Mobile applications for weather and climate information: their use and potential for smallholder farmers

Working Paper No. 150

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

Mobile phones are increasingly being used to provide smallholder farmers with agricultural and related information. There is currently great interest in their scope to communicate climate and weather information. Farmers consistently identify demand for weather information and whilst ICTs may be one way of delivering this at scale there are concerns that this should not be seen as a panacea. At a time when there have been a range of initiatives and projects that have been implemented this paper seeks to draw lessons and identify key considerations to inform the development of future mobile applications to provide climate services to smallholder farmers. A literature review, interviews with key informants and experts and 15 case study reviews were conducted. This focused principally on Sub Saharan Africa but included some examples from India.

Despite numerous initiatives few have developed fully beyond the pilot stage and few have been evaluated. Some of the provision to date has been of questionable value to farmers. A key observation is that relatively little attention has been paid in design, to the needs for and use of both the information and technology by farmers, and few attempts made to differentiate provision according to gender and other demographic variables. Other factors contributing to success included communications approaches, which are interactive and/or involve trusted intermediaries who can add context to and help interpret more complex information. Providing weather information alongside other services as 'bundles' and in conjunction with complementary communications approaches appears to work well. An important challenge is how to meet farmers' needs for location specific, timely and relevant information in economically sustainable ways. More widely there are challenges in achieving successful business models and potential conflicts between initiatives driven by mobile network operators and public goals.

The study identified areas of considerable potential which include: the use of increasingly available mobile data connections to ensure locally relevant content is available to farmers in timely fashion (including both historical climate information and forecasts); development of participatory decision making tools to enable farmers to interpret information for their own contexts and consider implications and management options; use of visual applications and participatory video on mobile devices to enhance learning and advisory services for farmers;

the potential for increased feedback between farmers and service providers as well as increased knowledge sharing between farmers provided by the use of social media

Keywords

Information and communication technologies; mobile applications; climatic data; agricultural extension; participatory communication.

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Acronyms

ACRE	Agriculture & Climate Risk Enterprise
AGRA	Alliance for a Green Revolution in Africa
B2B	Business to Business
B2C	Business to Customers
BoP	Base of the Pyramid
CABI	Commonwealth Agricultural Bureaux International
CKW	Community Knowledge Worker
F2F	Face to face
GIS	Geographic Information System(s)
GPS	Global Positioning System
GSMA	Groupe Speciale Mobile Association
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IFFCO	Indian Farmers Fertilizer Co-operative
IKSL	IFFCO Kisan Sanchar Ltd
INGO	International Non-Governmental Organization
IVR	Interactive voice response
KI	Key Informant
M4D	Mobile for Development
MIS	Management Information System
MNO	Mobile Network Operator
PICSA	Participatory Integrated Climate Services for Agriculture
RML	Reuters Market Light
SARI	Savannah Agriculture Research Institute
SMS	Short Message Service
TAHMO	Trans-African Hydrometeorological Observatory
USSD	Unstructured Supplementary Service Data
WAP	Wireless Application Protocol

Introduction

This paper aims to understand the current use of mobile applications in providing weather, and climate information to smallholder farmers, particularly in sub-Saharan Africa. It reviews the demand for information, the content and services provided, the delivery methods and communications approaches used and the business models employed. It explores the key factors that influence success and the constraints in order to inform the current and future landscape of development of mobile applications. The study has also been commissioned to help shape the development of a mobile application for the Participatory Integrated Climate Services for Agriculture (PICSA) approach. The PICSA approach aims to facilitate farmers to make informed decisions based on accurate, location specific, climate and weather information; locally relevant crop, livestock and livelihood options; with the use of participatory tools to aid planning and decision making (ccafs.cgiar.org/blog/new-manual-helps-expand-reach-climate-services-together-farmers#.VlaXqHbhDIU). The approach is explained in more detail in Appendix 1.

Background

Projects began using mobile phones to provide agricultural information to farmers in 2007, partly as a response to the decline in the provision of traditional extension services and partly in recognition of the potential of mobile phones as an information source (Aker, 2010). It is estimated that, at the end of 2014, the penetration rate of mobile phones in sub-Saharan Africa was 69% (ITU, 2014). The number of subscribers is predicted to increase twenty fold over the next 5 years so that, by the end of 2019, there will be over 930 million African subscribers, with 75% of those subscribers having access to the internet (Smith, 2014). The expected proliferation of mobile phones particularly into rural areas has also encouraged mobile network operators (MNOs) to become one of the main protagonists in the provision of agricultural information, as they attempt to use these services to gain rural market share and improve brand loyalty. Private technology companies, non-governmental organisations (NGOs) and research institutions are also key players in this arena.

Scope

Mobile Agriculture projects (herein known as mAgri projects) are not just concerned with providing information and services to farmers; they also provide a range of services across the whole of the agricultural value chain. This working paper, whilst recognising the significant benefits that mobile phones are having across the entire value chain, focuses on information provided to smallholder farmers. The provision of market intelligence information, trading facilities and financial services to farmers also falls outside the scope of this paper. It investigates specifically the provision to farmers of weather and climate information and any weather-related learning, advisory and extension services in respect of crop production. However, lessons can be drawn that may inform wider mAgri projects and studies.

Whilst the main focus of this paper is on mAgri projects in sub-Saharan Africa, the geographical scope is widened to include India due to the greater penetration of mAgri in India (many more projects have gone beyond the pilot phase) and the subsequently increased

body of research that has been undertaken. Moreover, some projects in India are seen to be good examples of mAgri initiatives. Although it is recognised that there are many socio-economic and political differences between India and sub-Saharan Africa, the inclusion of Indian projects is relevant to this study's findings and recommendations.

Methodology

This study included a literature review, key informant interviews (KIIs) and a case study analysis of projects that are using / have used mobile applications to provide weather and other services to smallholder farmers.

The literature review drew on a wide variety of sources of grey and published literature including journal articles, reports and websites. KIIs were undertaken with fifteen individuals, selected from a range of organisations[1] that are involved in the mAgri sector (NGOs, MNOs, private companies, multilateral agencies, industry associations and consultancies). It is not intended that these key informants are representative of the whole of this sector but they were selected because of their knowledge and appreciation of certain aspects of it. The interviews were focused around three main themes: weather and climate information - to try to better understand how this part of the mAgri service was functioning; specific case studies - to try to gain more detailed information on specific projects / programmes; and key factors for success of mAgri projects - to try to obtain the key informant's insight into what was working well, what was not, and why.

The fifteen case studies[2] are a selection of different projects that use mobile phones, tablets or phablets[3] to provide smallholder farmers with agricultural information. The selection of these particular projects from an extensive array of mAgri projects is not intended to be representative but has been influenced by several key factors. These include the extent to which projects provide weather related information; whether they showcase a particular business model or partnership arrangement; and whether they display interesting, unusual or particularly successful features. The case studies draw mainly from information found in grey literature (websites, reports, press releases) and from discussions with key informants. The GSMA website[4] was particularly helpful with its evaluations of some of the projects. There are very few peer reviewed studies on which to draw. Furthermore, many of the case studies are in a pilot phase and so it is difficult to draw conclusions about their sustainability. A matrix was used to analyse the case studies.

[1] Key informant organisations are listed in Appendix 2.
[2] A list of the relevant case studies is included in Appendix 3.
[3] A Phablet is essentially a mobile phone with a larger screen.
[4] http://www.gsma.com/mobilefordevelopment/

Literature Review

The literature review initially focuses on the content and services that mAgri initiatives provide. It then discusses the adoption and use strategies that are employed by these initiatives, including delivery methods and communications approaches. Finally, it explores mAgri business models and impact assessment.

Content/Services

Information Requirements

Although most mAgri projects do undergo some research on the information requirements of their target farmers, there is concern that these requirements are not properly assessed and not understood well enough to develop valued services (Hellstrom, 2010). This section attempts to highlight some of the information requirements of farmers before examining the content that is currently provided.

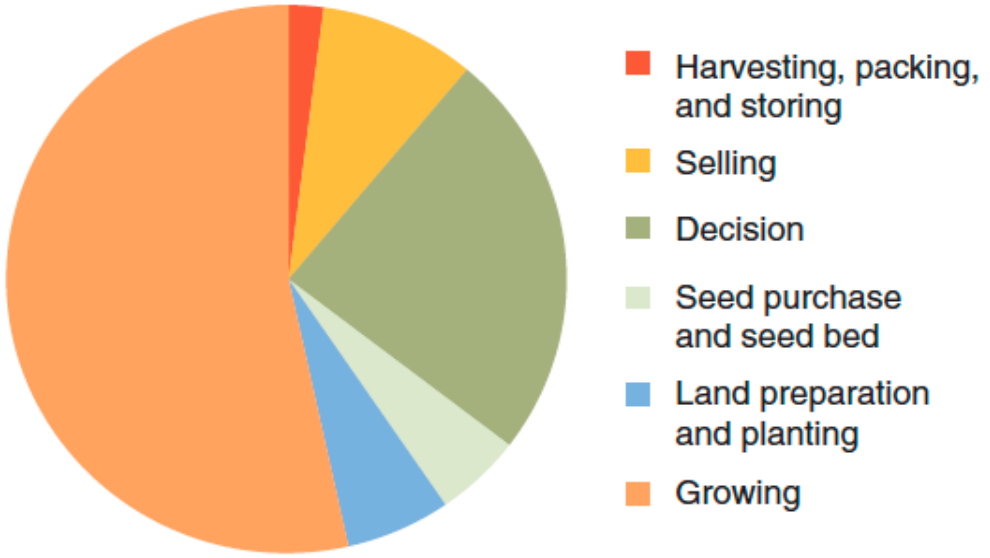
Recent research has found that market and crop advisory information are two of the main types of agricultural information requested by smallholder farmers (GSMA, 2015). In terms of crop information, the research has shown that, in particular, farmers would like information around the planning of crops; that is, what crops to plant and when (ibid).

A randomised trial (n=300) of a sample population of 8,000 smallholder farmers in Sri Lanka analysed the informational transaction costs[5] of farmers who were producing and selling tomatoes, onions, aubergines and chillies. It found that the greatest informational transaction costs (53%) were during the growing phase followed by the decision-making period of whether and when to plant (23%); only 9% of these costs were related to the selling phase (De Silva and Ratnadiwakara, 2008). The pie chart below (figure 1) shows the information search costs by stage of farming.

