1 Mobile Phone Applications for Weather and Climate Information for Smallholder Farmer Decision Making

Amanda Caine,[1] Chris Clarke,[2] Graham Clarkson[1] and Peter Dorward[1]*

[1]School of Agriculture, Policy and Development, University of Reading, UK;
[2]Statistics for Sustainable Development, Reading, UK

1.1 Introduction

Smallholder farmers are particularly vulnerable to climate variability and change. Providing smallholder farmers with climate information can enable them to make better farming decisions which can in turn lead to increased food security. The Participatory Integrated Climate Services for Agriculture (PICSA) approach (Dorwood *et al.*, 2015) seeks to support decision-making and build resilience amongst smallholder farmers in Africa by providing climate information and decision-making tools. Whilst it has been successful to date and reached tens of thousands of farmers, greater use of mobile phones and apps to support PICSA may have the potential to enhance certain aspects. Mobile phones are being used increasingly to provide smallholder farmers with agricultural information and advisory services, with a wide variety of mAgri initiatives being established in the developing world over the last few years. These initiatives offer the potential of providing agriculture-related information and services to a large number of smallholder farmers at a relatively low cost. This chapter considers how mobile phone applications may be used to provide weather and climate information to smallholder farmers. In particular, it discusses the development and testing of two proof-of-concept mobile phone applications that use elements of the PICSA approach to provide climate information and decision-making tools. The chapter starts with a brief explanation of the PICSA approach before summarising the findings of a review that was undertaken to highlight the lessons learned from existing mAgri initiatives and inform the development of the mobile applications. The two mobile applications, which focus on historical climate information and participatory budgeting, are then described and the initial observations and findings from a proof-of-concept project in Northern Ghana are examined and discussed. Future developments of the two mobile applications are considered and further research questions posited.

1.2 Participatory Integrated Climate Services for Agriculture (PICSA)

PICSA is an approach that seeks to build resilience at the farm level by supporting

* Corresponding author e-mail: p.t.dorward@reading.ac.uk

decision-making through the integration of information on location-specific climate, crops, livestock and livelihoods (Dorward *et al.*, 2015). It emphasizes practical, hands-on methods that can easily be used and understood by farmers. The approach involves agricultural extension staff or community volunteers working with established groups of farmers ahead of the agricultural season to jointly analyse historical climate information and use participatory tools to develop and choose crop, livestock and livelihood options best suited to individual farmers' circumstances and the local climate. Closer to, and within the season, farmers may make adjustments to these plans with the aid of forecasts. Currently relatively little use is made of mobile phones in PICSA.

1.2.1 History of PICSA

Work on developing the PICSA approach started in 2011 at a small scale in Zimbabwe, and further research and development through work in Kenya and Tanzania brought it to a stage that, in 2015, it was scaled out to more than 10,000 farmers across three countries in sub-Saharan Africa (Ghana, Malawi and Tanzania). Building on this, work has continued and at the time of writing PICSA training has been carried out on a pilot basis in Colombia, Senegal, Burkina Faso and Mali, and in Rwanda the approach will reach all 30 districts by the end of 2018.

Good partnerships already exist with NGOs including Oxfam, ADRA and CARE as well as with the required government services. The team are regularly asked to support work in new locations, and requests have recently been made for PICSA to be implemented in Lesotho, Zambia, Niger and other countries including in the Caribbean, Latin America and Asia. Ahead of operating in new countries, groundwork is necessary on meteorological data, identifying agricultural options and training staff. The team are continually improving the approach and this includes learning from feedback and innovation, improving components such as analysis of crop probabilities, working on how to make better use of mobile phones, incorporation of satellite data to provide historical climate information where rain gauge records are unavailable, and developing additional training materials such as videos.

1.2.2 An explanation of the approach

Starting with the farmer at the centre, PICSA has three key components that are developed to encourage an integrated approach to extension. The three components are: climate information; crop, livestock and livelihood options; and participatory decision-making tools.

