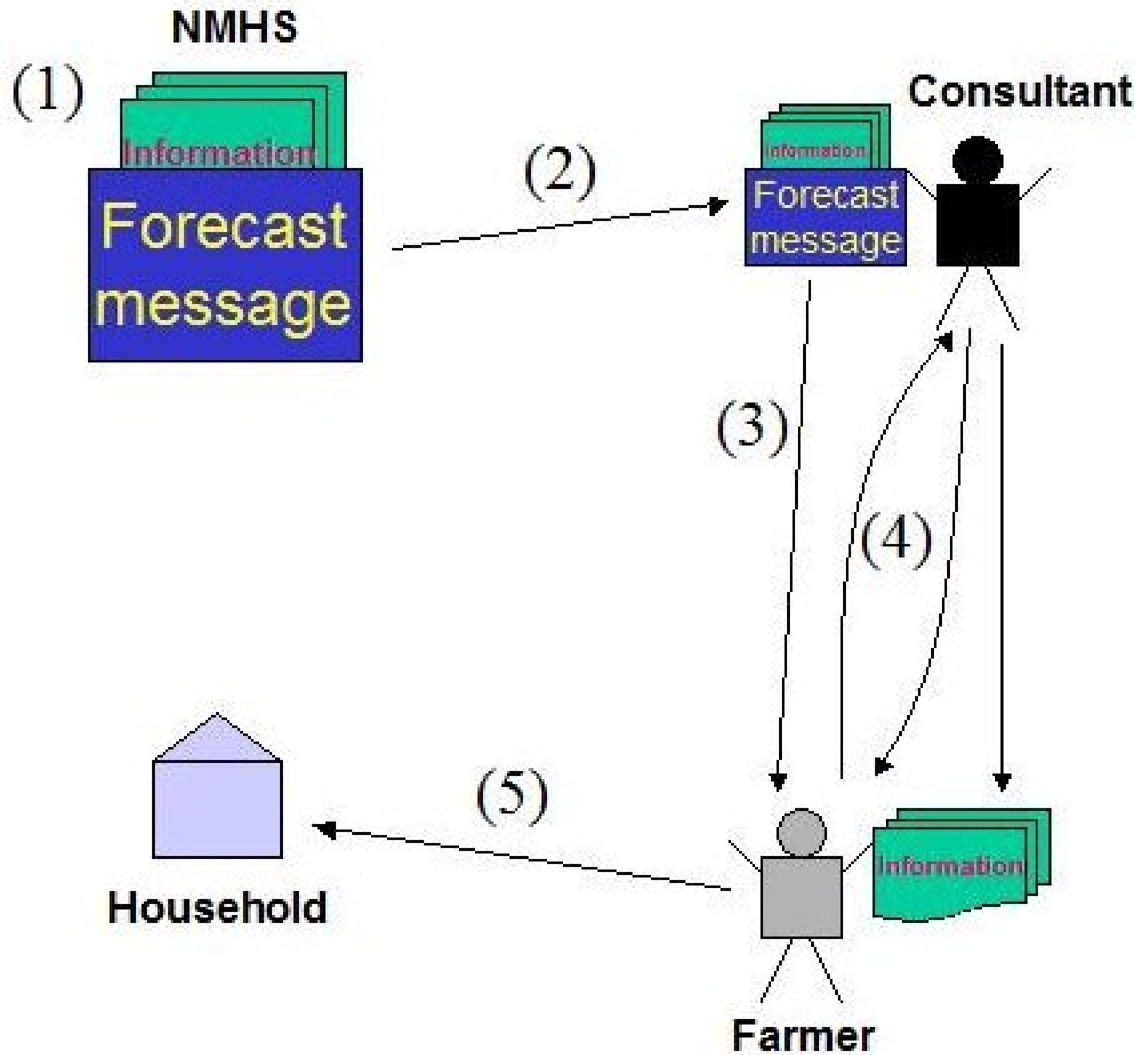

Figure 1 5-step minimum framework for most efficient forecast dissemination to rural farmers.