These two pieces of research highlight the importance of determining the farmers' requirements at a particular stage of the production cycle which will of course vary according to the local context and will be influenced by many factors including the crops grown and the input and marketing systems associated with them.

[5] Transactional costs are defined as being costs attributed to a specific economic exchange and include costs such as transport costs and storage costs. Informational transaction costs are the costs of information search related to an economic exchange.

Figure 1: Informational Search Costs by Stage of Farming (for smallholder vegetable farmers in Sri Lanka)



Taken from a diagram in Donovan (2011) adapted from De Silva & Ratnadiwakara (2008).

Weather is often part of the information "bundle" provided by mAgri projects. There is evidence to suggest that weather information, although not the most sought after information, is regarded as important by farmers. Mittal et al's small scale study (2010) of mobile information services for farmers in India found that smallholder farmers cited weather, seed information, market prices, plant disease and pest control as their top information requirements. Most of the farms researched lacked access to irrigation and were therefore highly dependent on rainfall and hence weather conditions for the success of their crops. The weather information was required throughout the crop cycle, not just during planting but also for the application of fertilisers and during harvesting and storing crops (ibid). In Tanzania, other research on mAgri requirements found that farmers mostly wanted to know the onset of the rains so that they knew when to plant seeds. Daily forecasts were not found useful but 5 day forecasts were just long enough to be useful to farmers without compromising on accuracy (Palmer, 2014).

The literature suggests that informational requirements are context specific. Farmers within a very close proximity of each other can have diverse informational needs as a result of geographical variations of soil type and water supply (Kameswari, 2011) or social and cultural differences (Masuki et al, 2010). One of the challenges is to ascertain these context specific needs. Ideally these needs should be investigated through a participatory, iterative process with the local communities themselves (Chapman and Slaymaker, 2002). However, in reality this may not be possible at scale. Most mAgri projects do undertake a broad needs assessment and often work with local organisations to understand their target audience, but are unable to do this with the level of detail that is required. Indeed, there is some evidence that these projects are filling perceived information gaps rather than satisfying actual information demands (Glendenning & Ficarelli, 2012).

There is a wealth of literature on the gender gap between men and women in terms of access to mobile phones. The high cost of ownership, higher levels of illiteracy and cultural barriers all play a part in reducing women's access (GSMA, 2010). This is not the focus of this study. However, it is interesting to note that even if women have access to mobile phones they are still less likely to use mAgri services (Pshenichnaya, 2011). The cost of these services may be prohibitive but it also appears from the literature that many mAgri services have developed a gender neutral approach to content provision and service design. There is little evidence of any gendered research taking place on farmers' informational needs, though the GSMA and its mFarmer projects have started to recognise the significance of developing women centric content and distribution channels (Pshenichnaya, 2011).

There are also requests for a broader perspective of informational needs to be considered. There is research that suggests that for rural women, healthcare, particularly for their children is a primary concern and information on agriculture is not high on their list of informational requirements (GSMA, 2012).

Characteristics of Good Content

As highlighted in the section above, good content must be 'localised' if it is to be of value to smallholder farmers. The greater the customisation of data and the greater the frequency of updating the data, the greater the value (Mittal et al, 2010). However, this is often difficult and costly both in terms of quality control and expense (Qiang, 2011). Ideally, localised and relevant content would be developed in conjunction with the local communities themselves, with farmers sharing their own local knowledge in a two –way exchange between farmers and experts (Glendenning and Ficarelli, 2012). Although, the use of mobile phones may have the potential to facilitate this type of knowledge exchange, the review of literature suggests that this has not yet happened.

Information must be 'actionable' if it is to be sought by farmers and then adopted (Burrell and Matovu, 2008). Literature suggests that it can only be actionable if some of the structural constraints (lack of credit, market access and input scarcity and quality) and the environmental constraints (poor soil quality, lack of water) are alleviated. In an attempt to address these broader constraints, mAgri projects have sometimes supplemented the information with other services or created more comprehensive information packages, containing different types of information alongside financial and insurance services. It is hoped that this will support behavioural change and help to mitigate any risks associated with it (Yonazi, 2012). An innovative example of this approach is an e-Learning project in India which has provided men and women with credit which they used to buy sheep and goats and also a mobile phone. The project then provided them with a structured learning course on sheep and goat production, delivered through 4 to 6 short voice messages each day on their phones. The results showed that the management of the sheep and goats by the participants improved compared to non-participants (Balasubramian and Daniel, 2010). Even where farmers have limited access to markets and inputs, it can be argued that weather information is still 'actionable' in that it can inform decisions on for example crop choice, timing of planting which will impact on production and food security.

Focus on Weather and Climate Content

Details about the provision of weather and climate information for mAgri projects are limited. Furthermore, there is scarce information about the accuracy and timeliness of weather forecasts and whether it is deemed useful by farmers. This section attempts to offer some insight on weather and climate information provision.

Weather information is often provided by national meteorological agencies. There is evidence that in Africa, some private companies (for example, Foreca, Ignitia and aWhere) have started to provide weather predictions for some mAgri projects. Most of the mAgri projects provide short-term weather forecasts. There are one or two that are providing medium range and seasonal forecasts (see the Findings section for details of the Grameen Foundation Community Knowledge Worker project [Box 5]). There is no evidence that historical climate data is provided through any mAgri service despite its value.

It appears that the MNOs that operate many of the mAgri services are not impressed by the accuracy of the forecasts that are provided to smallholder farmers (Pshenichnaya, 2012). In some cases, the lack of accurate weather information has led projects to try to establish their own on the ground weather stations. The ability to provide accurate weather forecasts for the precise location of the farmer using GPS or triangulation from their mobile phones has not yet been exploited fully. The lack of mobile phone base stations in rural areas reduces the ability to accurately triangulate in many parts of Africa (based on key informants discussions).

Integration of Weather and Crop Advisory Information

India has developed a sophisticated process for providing agrometeorological advisories to farmers some of which are being transmitted using mobile phones. Regional Meteorological Centres transmit weather information to 130 AMFUs (Agro Meteorological Field Units) which are located in each of the agro-climatic zones. Working with agricultural experts, they then produce agro-advisory information which integrates the weather information with soil and crop advice and makes suggestions for minimizing losses and optimizing inputs (Tall et al, 2014). In sub-Saharan Africa, little evidence could be found of this type of integration taking place using mobile phones as the communication channel.

Adoption and Use

Delivery Methods

There are differences in opinion as to whether SMS or voice is the best method of delivery of information to farmers who have basic mobile phones. SMS has the advantage that messages can be stored and retrieved (Mittal et al, 2010,) whilst voice messages allow illiterate farmers to comprehend information if it is provided in their local language (Vodafone, 2011).

The prediction is that over the next 5 years there will be a significant increase[6] in the use of mobile data services, driven by cheaper feature and smart phones, increased access to mobile

[6] A Guardian newspaper article is predicting a 20 fold increase in use of the internet through mobile phones in Africa over the next 5 years. (http://www.theguardian.com/world/2014/jun/05/internet-use-mobile-phones-africa-predicted-increase-20-fold

broadband and a reduction in the costs of data transmission. For example, Safaricom in Kenya are forecasting that 90% of their revenue will be from data in 2016 (Batchelor et al, 2014).

With this changing technological landscape, the possibility of farmers accessing information on demand, receiving visual and video information and retrieving information from the internet through mobile apps or browsers is becoming more likely. Information delivered visually or as video has huge advantages over voice or SMS messaging as they facilitate better comprehension of more complex ideas, specifically for illiterate farmers and allow for greater personalisation and contextualisation of information (Leeuwis, 2004). The benefits of video information in particular are discussed in the Findings section of this paper. Access to mobile internet opens significant new possibilities for knowledge sharing and exchange possibly through online social media networks. Less expensive instant messaging services such as MXit and WhatsApp are growing rapidly throughout Africa and Facebook already has over 51 million users. (Batchelor et al, 2014; IWS, 2014).

On the other hand, there are human capability, affordability and technical barriers that currently prohibit resource poor farmers from benefitting from these types of services. There are also constraints on the supply side. In the developed world, there are operator neutral platforms[7] such as Apple iOS or Android, which have retail outlets (the Apple App store and the Google Play store) through which apps can be bought or sold. The MNOs are simply data carriers in this model. However, in the developing world the situation is different. Platforms cannot be accessed independently from the MNO; mainly because the payment for services must go through the MNOs billing systems due to a lack of credit cards in use. MNOs want exclusivity for these apps which ties the application developer into working with specific MNOs, limits the possibility for selling at scale and therefore reduces the developer's incentives for development (Qiang, 2011).

There is an attempt by some key players in the technology arena to address these affordability and connectivity constraints for rural Africa. Here are some of the examples:

1) Google has launched its Project Loon initiative which aims to float balloons in the stratosphere to provide internet access to areas where there is currently no connectivity; this will be much cheaper than using satellites or fibre optic cabling (Project Loon, 2015);
2) Facebook, through its partnership organisation Internet.org is trying to develop new technologies that will improve data compression and hence reduce the costs of internet access. It is also attempting to increase connectivity:
    a) Internet.org has recently (late 2014 to early 2015) launched an app, through which people can access free weather information as well as health, employment and local information services. The weather information is provided by AccuWeather. The app is currently available to Airtel customers in Ghana, Kenya and Zambia as well as to Tigo customers in Colombia and Tanzania (Internet.org, 2014a);
    b) It is exploring Free Space Optics, geo satellites and drones as a way of providing internet access to even the remotest parts of the world (Internet.org, 2014b);

[7] Platform is defined as software architecture that serves as a foundation or base for other programmes or applications.

c) Facebook itself has recently also launched Facebook Lite in Africa and Asia for low end android devices. It is only 256kb in size and works across 2G networks;

3) A company called biNu has developed an autonomous software platform that enables superfast, data-lite access to the internet even from feature phones. It can be accessed by downloading and installing an app that will allow the phone to work efficiently even over 2G networks (biNu, 2014).