Climate information

This is made up of locally specific historical climate information and locally specific forecasts on both seasonal and short-term timescales. This involves considerable work and capacity development with national meteorological services. The climate and weather information is then 'packaged' and communicated using simple graphs that are useful and useable for extension staff, community volunteers and farmers. Farmers are able to use this information to examine and explore whether and how their climate is changing and, importantly, the variability in the weather conditions they experience, as well as to obtain better understanding of how different forecasts can be interpreted and may help in decision making.

Options

This component involves several steps. Preparation in advance of training of extension staff or volunteers who will work with farmers can help to identify potential options that may be available in specific locations and that help to address climate challenges. In the process of training trainers the extension workers or community volunteers are challenged to consider the different options that may be suitable for farmers in their location. Options may include new enterprizes and changes to management of existing ones (e.g., new crops, new livestock or other livelihood activities such as starting a new business, and changes to management practices through different crop varieties, planting dates, soil and water management practices, and use of veterinary care). During the roll out, farmers in groups are facilitated by extension staff to discuss and explore their options in a structured exercise.

Participatory decision-making tools

PICSA involves a set of participatory tools to enable farmers to analyse and use the locally specific climate information and then consider their options in the context of their local climate. After considering the information and options, farmers are able to use tools like participatory budgets to plan and make decisions about their farming and livelihoods for the coming and future seasons.

1.2.3 Key principles of PICSA

The key principles behind the PICSA approach are that the '*farmer is the decision maker*' and to provide '*options by context*'. As stated above, the PICSA approach keeps the farmer at the centre. This includes putting emphasis on farmers making their own decisions and contrasts with some extension approaches that often place more emphasis on providing 'advisories' or telling farmers what to do. PICSA looks to provide evidence for decision making and a set of tools that can help farmers to interpret this and then to make their own plans and decisions.

'Options by context' is the understanding that all farmers are individuals and have different 'contexts': different educations, access to resources, attitudes to risk and goals *inter alia*. Options that interest and/or will be of use to one farmer may be very different to another even if they are neighbours.

1.2.4 PICSA and mobile applications

PICSA has proven to be successful both at the pilot scale and is successfully going to large scale in several countries, as noted earlier. The participatory nature of interactions between facilitators and farmers is an important part of PICSA, and PICSA makes relatively little use of mobile phones and none of the mobile applications at present. There may be potential to make better use of, and to take advantage of, the increasing availability of low-cost smartphones and tablets in supporting PICSA implementation. These devices provide an opportunity to reach smallholder farmers on a large-scale with locally specific information and tools that are useful for their decision making. However, their ability to reach farmers on a large scale does not make mobile applications a panacea. As a first step in considering the potential for mobile applications to support delivery of PICSA, a review of a range of initiatives and projects that have been implemented using mobile applications for agricultural decision making was conducted.

1.3 Review of mAgri Initiatives

As explained above, the purpose of the review (Caine *et al.*, 2015) was to investigate the use of mobile applications to provide smallholder farmers with weather and climate information as well as any weather-related learning, advisory and extension services in respect of crop production. The review aimed to ascertain the types of weather-related information that were being provided to identify lessons to be learned from these initiatives and to consider their key factors for success. These lessons learned and factors for success would then be incorporated into a proof-of-concept project to develop mobile applications to provide farmers in the north of Ghana with weather- and climate-related information.

Although the initial intention was to look at the use of mobile applications within sub-Saharan Africa, the geographical scope of the review was broadened to include initiatives in India as a consequence of the greater penetration of mAgri initiatives and the increased body of research on these initiatives. The review also included the use of mobile applications on phones, tablets and phablets.