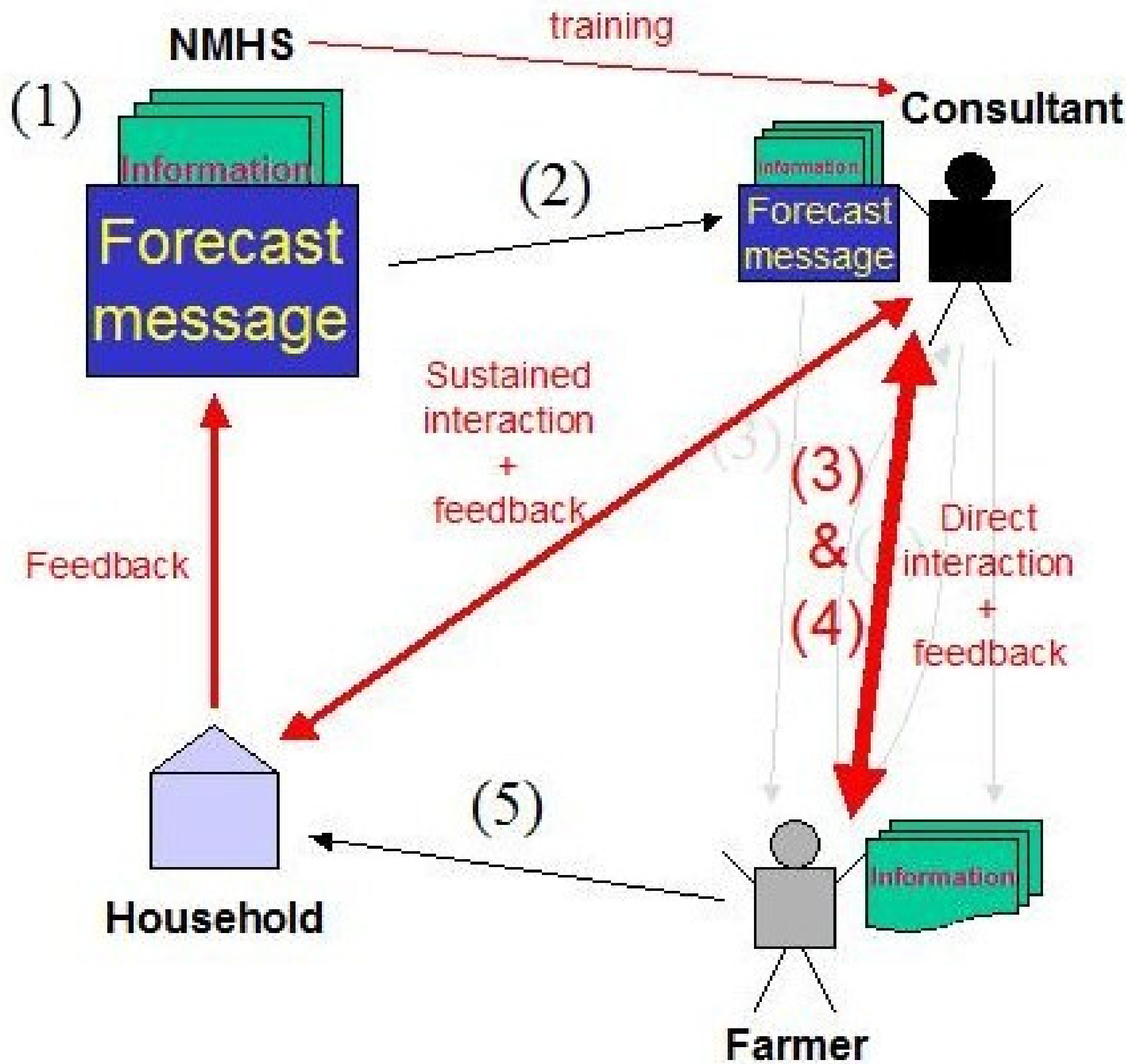

Figure 2 Information flow structure via mobile phones (changes in red; arrow thickness signifies efficiency). Steps 3 and 4 are combined at significantly reduced cost.