4) The expansion of mobile money applications such as mPesa may provide a better enabling environment for the development of business models for application development and for complementary mAgri services.

The literature recognises how only the most appropriate technology should be used for conveying information to rural farmers. It is futile to use more complicated delivery methods when simple ones can be just as effective (USAID, 2010). On a wider note, in some of the literature, caution is advocated when using new technologies. There is a warning that they are not independent variables to be inserted into a situation; their meaning can be socially construed and if they are not used appropriately they may reinforce existing dependencies and inequalities (Brugger, 2011).

Communications Approaches

The importance of using pre-existing personal and social networks to communicate information through mobile phones is highlighted in the literature. This replicates traditional methods of communicating ideas within rural communities that are face to face and with trusted individuals such as input suppliers and other farmers (Duncombe and Heeks, 2002). If these traditional networks can be enhanced by mobile phones, then the evidence suggests that there is a significant rise in the quality and speed of information delivery in addition to an increased awareness and knowledge gain by farmers (Fu and Akter, 2011).

There are different ways in which mAgri projects can capitalise on these pre- existing networks. Some have used intermediaries, or rather infomediaries, who are respected community members that can provide information that they receive on their mobiles phones to other members of the community. An example of this is the Community Knowledge Worker project in Uganda (one of the case studies examined in the Findings section). Other mAgri initiatives have used farmer co-operatives to spread information to farmers through their social networks (World Bank, 2012).

To date, many extension services have been through group based activities such as farmer field schools but there is evidence that farmers with mobile phones and access to outside information are less likely to participate in group learning activities (Lwasa, 2011). This raises the question of whether the use of mobile phones by individual farmers to obtain information is encouraging a more individualised culture within communities (Duncombe, 2012). This is an area that perhaps warrants further research.

Nevertheless, there is evidence that information spreads quickly from farmer to farmer when individual farmers have mobile phones. As discussed, the technological advancements predicted may lead to the use of social networking media on mobile phones by farmers. This

could potentially lead to the co-construction of knowledge between farmers and between farmers and experts that could transform extension type services in the future (Batchelor et al, 2014).

Business Models

From the literature, it appears that there are few proven business models for mAgri initiatives. IKSL is one of the only scaled projects that has achieved financial sustainability. There is a "forever pilot syndrome" (Hellstrom, 2010: 63) where projects seem unable to scale up and remain financially viable once the initial intake of capital has been utilised.

The uncertainties of how to create sustainable mAgri projects at scale fits in with the wider challenges of developing business models for people at the base of the pyramid (BoP)[8], where the ability of customers to pay for services is limited. This section examines three key areas which must be considered if a mAgri business model is to be successful: target market size, revenue models, quality of service provided at a reasonable cost.

Target Market Size

For a BoP initiative to be financially sustainable, there must be a large enough target audience who want to use and are able to use the service. The literature underlines how farmers are often not aware of the service and are unable to access it because of the lack of basic phones, problems with connectivity, electricity and technological illiteracy. In India, some of the successes with mAgri projects appear to have been associated with the large membership bases of the organisations setting up the service (for example, IFFCO, the Indian fertiliser cooperative that partners the IKSL mAgri project, has 60 million members) (GSMA, 2011). In Africa, the numbers of potential customers within each country are not so large and there may be difficulties in operating these services across borders.

Revenue Models

In terms of Business to Customer (B2C) models, the evidence is mixed as to the extent to which farmers have the ability and willingness to pay for agricultural information. It appears that it is dependent on income levels, educational attainment and the scope of information services provided (Qiang, 2011). The methods of payment include charging a monthly subscription or a pay for use agreement whereby airtime is deducted from pre-paid accounts. Successful products seem to use "freemium" pricing models which allow farmers to receive basic "push" information for free but then pay for premium pull-based services, such as call centres (GSMA, 2011). The GSMA have concluded that the modest revenue from farmers themselves is rarely enough to support a sustainable service and that alternative Business to Business (B2B) sources of revenue are required in addition to B2C revenue.

Table 1 sets out some of the alternative revenue sources which include income from advertising revenue and from providing data collection and market research services. An interesting alternative is third parties, such as agribusinesses or micro-insurance companies, paying for farmers subscriptions through contract sales in order to increase long term sales and reduce their own risks. Another credible business model is for government agencies and departments to pay for these mAgri products as a way of partially outsourcing their extension

[8] Base of the Pyramid is a term which originates from the work of C K Prahalad and colleagues for those people who have annual per capita income of less than US$1,500 or $2,000 (@ PPP).

and advisory services. This could be a cost-effective option although the sustainability of the business model and the quality of the services provided would then be dependent on available funding from the public sector.

Table 1 Alternative Revenue Sources (B2B)

Revenue Source	Description	More Details
Contract Sales	Farmers' subscriptions are paid by a third party, such as an agribusiness or micro-insurance company.	1) Agribusinesses benefit from increased productivity and/or increased input sales. 2) Micro-insurance companies benefit from reducing farmers' risks.
Outsourced Services	The provision of supplementary extension type services	Government agencies, NGOs or private sector buyers may pay for services which increase agricultural productivity.
Advertising & Public Service Announcements	Adverts or public service messages could be included as part of the service.	Agribusinesses may want to advertise particular products which relate to the advice given.
Data Collection & Market Research Services	Surveys can be used on mobile phones to gather information.	NGOs, government agencies, research institutions and companies may be willing to pay for information collected from farmers.

Adapted from work undertaken by GSMA, 2011.

Quality Services Provided at a Reasonable Cost

As discussed in the Findings section, farmers require quality, localised information. However, this comes at a high price and there is often a trade-off between the provision of local information and scalability (World Bank, 2012). Local content provision is expensive as it requires the gathering and validating of local information. Furthermore, pull services such as call centres require a wide range of expertise and significant infrastructure.
One of the ways to reduce costs is to be able to use an underlying database of answers that are readily available and can be automised as much as possible so that only unusual questions are passed onto experts (World Wide Web Foundation, 2011). New ideas are emerging as to how the costs of content provision and management could be reduced. Some initiatives are taking place that will develop open source content databases that can be used to create tailored content for farmers. This will be discussed further in the Findings section.

Impact assessment

Whilst there is evidence that mobile phones in themselves are having an impact on rural communities (Donovan, 2011), there are only a handful of formal studies on the impact of services providing agricultural information to farmers. The scarcity of formal evaluations is

hardly surprising given the small number of projects that have successfully moved out of their pilot phase. The few studies that have been undertaken mainly focus on the impact of market information on market inefficiencies and subsequent increases in farmers' income. There has been even less research on the impact resulting from the provision of crop advisories or weather information.

Where there has been research, the results have been mixed. In a randomised control experiment in respect of the Reuters Market Light (RML) mAgri project in India, Fafchamps and Minten (2011) found no statistically significant effect of the treatment on the likelihood of changing crop varieties and cultivation practices and on the effect of rainstorms on crop losses. Mittal et al's small study (2010) of the impact of mobile phones and mAgri services in India (including RML and IKSL users – see later case studies) on smallholder farmers in the crop sector presented mixed findings. Using information collected from focus groups and farmer interviews, only some farmers stated that they had benefits from improved access to information in respect of protection from weather-related damage, cultivation practices and seed variety selection amongst other things. Farmers identified infrastructural constraints, lack of access to credit and lack of capacity for risk-taking as the main constraints for using the information to full effect.

There is concern that mAgri services may be reinforcing inequalities as they are possibly benefitting wealthier, younger, male farmers more than other farmers (Donocan, 2011). Mittal et al's research (2010) suggests that farmers with larger farms were better able to leverage the benefits of access to information as they faced fewer constraints than less wealthy farmers. As already noted, women are less likely to access information services even if they have access to mobile phones (Pshenichnaya, 2011). Interestingly, Masuki et al's (2010) study of mobile phone use in Uganda shows that though women are less likely to use mobile phones, when they did use them, they were more likely to try to seek information about natural resource management than men.

It is evident from the literature review that further research is needed in many areas, but in particular in the area of impact assessment and in respect of the inequalities that may be enhanced by the provision of information services. It must be also remembered that there are research challenges in attempting to measure impact. It is especially hard to disentangle the effects of mobile phones per se and the effects of the provision of mAgri services especially given the spillover effects that these types of projects have as information spreads amongst farmers who are not in the treatment group (Aker, 2010).

Findings from case studies and key informant interviews

Overview

This section presents the findings from the analysis of fifteen case studies and fifteen separate key informant interviews. A list of the case studies can be found in Appendix 3 and the key informants' organisations are listed in Appendix 2. This section highlights the key factors that influence success as well as the constraining factors, identified from the analysis of the case studies and interviews.

All of the case studies have smallholder farmers as their main target audience and provide a combination of different types of agricultural information. The majority of the case studies are geographically located in sub-Saharan Africa and communicate to farmers with technology appropriate to basic mobile phones. The partnerships involved in these projects span across the public and private sector with MNOs, NGOs, private companies and co-operatives acting as lead partners in different case studies. The start dates for the case studies range between 2007 and 2014. The scale of the case studies varies significantly, Indian case studies have the largest outreach (IKSL has 1.5 million active users). There are a wide range of business models employed to support these projects, including a variety of B2C and B2B revenue models.

A matrix was used to analyse the case studies. It examines the following characteristics of the initiatives studied: start date, duration, geography, stated objectives, target population, needs assessment, type of content, devices used to deliver the information, delivery channel, communications approach, scale (current, actual or expected), partnerships (content, technology, funding) and business models. It also gathered details on outreach approach, consideration of women farmers (if any), overall efficacy (if known) and identified key factors that influence success as well as key constraints that hinder it. Whilst not all the detailed information was available for each case study, broad conclusions about the key factors for success and the constraining factors can be drawn

Key Factors that Influence Success

This section initially focuses on the information requirements of the farmer and how the content and services can best meet these requirements. It then moves on to reveal issues concerning adoption and use and considers the characteristics of successful delivery methods and communications approaches. Finally, the factors for success in terms of outreach strategies, business models and partnerships are discussed and conclusions are drawn.