The review was based on the literature, 15 key informant interviews and a case study analysis of 15 initiatives that have used mobile applications with smallholder farmers. The key informants worked for a range of organizations that are involved in the mAgri sector in Africa and India, such as non-governmental organizations (NGOs), mobile network operators, multilateral agencies, industry associations and private companies and included USAID, CAB International, Oxfam GB, Bill & Melinda Gates

Foundation and Vodafone. It was not intended that the informants would be representative of the whole of the sector, but they were selected on the basis of their knowledge of certain aspects of it. The initiatives used for the case studies were selected because they displayed particularly interesting, unusual or successful features, had a focus on weather-related information or showcased a particular business model or partnership. The initiatives are shown in Table 1.1 below. The case study analysis was based on information found in grey literature and from discussions with key informants.

1.3.1 Establishing user needs

The literature review, key informant interviews and the case study analysis all highlighted the importance of ascertaining farmers' specific information requirements and understanding how information will be used by farmers within their local context whilst or before developing the application. This entails engaging with farmers and local communities to ensure that the content is relevant to them, relates to their own knowledge base and the information can be easily accessed, assimilated and applied by them. The content and the design of the mAgri products must therefore take full cognizance of the educational attainment, gender, age and the informational and technological skills of their target audience as well as the local circumstances in which they are being used (Masuki *et al.*, 2010; Kameswari *et al.*, 2011). All too often the focus is on what the technology can deliver and the 'perceived' needs of the farmers by outsiders, rather than developing an in-depth understanding (Hellström, 2010; Glendenning and Ficarelli, 2012). The review therefore reveals how, ideally, mAgri applications should be developed with farmer involvement. Indeed some of the more successful mAgri initiatives, for example, IKSL, have reaped the benefits from their human-centred design approach, with

Table 1.1. List of case studies.

mAgri Initiative	Country	Main information and services provided
Digital Green	Ethiopia, India	Rural livelihoods information
Esoko	Ghana	Market prices, weather forecasts, agricultural tips
Farmerline	Ghana	Weather forecasts, agricultural news, pest alerts, crop prices
Reuters Market Light	India	Extensive crop information, market prices, detailed weather information
IKSL	India	Crop information, horticulture, animal husbandry, news alerts, weather forecasts, entomology
Green Phablet	India	Weather information, forecasts, pest information, crop and agricultural input prices, expert talks, learning packages
MKisan	India	Crop information, market prices, animal health, weather forecasts
Kilimo Salama (now ACRE)	Kenya, Tanzania	Agronomy and agricultural meteorology, weather forecasts
Airtel Kilimo	Kenya	Weather forecasts, crop information, market information
Senekela	Mali	Agronomy, market information
Tigo Kilimo	Tanzania	Weather forecasts, agronomy tips, market price information
Beep4weather	Tanzania	Weather forecasts, agricultural meteorological information
Sesame Marketing Project	Tanzania	Information about sesame production and marketing
Community Knowledge Worker	Uganda	Weather information, market prices, crop and livestock management
Agri-Fin Mobile	Zimbabwe, Uganda	Crop information, weather information, financial services

increased and more sustained farmer engagement with their mAgri products and services over the long term.

1.3.2 Content

The provision of localized content that is accurate, credible and reliable is a significant challenge for mAgri initiatives. Some initiatives have been able to develop partnerships with local organizations who can produce such high-quality content whereas others, such as Esoko, have developed their own content. The provision of localized content and the maintenance of its quality control is expensive, and this partly explains the paucity of sustainable mAgri business models. The integration of different types of complementary information into 'bundles' is a way in which the service can become financially sustainable and can also make the information become more actionable by the farmer. In particular, it provides a way in which more profitable services, such as micro-insurance or financial services, can subsidize less profitable services, such as weather or crop information.