Content/Services

Ascertaining Information Requirements

There is a perception by some key informants that the actual information requirements of farmers are not being fully understood let alone met by many of the providers of the mAgri

service (KI 7, 11[9]). It proved difficult to obtain information about how the case study projects initially ascertained what information the farmers may want and how they may want to use this information. However, it appears that those case studies that take a human centric design approach have had greater success in engaging with farmers and maintaining interest in the service. IFFCO Kisan Sanchar Limited (IKSL), one of the case studies in India, for example, spent a long time surveying farmers at the beginning to ensure that the content and design of the service met their needs (KI 5). Furthermore, they are one of the few mAgri projects that have undertaken specific gender research and now provide women-centric information.

The concern around meeting farmer requirements was particularly highlighted for weather information. There is little evidence that service providers understand farmers' requirements concerning weather information, that is, what information farmers want, in what format and/or what farmers will use it for. As a consequence, there is a sense that weather and climate information is not being used to its full potential (KI 1, 2, 6). Farmers are often just provided with the weather information that is readily accessible by the service provider; this tends to be in the form of short-term forecasts. Further there was little evidence of providers focussing on how information is interpreted and the need for commonly agreed and understood terms.

Another aspect to this is that farmers themselves may not be able to determine and adequately express their own weather and climate requirements; often lacking awareness of the type of information it is possible to produce and how this information may be useful / beneficial for them (KI 6, 9). This connects with the point raised in the literature review that rural women select health and education and not agriculture as their key informational requirements. This suggests that a deep, holistic understanding of farmers' lives, undertaken with the farmers themselves is fundamental to determining the most beneficial mAgri service.

Salience

Evidence from case studies and key informants highlights the importance of specific and relevant content as a key determinant for the success of mAgri projects (Tigo Kilimo, IKSL). Information should be tailored to farmers' local needs and should reflect the agro-climatic zone where they live (Airtel Kilimo). Many of the projects spend a significant amount of resource attempting to gather local, relevant information since there is an appreciation of the value of such information to its customer base (KI 8). Furthermore, the ability of the farmers to choose the information that they would like to receive also appears to work well (RML[10]).

Weather information has to be locally specific and reflect micro-climatic conditions otherwise it will not be relevant and actionable for the farmer (KI 1, 2, 11). Rainfall predictions in localised areas are very important (KI 8) as patterns vary even across small areas. Some weather forecasts in the case studies are covering a large area, for example, 50km grids. The smallest distance covered appears to be the 9km grids produced by aWhere, a private weather forecasting company which feeds weather information into the mAgri services provided by Esoko (one of the case studies in West Africa). Farmerline, a technology company in Ghana that provides an mAgri service has recently formed a consortium called TAHMO in an

[9] Explanation of code: KI = key informant,; 1 = number of key informant
[10] Reuters Market Light

attempt to provide a more localised, accurate weather information service for farmers (see Box 1).

Box 1: Farmerline and the TAHMO Initiative

In response to the need to provide better weather information to cocoa farmers in Ghana, Farmerline has formed a consortium with the Kwame Nkrumah University of Science and Technology in Ghana and the Delft University of Technology in the Netherlands. The consortium, under the umbrella of the TAHMO Initiative (Trans-African Hydrometeorological Observatory), will develop a dense network of TAHMO weather stations with the accompanying technological infrastructure to enable 10,000 cocoa farmers to access this weather data on their mobile phones through voice messaging (Kaisaris, 2014).

The weather stations will use low-cost, high precision weather sensors to measure meteorological and water resource variables that will then be conveyed to a central server using mobile phone technology. These weather stations will be hosted at and maintained by local secondary schools, which will be provided with educational materials to facilitate hands-on education about weather.

The TAHMO initiative is also working with ACRE (formerly known as Kilimo Salama) in Kenya (TAHMO, 2014).

Timeliness

For the information to be salient it has to be timely. Successful projects have recognised the importance of co-ordinating the dissemination of information around the crop cycle. CABI[11], who oversee the content management for the IKSL project have devised a template for managing information according to the relevant timings for each crop. The Reuters Market Light project in India also uses the crop cycle as a basis for the dissemination of information as does the Agri-Fin Mobile Project.

Some information has a short-term lifespan in terms of relevancy and therefore must be delivered within an appropriate timescale to the farmer (e.g. short-term weather forecasts [daily up to 8 day]). Farmers also demand timely responses from call centres around risk management issues; for example, outbreaks of pests, crop diseases and an imminent climatic event. Several of the case studies have highlighted problems when information is not provided within a reasonable timescale (Agri-Fin Mobile, Airtel Kenya).

Credibility

The credibility of information is another key factor, with accuracy being particularly important (KI 4). A number of key informants and case studies highlight problems with the lack of good local content providers and the importance of quality assurance (KI 1, 4, 5, 8). If information is inaccurate it could have significant consequences; decisions based on inaccurate information could lead, for example, to crop failure with significant financial and food security consequences for farmers and a loss of reputation for the service itself.

[11] Commonwealth Agricultural Bureaux International

Good local content provision

Ideally, local organisations such as research institutions, local extension services and government bodies, who are credible in the eyes of the farmers, would provide the information. However, in some countries, there is a dearth of organisations that can produce the content. Some projects have therefore decided to source their own information rather than use inaccurate and unreliable local providers. Esoko in Ghana, for example, decided to provide their own agronomic content but still has links with the Ministry of Agriculture and SARI (Savannah Agriculture Research Institute).

In terms of weather information, there are concerns over the lack of options for weather forecasting and the accuracy of the forecasts provided. As discussed above, it is often not possible to obtain accurate, local, short-term and seasonal forecasts. In cases where information is sourced in-house or from organisations that are not already deemed as credible by the local farmers, it can take years to build trust and gain credibility.

The development of credible, accurate and meaningful content is a significant challenge for all of the mAgri case studies. In response to this challenge, a considerable amount of resource has been directed at developing large databases that can be used as sources of information. Toto Agriculture is an online collection of localised, agriculture-related information such as weather forecasts, soil health, planting tips and pest management advice. CABI, which is an important player in this area, is creating an agro-extension information repository in India that will contain large amounts of agricultural data that can be synthesised by its Direct2Farm services into messages (SMS and voice) and delivered via mobile phones. These services will be able to include weather information. The issue of content provision and the debate over whether it should be proprietary or open source is discussed in constraints section below.

Contextualisation

Four of the key informants raised the importance of appropriately contextualised information as a key factor for success (KI 3, 7, 8, 10). This accords with communications and innovation theory that states that contextualised information is more likely to be readily integrated into the farmers own schemata of experiences (Leeuwis, 2004). This contextualisation not only involves translating the information into local languages but taking the data and breaking it down into comprehensible pieces of information based on the farmers' current knowledge base and presenting it in a way that it can be understood by the farmers within their own frames of reference (KI 3). This 'translation' of the information can be very time consuming and costly. The use of local intermediaries (or infomediaries) to help with the contextualisation of information is discussed in the Delivery Methods section below.

Quality Assurance

In order to be certain of the validity of the information, particularly if it is coming from a variety of local sources, there must be an element of quality assurance. The IKSL project (Box 2) has, in conjunction with CABI, developed a variety of quality control mechanisms to maintain control over content. CABI has devised protocols that cover the standardisation of data, content sourcing and editing. It subjects the content database to regular reviews and there is a panel of experts that not only answers any difficult questions that cannot be

answered by the helpline experts, but also scrutinises helpline responses on a regular basis. As a general point in many (even most) countries, with respect to forecasts (seasonal and/or short-term) there is seldom information available from Met. Services or other providers to users on their past accuracy and skill.

Box 2: IKSL

The IKSL project in India is highly regarded by many of the key informants. Its service has over 1.5 million active users, 87% of which earn less than $2 a day. Through a special Green Sim card, it provides 5 push voice messages per day concerning crop calendar activities, yield increase tips, entomology, weather information, market prices and agricultural news. This information is sourced from IFFCO, local universities and research institutions, AG Market and the Indian Meteorological Department. There is also an Agri Helpline where farmers can speak to a local call centre that is manned by graduates who have field experience (GSMA, 2011).

In a GSMA survey, 98.3% of users indicated that they believed that the information is accurate and 64% of message listeners stated that they have implemented or plan to implement the advice that they received. It is one of the only self-sustaining mAgri projects, with estimated profits of over $1.1million (Misra, 2014).

Actionable

Successful projects must ensure that the information that they provide is actionable. For information to be actionable it must be complete and yet broken down into practical steps. Ideally it would also be accompanied by complementary information and services which would support the farmer to make any changes that they wish to make.

Completeness

In the GSMA mKisan evaluation, incomplete information is given as one of the factors that is highlighted by farmers as inhibiting their behaviour change. If part of the information or advice is missing then this may mean that the new practice is not understood fully by the farmer and is either not implemented or is implemented partially. In the case of the latter, it may result in the full benefits of the new practice not being realised.

"*I can say that it worked 50 percent in controlling the retardation… I felt that the information was not complete. It mentioned the name of the spray, but it didn't mention how much (quantity) should be used on one acre of land."* (Ajay Vidisha, Madhya Pradesh, one of the farmers using mKisan).

Complementary information and services

There is a recognition in most of the projects reviewed that farmers need a selection of complementary services to ensure that they can act upon the information they receive. Some of these, to a certain extent, can be provided through mAgri services. Most mAgri services provide a "bundle" of information which adds value to the farmer and increases their

willingness to pay; thus improving the sustainability of the business model. The provision of financial services particularly increases revenue.

"*It's not just about localised, useful information but about supporting the farmer to then act upon the information. They are not going to make big decisions about changing crops without having safety nets, loans, insurance schemes etc that mitigate the risks of doing this. They would need daily support throughout the crop cycle etc. The information through the mobile phone is just part of this*" (KI 8).

The Agro-Fin Mobile project, which operates in Zimbabwe, Uganda and Indonesia, is primarily about providing financial services using mobiles. However, it takes a holistic perspective and also provides weather information, market prices, costs and availability of inputs (seed and fertiliser) and pest recommendations. This 'bundle' of information is timed around the crop cycle (see Figure 2).

Figure 2 Agri-Fin Mobiles Services developed around the Crop Production Cycle

Taken from Mercy Corps, 2015.

Most case studies recognise the importance of farmers having a single platform to access a wealth of information on different topics. This is one of the main advantages of the mAgri services over and above other providers of information, for example, agri-businesses or extension services. However, though the complementary suite of information may be helpful to the farmer and may support the sustainability of the project, it may also reflect the fact that the quality of each strand of information is not good enough to maintain a credible service on its own (KI 4).

Adoption and Use

Voice rather than SMS?

Despite the popularity of SMS, some of the case studies have identified problems using SMS as a delivery method and some of the most successful projects use voice methods. The GSMA evaluation (Pschenichnaya & Palmer, n.d.) of the Tigo project in Tanzania identified that the use of SMS excludes illiterate farmers and, in particular, women who are less likely to be literate. The messages are sometimes too short to allow adequate comprehension of more complicated information. The Farmerline project moved from SMS to native voice and interactive voice response (IVR) on the basis that it was necessary for sustainability and profitability. Figure 2 compares the different delivery methods.

Figure 2 A Comparison of Advantages and Disadvantages of Different Delivery Methods across different delivery technologies.

Delivery technology	Advantages	Disadvantages
Voice	■ Works on all phones ■ Has the potential to reach more people ■ Automated voice systems (IVR) have the potential to generate sustainable margins at scale ■ Richer content ■ Higher quality of service	■ High upfront set-up costs ■ IVR systems are difficult to install and configure ■ Need significant infrastructure support to deal with all incoming calls ■ Customers cannot save content (e.g. messages from an IVR system) on the phone for future reference
Text-based	■ Works on all phones ■ Low set-up costs ■ Low technical set-up ■ Can be stored for later viewing or shared/ forwarded. Customers can refer back to the SMS	■ Limitations due to illiteracy (both language and technical) ■ Some mobile phones do not support local languages ■ Costs escalate in-line with scale
Mobile data	■ Richer user experience (functionality and content) ■ Fewer limitations of content (as number of words, broader access to content) ■ Helps overcome illiteracy by having images	■ Limitations due to technology literacy ■ Less ability to understand user behaviour when communications run over the internet ■ Device requirement and cost implication

Mobile for Development Intelligence, n.d.

Voice services include native voice, IVR and outbound voice messaging (OBD). Text based messaging can be divided into SMS, USSD and Text-to-Speech. Mobile data refers to browsed services (web and WAP) and Apps.

Potential of Mobile Data

With the recent decrease in the costs of feature-phones and smartphones and the subsequent increase in their prevalence in the developing world, some mAgri projects have started to develop mobile and web Apps to be used by farmers or intermediaries (Batchelor et al, 2014). A mobile App has the advantage of providing visual information or even video clips which can be advantageous when the messages to be conveyed are complex and the target audience is illiterate.

In Uganda, the Grameen Foundation uses smartphones that are preloaded with Apps to provide information to its Community Knowledge Workers who can share this information with local farmers. FARM-Africa is piloting a project in Tanzania which is using tablets, coupled with a learning application called Elimsis, (http://elimsis.org/) to provide farmers with training on sesame production. In India, Reuters Market Light started its MyRML application for android smartphones and feature phones in 2014. ICRISAT, at the end of 2014, launched its Green Phablet project where it hopes to provide weather, agricultural and market price information through an application on the Phablets that will be given to infomediaries.

Video

Video has been highlighted by several key informants as a powerful medium for the dissemination of extension information to smallholder farmers (KI 5, 7, 10). The work of Digital Green uses participatory video to provide information to farmers and initial results in India suggest that it can produce a seven fold increase in adoption of certain agricultural practices over traditional Training and Visit-based extension approaches (Gandhi et al, 2009). Participatory video has some unique features which contribute to its success. It satisfies farmers' requests to be able to physically verify that the new technique works, by seeing it demonstrated on the video. It also allows farmers to relate to the farmers in the video who are undertaking the new practice, thus increasing uptake. In the preliminary review of Digital Green the authors' state:

"In a text book example of Roger's theory of diffusion, farmers appeared most swayed by videos of other farmers in the same socio-economic strata as themselves" (Gandhi et al, 2009)

Digital Green has recently started working with partners in Africa (see Box 3 below). The Green Phablet project is planning to use its mobile application to show participatory videos and the use of videos on mobile application will no doubt be replicated in other projects.

Box 3: Digital Green in Africa

Digital Green is an iNGO that partners with local public, private and civil society organisations to share knowledge on improved agricultural practices, livelihoods, health and nutrition using participatory video. They work with local communities to produce localized participatory videos that are disseminated to groups with human mediation. To date they have supported the production of 2,800 videos in over 20 languages which have reached over 330,000 farmers.

They initially started in India but have now established partnerships in Ethiopia, Ghana, Mozambique and Tanzania. In Ethiopia, they have several partnerships. One of them is with AGRA which aims to work with extension workers to amplify the effectiveness of AGRA's soil health programme. Digital Green trained Ministry of Agriculture Development Agents (DAs) on video production and group facilitation. The DAs then worked with local farmers to produce videos on integrated soil fertility management. These videos will be disseminated by the DAs in 5 kebeles in each district (Digital Green, n.d.).

The consideration of the appropriateness of the delivery method is a key factor of success. It must be appropriate to the device being used, the information being delivered and the social, economic and cultural context of the farmers who will participate. This is highlighted in the scoping study of the FARM-Africa pilot:
'*The ability to make extensive use of video and audio files is particularly suited to cultures with an oral tradition of learning and sharing of information, and for targeting users with low levels of literacy, which is a pervasive problem in rural communities in Sub-Saharan Africa"* (Allan et al, 2014).

Interestingly, this study found that the ability of farmers to access information at a time of convenience to the farmers was of great benefit to them. This flexibility was particularly beneficial to women farmers who could access training information without having to get their husband's permission to attend a training course and could fit the learning sessions around household chores.

Interactivity

The ability of farmers to interact with the information presented appears to increase the likelihood of successful learning. Many of the case studies, for example, mKisan and Esoko, started off simply providing "push" services but, based on feedback from farmers, have moved to provide "pull" and interactive services. These pull services may just be selections about the choice of information that farmers can access or it may be the provision of call centres. The call centres not only provide tailored, interactive solutions but they offer the potential to provide timely responses and can be used by illiterate farmers. They also provide a mechanism to receive feedback on the service, identify poor or unclear information and receive suggestions for additional areas of content (KI14).

Use of Intermediaries

The use of "infomediaries", who reside within the local communities, and who can access information on behalf of farmers and share it and discuss it with them, appears to be an important element for success. In some of the case studies these intermediaries are local extension workers, in other cases they are lead farmers, community knowledge workers, trusted agri-businesses, MNO sales agents or other paid intermediaries. The importance of information being delivered through face to face contact with someone whom the farmer knows and trusts and who can contextualise the information and discuss risks cannot be underestimated, particularly in some cultures.

Two-way flow of information

Mobile phones provide the opportunity to obtain information from farmers. This can be directly through phone calls to helplines or through surveys undertaken by SMS or IVR or through information gathered by intermediaries. This has many advantages. It provides feedback to the service providers as to the information requirements of the farmers and the quality of the service. This can help better tailor information to farmers in the future. It can also provide socio-economic and geographic data on the farmer and their surroundings that can be used by businesses, NGOs or research institutions to improve their understanding of rural markets, livelihoods, and ecologies (see Box 4 for more information about the Grameen Foundation's work in Uganda). Finally, this information has a value and can generate revenue for the service when it is sold on to third parties. Most of the case studies incorporate two-way information flows.

Box 4: Community Knowledge Workers in Uganda

The Grameen Foundation launched its Community Knowledge Worker (CKW) initiative in Uganda in 2009 to help smallholder farmers get accurate and timely weather, crops, livestock and market information using mobile phones. The Community Knowledge Workers, who act as local advisors, are respected members of the community that are chosen by their peers. They are given a Java enabled feature phone or Android smartphone that contains a suite of applications to provide farmers in their locality with on-demand information.

Their role is also to collect information from the community, using a survey application so that, for example, information about traditional farming methods can be obtained or experts can identify disease or pest outbreaks. Local farmers provide information for free in exchange for the free information given to them. There is a Community Level Crop Disease Surveillance (CLCDS) application which uses mobile phone and GIS technology to enable scientists to identify, map and control diseases and which can also act as a diagnostic tool to identify disease and make recommendations for treatment (Brugger, 2011). More recently, Grameen, in partnership with AGRA and CABI, is developing a fertilizer optimization tool as a mobile application that can provide practical decision support to farmers on how much fertilizer to use to maximize profit in their specific circumstances (OFRA, 2013).

An IFPRI/Grameen study in 2012 in the Mount Elgon area in Uganda found that as a result of the introduction of the CKWs, 30% more farmers reported having access to extension services. There was also evidence of a change in crop portfolios and an increase in the uptake of good agricultural practices such as crop spacing and the use of manure (Van Campenhout, 2012).

Complementary communications approaches

There is recognition by several key informants that using a range of complementary communications approaches is crucial if farmers are to change behaviour. As one of the key informants stated:

"*One of the main problems is that communicating through a single channel doesn't work for communicating complex information. You need to use different channels and approaches (e.g. using radio, TV, farmer-to-farmer, women's groups, physical spaces to interact) to be able to convince people to change behavior. Companies just pushing IVRs and SMSs have found that this isn't enough.* (KI 4) "

As another KI suggested, radio campaigns can be employed to start building awareness and sensitising farmers to issues; videos can then be used to demonstrate good practice and increase people's interest and finally IVR can be sent out to reinforce the practice and provide timely advice (KI 10). Although this opinion was echoed by other key informants and by some of the evaluations of the case studies, there was also acknowledgement that there has to be consistent messaging across different approaches (KI 4, 7). Without consistency of message, the danger is that the farmer will become confused and lose confidence in the services. Furthermore, the use of complementary approaches is problematic in terms of creating sustainable business models that depend upon ownership and exclusivity of information.