1.3.3 Timeliness and context

For the information to be relevant and actionable by farmers, it must also be timely. Some initiatives, for example Agri-Fin Mobile, Reuters Mobile Light and IKSL, coordinated the dissemination of information around the crop cycle, with different information being provided around the relevant timings for each crop. This worked well since farmers were more likely to engage in responsive action when the information about good farming practices was provided at the appropriate time. Contextualizing information was also a key factor for success. The key informant interviews identified how this could entail translating the information into the farmers' local language, breaking down information into comprehensible pieces based on farmers' current knowledge and/or using local intermediaries, such as extension staff, to assist with interpretation. These intermediaries, sometimes known as 'infomediaries', can access the information from the applications on behalf of farmers and/or share it and discuss it with them in a contextualized way. As shown in the Sesame Marketing Project, Community Knowledge Worker and ACRE initiatives, intermediaries can be local agricultural extension workers, lead farmers, or trusted agri-business owners, who, for example, also increase the credibility of the information provided.

1.3.4 Understanding constraints

The adaptation of delivery methods and communication approaches to cope with specific constraints was important. Many smallholder farmers have poor literacy and therefore interactive voice-based applications rather than SMS often worked better. The ability of farmers to interact with the applications and to tailor the information more towards their needs appeared to increase the likelihood of success, with the initial 'push' services in mKisan and Esoko, for example, giving way to more 'pull-' based applications. Complementary communication approaches linked to the applications, such as call centres and radio programmes, also appear to enhance success. Furthermore, the use of visual applications and video clips worked particularly well where the technology permitted. The following quote relates to one of the case studies which used tablets to convey information to sesame farmers in Tanzania.

> 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, p. 13)

1.3.5 Weather and climate information

In terms of weather- and climate-related information in particular, several lessons could be learned. The review established that weather-related information was prioritized by farmers when they were asked about their information requirements from their mobile phones (Mittal *et al.*, 2010, Palmer, 2014). In most cases only basic short-term weather forecasts were communicated and there were no initiatives in which historical climate data was provided. The accuracy of the information and its localization was a concern particularly as weather patterns can vary significantly across even small geographical areas due to specific topographical variations (Pshenichnaya, 2012, Palmer, 2014). Indeed, some initiatives attempted to develop their own local weather stations to help improve forecasting. Farmerline developed a consortium under the umbrella of the TAHMO initiative (Trans African Hydrometereological Observatory) to develop a dense network of small weather stations to help to provide accurate weather information to 10,000 cocoa farmers on their mobile phones through voice messaging (Kaisaris, 2014). There was little evidence of weather and climate information being integrated into other agricultural information or being contextualized in any way so that it can be useful for decision-making purposes. There are therefore opportunities to improve the provision of this type of information using mobile applications. Looking ahead, there are technological advancements, such as GPS and GIS, which offer the possibility of providing more accurate, localized weather and historical climate data to smallholder farmers and of combining it with other agricultural information such as soil type and water management.

Overall, the review confirmed the demand for weather and climate information through mobile applications by smallholder farmers. It also highlighted some of the key factors for the success of mAgri initiatives reviewed, and these lessons learned were then drawn upon for the development of the two mobile applications. One of the lessons learned was the importance of co-developing some elements of the applications to ensure that they were meeting the needs of farmers and that any technological or socio-economic constraints were being addressed. The significance of using accurate, localized information was also recognized. Furthermore, some of the more successful applications were designed to be visual and interactive wherever possible and to be delivered through intermediaries who could contextualize the information and therefore make it credible.

1.4 Development of the Mobile Applications

Using the lessons learned from the review wherever possible, two mobile applications (from now on referred to as apps) were developed to support different specific components of the PICSA approach. The two components were selected so that they might be sufficiently different, whilst also likely to lend themselves well to an app experience.

The first app developed (*see* Fig. 1.1) aims to present relevant climate information and provide a set of tools to support decision-making around the data. Within the app itself users can select data related to one of ten sites available for the northern region of Ghana, or automatically select their closest site using the device's GPS. There are then presented with four separate graphs available to view: seasonal rainfall totals, seasonal length totals, date of start of rains, and date of end of rains. The graphs can be interacted with by directly selecting points to view more information, or by inputting values into the line tool. The line tool is used to take an example of specific crop water requirements and automatically calculate how many years there have been totals both above and below this requirement. This information is then displayed as a line, as a probability (percentage) and as a '1 in x' visual block representation. Without the app, this probability is calculated by PICSA participants. The app is fully functional offline, with all data read from locally stored csv files and a map cached as a series of tile objects.