Box 5: Beep4Weather

The Farm Radio International initiative, Beep4Weather combines local radio and mobile phones to provide farmers in the Manyara, Kilimanjaro and Arusha districts of Tanzania with agronomy advice based around the weather forecast. The local weather forecast is broadcast on local radio using data from the Tanzanian Meteorological Department and Toto Agriculture. Farmers can then use their mobile phones to "beep"* into the radio station to receive a free voice message recorded by a local extension worker with weather-related agronomy advice and tips. For example, following the weather forecast, an extension worker may give the following advice:

"For areas that have had enough rain that the soil is now wet…. If you planted Irish potatoes that are now ready… they should be harvested now before they get rotten from the wet soil' (Taken from a Beep4Weather message).

(Farm Radio International, 2014)

*** A "beep" is when you call a number and then hang up, expecting someone to call you back or leave a message.**

Outreach strategies

A number of KIs felt that smallholder farmers in rural Africa and India are conservative by nature and therefore mAgri services need to persuade and incentivise farmers to participate and to adopt new practices (KI 5, 6, 7). The use of games and quizzes were suggested as ways of attracting farmers, of testing knowledge transfer and providing incentives to change activities. For example, IKSL use quizzes to keep farmers interested in the service, to get

them to self-test their knowledge and to provide them with 'sweeteners' on particular seeds and fertilisers that they want farmers to adopt (e.g. price reductions if they answer questions correctly).

Business Models

There are very few mAgri projects that demonstrate sustainable financial models. Indeed, it appears that the IKSL project is one of the only case studies that is self-sustainable. It has over 3 million subscribers which helps to generate enough revenue for the project to make a profit. Whilst many of the projects and case studies are still in their pilot phases, there are some factors that may hinder them from becoming sustainable:

- the significant startup costs that are incurred when local content is not available;
- the technological difficulties and high cost of communications in certain countries;
- the poverty levels of the farmers in certain countries which reduce their willingness and ability to pay;
- the focus of MNOs on using the mAgri services as part of their acquisition strategies to increase rural market share, strengthen their brand and reduce churn[12];
- the inability to effectively market and raise awareness of these services to rural customers.

As pointed out by one of several key informants (KI 4), weather is a service that is usually provided free of charge over the radio and TV; farmers will therefore not be prepared to pay for the information unless it is significantly more tailored to their needs. Consequently, it is likely that the provision of this information must be subsidised by other information within the bundle.
Despite all these constraints, there are some lessons learned about best practice that can be identified from the case studies and key informant interviews.

Plan for Sustainability and Scale Up

Some key informants have commented on the failure of mAgri services to develop a sustainable business model from the outset and to understand how they will realistically scale up the service (KI 1, 4, 8, 14). However, in some regions and countries, it may not be possible to achieve large numbers of subscribers because of the smaller number of farmers within a climatic region or the dominance of a particular MNO whose market share is very large (KI 5). As shown in the case studies, there is also a tension between providing and maintaining good quality, tailored information and services across a wide variety of subjects and achieving scale up and sustainability. As you scale up and try to automate the provision of information, for example, you may lose the granularity that is required. Furthermore, the cost and difficulty of providing quality information through local intermediaries increases as the number of locations increases, and economies of scale are more difficult to achieve (KI 5, 8). Some of the key informants have suggested that focusing on a particular target audience (for example, coffee farmers) and just providing coffee crop information may be more effective (KI 5, 14).

[12] Churn refers to the rate at which subscribers discontinue their subscription to a service

Hide Costs through Bundled Services

Although it appears that there is a willingness to pay for good quality information, the cost of mAgri services is still an issue for poor farmers. There are examples where the bundling of profitable financial and insurance services with other less profitable services such as crop advice and weather forecasts can help to subsidise the overall provision of this information. The ACRE[13] project, formerly known as Kilimo Salama, has an interesting business model which could be relevant for the provision of weather and climate information. It provides micro-insurance to smallholder farmers in Kenya, Rwanda and Tanzania by charging them an additional fee on top of the cost of their agricultural inputs. In addition to their insurance cover they also receive tailored extension messages using local weather information from nearby automated weather stations (see Box 6).

Box 6: Kilimo Salama (now ACRE)

This initiative offers farmers the possibility to insure the costs of their inputs (e.g. seeds, fertilizer, chemicals) against extreme drought or excess rain. When they purchase their inputs from a local agro-dealer, they can pay an additional fee to insure these inputs. This fee is often a 5% or 10% mark-up on the normal price of the inputs which is sometimes split with the input company (who benefits from reducing the risk exposure of their repeat customers). Using Quick Response (QR) codes on the inputs and the farmers' mobile phone number, the agro-dealer sends off the information about the insurance to the insurance company. If there is a period of excess drought or rain, the farmer will receive an automatic payout of the cost of the input through the mPESA system onto their mobile phones.

It is an index based insurance product whereby payouts are determined by comparing historical rainfall patterns to actual rainfall. For example, if the actual rainfall is more than 10% above or below the historical pattern, then the insurance may be triggered. The index is based on location-specific crop models, adapted to local climatic circumstances. The premium is calculated based on frequency of the risk covered.

The costs are kept to a minimum because there is no need to process claims or verify the farmers' crop damage and the brokerage costs are low because of the use of mobile technology to register the insurance and make the payment.

The actual rainfall is provided by automated ground weather stations. The farmer has the additional benefit of receiving up to date climate and weather-related agronomy information.

(IFC n.d. Syngenta Foundation.n.d.)

Demonstrate Cost-Effectiveness and Impact to Encourage other Organisations to Pay for the Service

The Digital Green case study is an example of how governments or NGOs may be willing to pay for services to increase the effectiveness of their agricultural extension work. Alternatively, Esoko charges farmers on a tiered subscription basis for its services but also franchises out its technology platforms which allow the public and private sector to target farmers and gather information from them as part of its business model. Other organisations

[13] The Agriculture and Climate Risk Enterprise (ACRE) company has recently taken over the some of the work of the Syngenta Foundation in East Africa

within the value chain may also be willing to take on large subscriptions for their members or their producers (KI14).

Partnerships

One of the main factors of success which was highlighted through the analysis of the case studies and the key informant interviews is the importance of developing good partnerships with project stakeholders, technology service providers, content providers, trusted organisations on the ground, as well as national and local government bodies. Some of these partnerships are discussed below.

Building partnerships with trusted organisations on the ground increases credibility amongst farmers and can help with developing the service and marketing it. A good example of this is IKSL which partners with IFFCO, a large fertiliser co-operative with 60 million members. IFFCO is a highly regarded organisation and uses its premises and brand to market IKSL. Another option is to use local co-operatives or buyers networks as the primary customer who can then disseminate information (KI 8).

Several of the key informants have emphasised the importance of engaging positively with governments at national, district and local level at the beginning of the project both in terms of the provision of meteorological or extension services. (KI 4, 7) If their support is elicited early on in the process this will prevent them from undermining the project politically and practically. It will also ensure that the same messages are sent out from different sources and they may even be willing to subsidise some of the project's service. The IKSL, Digital Green and Farmerline case studies have all highlighted the importance of early engagement with these institutions.

Summary

There are many factors that influence success that have been revealed in the review of the case studies and the key informant interviews. Ascertaining a deep, holistic understanding of the information needs of different farmers (e.g. women, poorer farmers) within their specific technological and socio-economic circumstances is an important starting point for designing successful mAgri products. The content must be salient, timely, credible, contextualised and actionable if it is to be used effectively by a smallholder farmer. Finding inexpensive solutions to providing quality, local information is crucial.

Voice appears to be a better delivery method than SMS and, with the increasing prevalence of feature and smart phones, visual applications and video offer significant advantages over voice and SMS for the transmission of more complex information. The potential of social networking to foster knowledge exchange is significant although but little work has been conducted on this to date. Of particular note are projects that offer integrated bundles of information that include financial and insurance services and are focused around the crop calendar. Communication approaches that are interactive, two-way and are delivered through local intermediaries who are known and trusted by the farmers and are combined with complementary communications approaches may offer the best chance of uptake of new practices.

The above-mentioned factors of success all reflect well established principles of good communication for innovation (Leeuwis, 2004). The lesson learned is to ensure that these

principles are not dismissed in the excitement to use the latest technology to provide solutions to information gaps.

There are few successful business models that can be replicated although it appears that those mAgri projects that plan ahead for scale up and sustainability are more likely to succeed. Furthermore, using innovative ways to reduce the farmers' cost burden by generating income from the private or public sector, for part of the service provided, works well. As is often the case with development projects, these case studies have confirmed the importance of developing strong partnerships with existing organisations (government bodies and institutions, value chain businesses etc…) in the early development of the project / initiative.

From the analysis, it is evident that weather and climate-related services are not meeting the principles of the key requirements for success. There are significant opportunities for improvement in this regard and these will be explored further in the discussion section.

Constraints

This section will consider the constraints which prevent mAgri services from being used effectively by farmers and which hinder the development of these services, based on the case studies and key informant interviews. It will not look at the wider constraints preventing access to mobile phones that have been documented extensively in other literature (GSMA et al, 2010). It will also not repeat constraints that have already been touched upon in the key factors influencing success section.

Infrastructure

Poor connectivity and the instability of mobile phone networks was stated in several case studies as a major constraint as it prevents farmers from using the service and often puts them off trying again, particularly in rural areas (e.g. case studies: Orange Senekela, AgriFin Mobile). Electricity was also identified as a problem as farmers found it difficult to recharge their mobile phones (e.g. AgriFin Mobile). In Uganda, the Grameen Foundation supplies a solar charger to its CKWs that they can use, not only to charge their own smartphones, but also to supply other community members with power for a small charge.

Human Capabilities

There is evidence that illiteracy and poor education reduce farmers' ability to use these information services effectively. In the Orange Senekela service in Mali, repeat users were more likely to have had formal education. This is strongly linked to technological illiteracy as it has been found that even with numerical and voice systems, a large proportion of users are unable to follow the instructions and register for the service in the first place. In the mKisan case study, 25% of the trial users stated that they would not access the service again because they could not understand how to work the IVR system (GSMA, 2014a).

There are also constraints around the capabilities of service designers and providers within particular countries who may not be able to adequately support these services. Often the services are designed, managed and supported outside the host country which can bring its own problems in terms of lack of understanding of technological or educational constraints (KI14).