The second app (*see* Fig. 1.2) focuses on individual farmers and resource management. Within the app there are a series of time periods, activities, and associated budget considerations from which the farmer builds a picture of their seasonal budget. Farmers are guided to think about their net inputs, family labour hours, net outputs and produce consumed, which are then in turn quantified in terms of monetary value, time and/or resource consumption. For direct inputs and outputs, such as bags of seed and sacks of produce, farmers are prompted to input a number of units (be it bags, kilos or anything else) and unit costs. The app then automatically calculates running and total costs, the final cash balance, as well as net non-sale consumables and total family labour hours. Data within the

Fig. 1.1. Screenshot from the historical climate PICSA app.

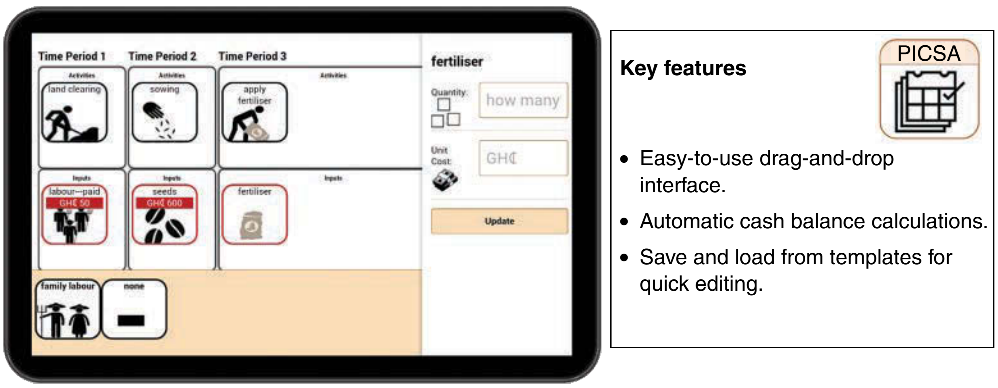

Fig. 1.2. Screenshot of the participatory budget PICSA app.

app is stored locally to avoid the need for internet access, and individual budgets can be loaded and modified either from those previously saved or templates included.

1.4.1 Proof of concept project

Based on the lessons learnt from the review, it was decided that the apps should be tested in the field with local farmers and extension officers during the early stages of development. This participatory approach to the app development was also in line with PICSA's core philosophy. The team initially hoped to generate feedback on the interest, requirements and ideas for PICSA apps, and how they might be used within the existing PICSA programme. Additional research questions included determining the extent to which demographic and socio-economic factors, such as gender or levels of literacy, might influence uptake and use of the apps. Finally, it was planned that some app development would take place directly in the field, providing the opportunity to enhance the app with local content as well as giving a sense of ownership to those providing input.

The proof-of-concept project took place with farmers across six communities in Northern Ghana, five of which had previously received PICSA training, and one that had not. Two extension officers visited each community with a set of eight tablets, and were accompanied by the lead app developer. Each community consisted of roughly 30–40 farmers, male and female, to whom the extension officers would first briefly introduce and demonstrate the apps, before splitting into groups so that the farmers could get hands-on experience of the apps for themselves. Figure 1.3 shows how several tablets were arranged in the centre of the meeting space to allow everyone to have a good view of the demonstrations. Each group was given a tablet to interact with and the extension officers moved between groups to support and encourage discussion. Final discussions were then held with all participants at the end.

1.4.2 Initial observations

The following section sets out the observations from the proof-of-concept project, which are based on notes taken during group and community discussions, and notes taken from discussions with extension officers after each session and at the end of all six training sessions.

All farmers responded very positively to the introduction of the apps, with many stating that it was something they could see immediate value in having. During demonstrations by the extension officers, farmers were actively engaged and provided lots of feedback when the extension staff started discussions. In particular, the historical climate app was recognized immediately by nearly all as a means to greatly facilitate the activities they had previously done with pen and paper; the graphs were identical to those on paper but you no longer needed to count or calculate, or manage multiple sheets. In the community that had not used PICSA before, both the climate app and paper graphs were presented and used for a short training session. At the end of the session a good amount of material had been covered, with the app appearing to take little additional time to understand, and the majority stated that they would prefer using the app over paper[1].

When the farmers were split into groups, it was interesting to see high levels of engagement with the apps. Despite the fact that very few farmers had ever used tablets before (only one farmer across all the communities owned a smartphone), most were keen to hold the tablet whilst trying to interact. At first it was not immediately obvious how to use all of the features, however after a very short period of time, users typically had mastered the basics of selection and navigation, as well as more advanced drag-and-drop and numeric inputs.

Even though the apps were written in English and literacy levels were reported by extension staff to be low, this did not have a noticeable difference on the farmers' abilities to use the apps. Comments were made on multiple occasions with regards to the participatory budget app that, although some people couldn't read or understand the words given to the drag-and-drop tiles, the symbols used made sense or at least could become familiar over time. It was also commented that those who are illiterate often struggle to hold and use pens to draw symbols anyway, and that interacting by touch is easier. The visual feedback generated by the app supported building the required utilization skills and also appeared to encourage people to participate and engage.

One further aspect that was particularly positive to see was that women in the communities seemed to be afforded equal access to the devices and within most of the sessions were actually the first to volunteer to come forward and experiment with the tablets (*see* Fig. 1.4). The extension officer claimed that within these communities it was common for women to be seen as 'innovators', who were happy to experiment and take risks whilst the men preferred to watch at first and avoid making mistakes.

One of the main talking points that arose within all the communities was how they might be afforded continued access to the applications and support once they are developed further. Access arrangements suggested included community ownership of tablets that might be stored in locations such as local schools, libraries or meeting spaces, as well as regular visits from extension or technical officers. It was also suggested that the community could assign one or two individuals to receive training to support the community instead of necessitating the availability of extension officers; it was claimed on numerous occasions that people are good at learning new things when they perceive value such as they had done, akin to the relatively recent widespread adoption of basic, or 'yam' phones. All communities also believed that the logistical issues of device charging could be resolved simply, as all either had some form of power (usually small solar generators) or knew of nearby places that could be visited on a weekly basis.

Fig. 1.3. Farmer groups using and engaging with the PICSA apps.

Fig. 1.4. Two women who were keen to be actively involved in learning to use the apps.

1.4.3 Main findings

Following the field-testing and subsequent discussions with farmers, extension officers, researchers and NGO staff, it appears that the apps do have the potential to facilitate and enhance areas of the PICSA approach. The historical climate app seemed to fit most naturally into existing training practices and with a few minor 'tweaks' could be considered ready to utilize as a tool for presenting graphs and calculating probabilities. The participatory budget app was interesting and definitely had its uses, however the fact that it took longer to master than pen/paper methods leads to the suggestion that in its current form it is not ready to integrate into the existing PICSA structure. The added value from the use of the app, such as the ability to quickly modify templates, explore different scenarios e.g. for a range of prices, and the rigour it encouraged when creating templates, should not be disregarded and could possibly fit into an additional training session within PICSA.

Establishing user needs and understanding constraints

The proof-of-concept project highlighted the importance of considering who exactly will be using the apps, establishing what they want to achieve from using them and understanding their particular constraints. The co-development of some of the parts of the apps in the field with farmers certainly helped with the process of developing a better understanding of these issues. As discussed in the content section below, it became clear that the farmers ideally required further information to make the apps useful and actionable from their perspective (information that is currently part of the PICSA approach but not through the app). It was also interesting to observe that traditional divides such as gender, literacy and digital skillsets did not appear to be a barrier to engagement with the apps. Overall, there was positive engagement with the technology. The interactivity of the apps was appreciated and appeared to heighten engagement and interest, and the visual nature of the apps allowed for illiterate farmers to use the apps with perhaps greater ease than with using pen and paper. The co-development of the apps benefited the process and led to improvements. To determine the exact contribution of this would require further research. The impact of some of the literacy and skillset constraints can be lessened through the use of well-designed applications that are tailored to farmers' needs.