Costs

The cost of the service is a major constraint for farmers. There are many examples where farmers do not have enough credit to receive all the information they need. GSMA's research across its mFarmer projects has found that the farmers who are using the service are less likely to be below the poverty line than those that do not. For example, only 4.6% of Airtel Kilimo users were below the poverty line compared to the national average of 42-49% (GSMA, 2014b). As a result of cost constraints, 'freemium'[14] models have been adopted by some information providers. For example, the CKW model does not charge its villagers for use of the service.

Some key informants strongly criticised mAgri projects that do not charge farmers for the service. They claim that this distorts the market and crowds out the private sector, making financial sustainability for other information services (that are not funded from external donors) very difficult.

Databases to Provide Content

As already discussed, there is a clear tension between the provision of locally specific, tailored, information and achieving economies of scale by reaching out to a large number of farmers. There are very few content providers at a local level and the cost of creating this type of information is high. In response to these challenges, databases of agricultural content (and sometimes weather and climate information) are being developed. Toto Agriculture and Direct2Farm are two examples.

There are many issues arising from the development of these repositories of local content. One of the key questions is whether databases of content should be proprietary or open source. On the one hand, there is the argument that the content has been expensive to develop, that it belongs to the service provider who has paid for it and that unless it is kept exclusive, it will be difficult to develop a business model around it (KI 9). On the other hand, open source databases will allow information to spread as far and wide as possible and may prevent the information being subject to commercial or political interference (KI 4). There is recognition of the danger that these services could be hijacked for marketing particular products and that farmers may not be able to distinguish between expert advice and advertising (KI11).

It is worth noting the approach of a new project called mNutrition which will support the use of mobile phone based technologies to increase the access of rural communities to nutrition and agriculture related information (KI 4, 5). For this project, an underlying content database will be created that can be accessed by any service provider; the role of the service provider will be to reformat the information and deliver it through appropriate technology.

There are other concerns about how these databases can combine top down, 'expert' knowledge with bottom up, local knowledge (KI 2). There is no evidence to suggest that this is happening effectively at the moment even though information is being gathered from local farmers through projects such as the CKW project in Uganda.

[14] a business model whereby basic services are provided free of charge while more advanced features must be paid for.

Two- way information flows

The benefits of having a two- way flow of information have already been discussed. However, there are issues about the gathering of information that were raised in the case study examples and by key informants. It is unclear how farmers are incentivised to provide information and there is a risk that the information could be used for commercial or other reasons without the full consent of the farmers themselves, leaving them vulnerable to exploitation. Of course, many of the key players in the mAgri arena have strict codes of practice around data protection and privacy and some countries have developed regulations protecting farmers but this is still an area of concern for the future (KI 16).

Public private partnerships

The mAgri services often involve partnerships between a variety of different public and private sector organisations. It takes a long time to develop these relationships and some difficulties with these partnerships have been identified:

- Private sector organisations have different aims when compared to public sector organisations. The primary concern of MNOs is with longer term development of market share, brand development and a reduction of churn. Public sector organisations may have the overall objective of improved food security and poverty alleviation. These objectives are not incompatible but it can be difficult to reach a position where all partners can appreciate the value proposition that these mAgri services offer (KI 1, 4, 5). Developing a good relationship with MNOs and public sector organisations is key to long term success (KI14).
- Some case studies have encountered difficulties working with National Meteorological Agencies. It is stated that there is sometimes a reluctance to share data and to provide data in formats that may be useful to farmers (KI 8).

Different levels of control over content are imposed by national and local governments and by private sector organisations (KI 10). In India, for example, content development is often supported by district level extension services whereas in Ethiopia, high level national bodies tend to determine content provision. This can have implications for developing appropriate localised content. All partners need to be able to work within the particular circumstances that the project affords.

There are a wide range of constraints that limit the effectiveness of mAgri services. These will differ from country to country and from continent to continent and will depend upon the technological, socio-economic, political and policy landscape in which the initiative resides.

Discussion and conclusion

There are many common themes arising from both the literature review and the findings from the analysis of case studies and key informant interviews. This section discusses those themes, paying particular attention to areas that could be exploited for improving current and future projects that aim to provide weather and climate information to farmers using mobile phones.

Content/Services

Better understanding of Information Requirements

It appears that not enough care and attention is being paid to farmers' information requirements, not only in respect of weather and climate information, but in order to gain a holistic appreciation of what they really need. This may be more difficult than it sounds, as there is anecdotal evidence that farmers do not always have an awareness of certain types of information that could be made available. Nevertheless, this should be explored with farmers and services designed in partnership with them. A better understanding of how they would like the information presented, in what format and when would be invaluable. It may not yet be possible to supply the farmer with all the information that they require or it may not be appropriate that this information is provided through mobiles or tablets but this should be fully comprehended, nonetheless.

There are some mAgri projects that actively consider the heterogeneity of the rural populations that they are seeking to serve. However, in many cases, farmers are treated as a homogenous group when their information needs are considered. There are therefore opportunities for disaggregating the target audience by gender, age, educational attainment and socio-economic status to obtain a more nuanced understanding of their requirements. As technological improvements are made it may become easier to tailor information to different individual needs.

Content Provision

Although the need for quality, localised information has been established, it is not clear how this information can be developed, quality controlled, digitised, formatted and updated at a minimal cost. The creation of large databases of information that can be interrogated and

tailored by service providers or even the farmers themselves is currently being undertaken. This will potentially allow for content that can be shared across different applications and services and therefore transcend problems of ownership and create scalability. However, there are still issues of financing, exclusivity, control and monetisation that have yet to be resolved. Ideally, content would be developed in conjunction with experts and local farmers. Although information is starting to be collected from farmers it is unclear how this will be amalgamated effectively into these databases. There are also issues of privacy and protection from exploitation when these two-way flows of information occur.

Integration of information

There are benefits to providing farmers with different types of information as part of a "bundle" as it helps to make the information more complete and actionable and supports decision-making. However, it is not clear to what extent these different strands of information should be linked or integrated and when it may be more appropriate to provide simpler, stand alone, high quality information rather than attempt to provide comprehensive and integrated packages of information that are more complex and more expensive to produce.

Focus on Weather and Climate Information

There is evidence that weather information is prioritised by farmers when they are asked about their information needs. However, it is not clear exactly what weather and climate information farmers would like and in what format. With regards to the information farmers are given, it is not clear whether farmers understand it or find it useful and it appears that the weather information that farmers receive is neither local enough nor tailored to their specific topography. Though there are some exceptions, in most cases, farmers are provided with basic short-term weather forecasts. This study found no evidence that historical climate information is provided to farmers and there are very few examples of how weather and climate information is being linked into agricultural information; how it is being contextualised in any way or used for decision-making purposes. There are therefore significant areas for improvement in the provision of weather and climate information.

Technological advancements offer opportunities for providing more accurate localised weather and climate information. The TAHMO and Kilima Salama initiatives with the subsequent increase in on the ground weather stations that can provide real-time data may

help improve local weather forecasting. Mobile phones can allow for establishing precise location using triangulation although GIS initiatives could enable better linkages between weather information, topography and soil type and water management. Moreover, using mobile phones, farmers can provide feedback on weather and climate information which can better help establish localised weather patterns.

Adoption & Use

Appropriate delivery methods and complementary communication approaches

Not only is there a need to better understand the information requirements of farmers, there is also a need to link these requirements with appropriate delivery methods. In some cases, it appears that information is communicated using channels that are inappropriate for the type of information that is communicated. For example, whilst direct SMS communication may be an appropriate approach for communicating an early warning weather forecast, it is not an appropriate approach for communicating complex ideas around crop management that have longer-term productivity and risk management implications. It seems that in the enthusiasm for new technologies projects may be forgetting the principles of good communication and innovation design and there is an opportunity to revisit these principles and clarify the links between different types of information needs and communication strategies. As part of this, the benefits of using complementary or hybrid communications approaches (e.g. using radio, TV and mobile applications) should be appreciated. Comparisons of the effectiveness of different approaches would be beneficial in this regard.

Knowledge sharing and exchange

Following on from the section above, it is widely recognised that successful communication and innovation is based on a sharing of knowledge and that providing a "magic bullet" SMS service is unlikely to illicit behavioural change. There is therefore a substantial challenge in ascertaining how meaningful knowledge exchange can be effectively built into these projects using new technologies, particularly if these projects want to operate at scale.

Channelling information through pre-existing networks to help spread information and contextualise it in appropriate ways appears to be a step in the right direction. Projects that use intermediaries on the ground to enhance communication between experts and farmers appear to have been more successful in changing behaviour. Currently, extension workers, respected farmers, community leaders and co-operatives, are all being used in this

intermediary role. There are opportunities to further explore the role of these intermediaries, gaining a more in-depth understanding of their contribution within these mAgri projects and how this may change as more farmers gain access to the technology. There is maybe the possibility to broaden the scope of intermediaries to use, for example, agri-shops to act as hubs for exchanging information.

The increasing use of feature phones, smartphones and tablets by "infomediaries" or even farmers themselves offers possible opportunities to use the internet and social media to share and exchange information. There are many new initiatives to reduce data transmission size and cost. In India, there have been experiments by Microsoft that have shown successful spread of agricultural messages through social media when intermediaries are given feature phones and internet access (KV 10). Harnessing these social networks to facilitate information exchange between experts and farmers and between farmers themselves either directly or through intermediaries would be a step in the right direction towards knowledge exchange.

Visual Applications

The introduction of feature phones and smart phones allows visual information to be shown. This would be particularly good for showing weather and climate-related maps, graphs and charts. If these applications could be interactive, they could provide very powerful tools for extension workers and farmers to explore climate data and decision-making.

The benefits of video have already been discussed in the Findings section. However, with the increase in feature and smart phones, further possibilities for its use at a greater scale in Africa are opening up. It is not simply that videos can be communicated easily using these new phones, farmers are able to produce videos themselves using the phone's camera; a potentially significant opportunity for increased farmer-to-farmer knowledge sharing.

Business Models

It is not yet evident how to create financially sustainable businesses around the provision of information through mobile technologies. There are challenges in scaling up these projects as a result of the constraints that they face. Even at reasonable scale, revenue from farmers is often not sufficient to support these services. However, there are other ways to supplement revenue from business to business revenue sources. Subsidising agricultural information provision with bundled services that contain financial or insurance components looks

promising. Furthermore, being able to demonstrate the value of these services may draw in actors from the government sector or even private sector that may be prepared to make a contribution towards them. It is evident that projects need to plan ahead for scale up and sustainability before the pilot stage of the project begins so that precious resources are directed into appropriate design and service features.

Areas for Further Research

Evidence of Behaviour Change and Impact

There are significant opportunities to undertake research into whether and how these mAgri projects are changing behaviours and how this may be impacting on farmers' lives. Most of the grey literature evaluates these projects from the perspective of adoption of the service by farmers and their satisfaction with it. There have been only a handful of studies to date that have undertaken formal research in this area and these studies have tended to focus on the provision of market-related information (e.g. Fafchamps and Minten, 2011) and to measure impact using economic metrics around price and productivity (e.g. Subervie, 2011). Minimal attention has been paid to the impact of the provision of other information, such as weather and crop advice.

Wider Impact

It appears that no research has been undertaken on the wider impacts of these services from a poverty, livelihoods or gender perspective. For example, there is an assumption that greater information will lead to a reduction in poverty but this has not yet been evidenced as part of a theory of change. Furthermore, questions remain as to what impacts these mAgri services having on the existing agricultural extension services or on the private sector? Are these services beneficial or harmful to them and what are the longer term implications?

Inequalities

Little is known regarding how these services are affecting different types of farmer and whether these services are reinforcing existing inequalities. There is interesting evidence to suggest that women and wealthier farmers may benefit more from these services if they gain access to them. This warrants further investigation in more detail. It is also not understood how those members of the community who do not have access to the service are being affected and to what extent there may be positive spill overs.

Conclusion

Within the confines of this study, there appears to be clear demand for climate and weather information by smallholders through use of mobiles that is not currently being met. Some of the provision to date has been of questionable value to farmers and relatively little attention has been paid in design to the use of the information by farmers (their needs are often assumed) and there have been few evaluations / studies of initiatives providing this information.

Key factors influencing success identified in this study include ensuring context, location and timing specific content provision to increase the relevance of information to users; the use of 'bundles' of information so that farmers are able to access integrated 'packages' of information; the benefits of interactive, two-way and complementary communications approaches; and the role that intermediaries can play in delivering content 'on-the-ground'. Key challenges included infrastructure (e.g. rural electrification, mobile phone network); levels of technological literacy; creating a financially sustainable business model; and the differing, and sometimes contrasting, aims of public and private organisations. Areas of considerable potential were identified including the use of visual applications and video, particularly participatory and / or locally produced video on mobile devices to enhance learning and advisory services for farmers; sharing information via mobile data connections to ensure locally relevant content is available to farmers in timely fashion; increased interaction with and feedback from farmers on content and service; and the increased use of social media which will enable farmers to build bigger networks and share ideas amongst their peers.

Appendix 1: The PICSA Approach

The Participatory Integrated Climate Services for Agriculture (PICSA) approach involves field staff (extension workers, NGO staff) working with existing networks of smallholder farmers in the lead up to and during the agricultural season(s). The approach enables farmers to make informed decisions based on accurate, location specific, climate and weather information; locally relevant crop, livestock and livelihood options; and with the use of participatory tools to aid planning and decision making. Where feasible this is supplemented with information and forecasts using radio and mobile phones.

The key components of PICSA include the following:

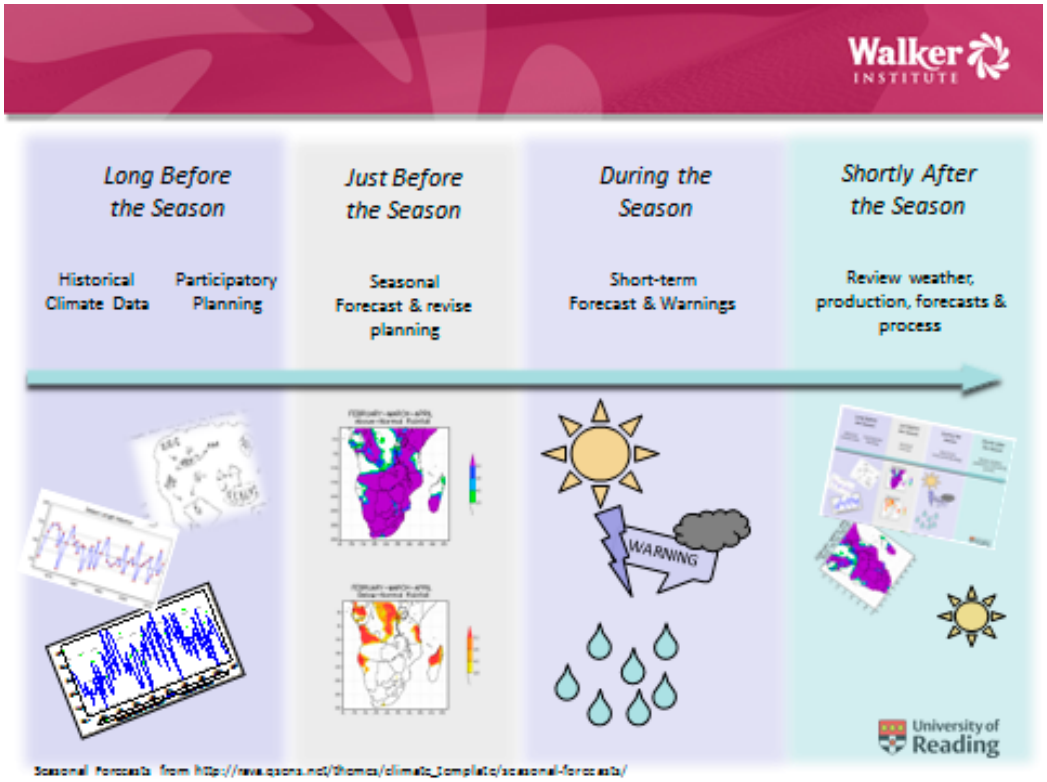
i. **The provision of information by field staff to farmers on climate and weather and exploration of:**
    - Historical climate information – how is local climate changing and how can farmers respond?
    - How can we use historical rainfall and other data to identify what crop, livestock and livelihood practices are best suited to local conditions?
    - How can we use the new, improved, downscaled seasonal forecast to plan?
    - How to integrate the use of SMS short term forecasts to inform farmers?

ii. **The consideration by farmers, supported by field staff, of crop, livelihood and livestock options and their risks**
    - Which crops / crop varieties are suitable for the local area and for different types of season (e.g. good, medium and poor seasons)?
    - What detailed management practices are most suitable for different seasons and conditions (e.g. planting dates, fertiliser input levels)?
    - What livestock and livelihood options facilitate improved coping and adaptation for households and communities?

iii. **A set of participatory tools to enable farmers to use this information in their planning and decision making**
    - How to use a set of participatory tools to help individual farmers identify which crop, livelihood and livestock options suit their individual circumstances – identifying 'options by context'.

For further information on PICSA see https://ccafs.cgiar.org/blog/new-manual-helps-expand-reach-climate-services-together-farmers#.VlaXqHbhDIU

The following diagram outlines the timing of field staff working with farmers through a season:



PICSA has been trialled in Zimbabwe in 2012/13 as well as in areas of Tanzania and Kenya in 2012/13, 2013/14 and 2014/15. The approach appears to have been successful with extension staff and farmers and it is currently being scaled out to reach thousands of farmers in the north of Ghana, Tanzania and Malawi (it will soon be scaled out in Lesotho also). The approach already uses mobile phones for communicating some information to farmers (short-term forecasts via SMS) and there is scope for increased use of mobile phones and/or tablets.

Appendix 2: Key Informant's Organisations

Organisation
Bill and Melinda Gates Foundation
USAID
Mercy Corp Agro-Fin Mobile
CABI
Oxfam GB
Microensure
GSMA
Sidai
Trans-African Hydrometereological Observatory (TAHMO)
Digital Green
Gamos Ltd
Biosciences for Farming in Africa (B4FA)
Fair Business Alliance
Farm Africa

Appendix 3: List of Case Studies

Country	Product Name	Sources of Information
Tanzania	Tigo Kilimo	GSMA 1b, 2012. Pshenichnaya,N. 2012. Pshenichnaya, N & Palmer,T.n.d. Key Informant Interviews
Uganda	CKW	CABI. 2014 Van Campenhout, 2012. Website: http://www.grameenfoundation.org/what-we-do/agriculture/community-knowledge-worker
Ghana	Esoko	Brugger, 2011 aWhere, 2014. Mobile for Development Intelligence, n.d. Subervie,J. 2011. Website: https://esoko.com
Ghana	Farmerline/TAHMO	Attah & Messina, 2014. Haggard, 2012. Kaisaris, 2014. Website: http://farmerline.org
Uganda, Zimbabwe, Indonesia	Agri-Fin Mobile	Mercy Corps,2013. Key Informant Interviews. Website: http://www.mercycorps.org/tags/agri-fin-mobile
Kenya	Airtel Kilimo	GSMA 1b. 2014. Key Informant Interviews
India	IKSL	USAID,2011. GSMA,n.d

		Key Informant Interviews Website: http://www.iksl.net
Mali	Senekela	GSMA 1c. 2014.
India	mKisan	Banerjee et al, 2014. GSMA 1a. 2014. ILRI.2012.
Tanzania	Beep4Weather	Farm Radio International, 2014.
Kenya, Tanzania	Kilimo Salama (now Acre)	USAID, 2012. Syngenta Foundation, n.d. IFC,n.d. Qiang et al, 2011. Website: https://kilimosalama.wordpress.com
India	Green Phablet	The Hindu Times, 2014.
India	Reuters Market Light (RML)	Donovan, 2011 Brugger, 2012. Fafchamps & Minten, 2011. World Bank, 2012. Parker et al, n.d. Reuters Market Light website: http://www.reutersmarketlight.com
Ethiopia, India	Digital Green	Gandhi et al, 2009. Digital Green.n.d Key Informant Interviews. Digital Green website: www.**digitalgreen**.org/
Tanzania	Sesame Marketing Project	Allan et al, 2014.

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