The lack of internet access to provide updates and new information for the apps was another constraint that needs to be considered. Even in the larger nearby city of Tamale, accessing the internet was very slow and highly unreliable throughout. This highlighted the need for applications that retain full functionality offline, and alternative methods for updating and delivery such as distributing via USB sticks or Bluetooth. These in turn require additional thought around how to best ensure delivery and facilitation.

Content

The provision of location-specific climate information (which could be accessed using GPS) was appreciated by the farmers who, after an explanation from the extension workers about the source of the information (the National Meteorological Service), were assured about the credibility of the information. However, it was apparent that the app could have gone further in providing information that would support decision making. One question that arose was how to use the probability calculations to specifically determine which crops are particularly risky. It became clear that synthesising existing app information, such as water requirements and maturity length, with specific crop variety characteristics/requirements is needed to assist farmers in making choices around crop varieties based on climate information (again, something that is already part of the PICSA approach). The app could be developed further with additional graphs or tables comparing climate measurements with stored variety requirements and could help enhance the current methods for linking rainfall probabilities with crop varieties. In addition to the historical climate data, there were discussions about whether to include more recent climate information such as seasonal forecasts. Whilst this would be useful, it would require a significant amount of additional development and collaboration.

Intermediaries

The observations reveal how the farmers were keen to gain access to the apps without the need for the intermediaries such as extension workers. At the moment this is physically difficult because of the lack of devices (in this case, tablets) on which the community can obtain access to the apps. However, as smartphones become more readily available, this raises issues about the necessity of using intermediaries, who can contextualize the information and provide the valuable support to farmers in interpreting the information provided. This issue is discussed further in the future developments and further research section below.

1.4.4 Future developments and further research

In addition to the two apps presented, a number of potential future apps were discussed which could serve the PICSA approach well. In particular, an app specifically designed to support extension staff in their role could hold great benefit. This app should include key reference material like the PICSA manual (currently printed and carried around), frequently asked questions, tutorial videos as well as monitoring and evaluation support via digital surveys, templates and forms. The monitoring element would greatly help with tasks such as logging visits, locating communities, and accessing specific key information. As mentioned above, developments on the historical climate app will help to better integrate crop information for farmer decision making.

The development and testing of the apps raised several issues that need to be addressed through further research. Although the apps appeared to be well received by the farmers, it is uncertain to what the extent the use of the apps affected the success of the PICSA training compared to a more traditional approach that does not involve technology. Further research is required as to whether and how farmers engage differently when technology is used and to what extent gender, age, literacy and the novelty of the technology influence attendance at the sessions and engagement with the materials. Each tablet screen was visible to a small group of 6–10 farmers with one person operating, and it is uncertain how what may be perceived as a more individualistic approach could change the learning dynamics used within a participatory framework such as PICSA.

The proof of concept project raised questions about the best access and delivery models to be used. Although the extension workers and NGO staff acted as intermediaries to provide training on PICSA through the apps, the farmers wanted direct access to the apps themselves after the initial training. Although most farmers do not yet have smartphones, they may do in the near future and so further research is required to determine the advantages and disadvantages of farmers accessing the apps without intermediaries who can, for example, help contextualize the climate information.

There are also questions about how climate information is spread from farmer to farmer when the information is sourced from apps and how this may change decision-making processes by farmers, particularly if they have access to the app on their own mobiles. Furthermore, it is important to understand how the apps impact upon the role of the extension worker / community volunteer from their own perspective and performance.

1.5 Conclusion

The initial findings from the proof of concept project, which developed and tested two mobile applications, suggest that mobile applications do have the potential to enhance the PICSA approach and therefore the sharing, analysis and use of climate information to support farmers in their decision making. The lessons learned from the review played an important part of the process of developing and testing these apps. Establishing user needs, understanding location specific constraints, developing accurate, localized and actionable content and the contextualization by intermediaries were all key considerations. Farmer engagement with the technology and with the content is complicated and there are a number of key questions that need to be explored as the apps are further developed for use on a larger scale in combination with PICSA. Nonetheless, the process has reinforced the principle that the apps need to be developed and refined in a process that puts the farmer at the centre.

Acknowledgements

The authors gratefully acknowledge: the support provided by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) which enabled the review reported in this chapter to be conducted; and the encouragement given by Philip Thornton and Wiebke Foerch.

Note

[1] This provides an indication of the interest that farmers showed in using the tablets as an information source but should not be considered as an objective assessment of their efficacy over paper.

References

Allan, C., Canales, C., Elibaraki, T., Knight, J. Marcheselli, M. *et al.* (2014) Elimsis – A mobile learning platform for strengthening extension services in Tanzania. Available at: http://elimsis.org/wp-content/uploads/2014/10/Brief_Farm-Africa-Final-Report_Brief.pdf (accessed 22 September 2016).

Caine, A., Dorward, P., Clarkson, G., Evans, N., Canales, C. and Stern, D. (2015) Review of mobile applications that involve the use of weather and climate information: their use and potential for smallholder farmers. *CCAFS Working Paper no. 150.* CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark.

Dorward, P., Clarkson, G. and Stern, R. (2015) *Participatory Integrated Climate Services for Agriculture (PICSA): Field Manual.* Walker Institute, University of Reading, UK.

Glendenning, C.J. and Ficarelli, P.P. (2012) The relevance of content in ICT initiatives in Indian agriculture. *IFPRI Discussion Paper 1180*. IFPRI, Washington, DC.

Hellström, J. (2010) The innovative use of mobile applications in East Africa. *SIDA Review 2010: 12*. Swedish International Development Cooperation Agency, Stockholm. Available at: http://www.sida.se/English/publications/Publication_database/publications-by-year1/2010/june/the-innovative-use-of-mobile-applications-in-east-africa/ (accessed 6 March 2017).

Kaisaris, J. (2014) Farmerline launches TAHMO initiative. Available at: http://farmerline.co/blog/farmerline-launches-tahmo-initiative/ (accessed on 6 March 2017).

Kameswari, V.L.V., Kishore, D. and Gupta, V. (2011) ICTs for agricultural extension: a study in the Indian Himalayan region. *Electronic Journal of Information Systems in Developing Countries* 48(3): 1–12.

Masuki, K.F.G., Kamugisha, R., Mowo, J.G., Tanui, J., Tukahirwa, J., Mogoi, J. and Adera, E.O. (2010) The role of mobile phones in improving communication and information delivery for agricultural development: lessons from South Western Uganda. *Paper presented to Workshop at Makerere University*, Uganda, 22–23 March 2010. International Federation of Information Processing (IFIP) Technical Commission 9.

Mittal, S., Gandhi, S., and Tripathi, G. (2010) Socio-economic impact of mobile phones on Indian agriculture, *ICRIER Working Paper No. 246*, International Council for Research on International Economic Relations, New Delhi, India.

Palmer, T. (2014) What do Tanzanian farmers want from Agri-VAS? Available at: http://www.gsma.com/mobilefordevelopment/programme/magri/what-do-tanzanian-farmers-want-from-agri-vas (accessed 6 March 2017).

Pshenichnaya, N. (2012) Tigo and Technoserve pilot Tigo Kilimo service, first lessons learned. Available at: http://www.gsma.com/mobilefordevelopment/programme/magri/tigo-and-technoserve-pilot-tigo-kilimo-service-first-lessons-learned (accessed on 6 March 2017).