The Efficacy of ICT in Weather Forecast Information Dissemination: Evidence from Farming Communities in Mbale and Rakai Districts, Uganda

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Abstract Information and communication technology (ICT) has pervaded all spheres of life from the upscale rich to the rural poor in developing countries. ICT is increasingly being harnessed universally to better the quality of life of communities. This chapter highlights the need to utilize ICT tools to improve livelihoods of farmers in Uganda, in the face of climate change and variations in seasonal weather. We investigated the use of ICT tools and services in enhancing farmers' access to weather forecast information to improve agricultural productivity in Uganda. The ICT tools in question included mobile phones and computers/laptops, while the services included the use of emails, websites, and social network sites. We used focus group sessions with farmers in Mbale and Rakai districts to (1) capture their perception of the use of ICT tools and (2) establish the mode of ICT-supported dissemination that would be most effective and efficient for relevant weather forecast information dissemination. Extra information was sourced from key informant interviews with agricultural extension workers and personnel from Uganda National Meteorological Authority. We transcribed the information gathered into descriptive narratives, used thematic analysis and coding with spreadsheets for analysis. We found the mobile phone to be the ICT tool that most farmers have access to, and we found them open to solutions designed around the mobile phone. We establish and recommend using ICT tools to complement existing and conventional weather information dissemination strategies such as mass media. ICT tools allow for customized information to be sent to farmers in text, graphic, audio, or visual formats.

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We also found that ICT tools enhance user control and interaction, allow farmers to query and receive specific responses of weather forecast information they are interested in, provide a mechanism to collect crowdsourced feedback that can be used to improve the weather information services and products provided by UNMA, and promote timely and easy access to weather information. We noted that if fully exploited, ICT tools have the potential to contribute to effective dissemination of tailored weather information, which would help to improve the livelihoods of the farmers in Uganda.

Keywords ICT efficacy · ICT tools · Farmer perception · Weather information dissemination · Mobile phone

1 Introduction

The use of information and communication technology (ICT) is on the increase the world over. There are several global problems that can be alleviated and supported by the application of digital technologies (Heeks 2008). ICT provides great potential for accelerating human progress (National Research Council and others 2007). According to Agenda 2030, one of the greatest challenges facing humanity today is climate change. The Sustainable Development Goals (SDGs), particularly goal 13, are geared toward taking action on climate change. Handling climate change will foster the achievement of some of the other SDGs such as ending poverty and hunger and making human settlements safe, resilient, and sustainable. Furthermore, the United Nations General Assembly 2015 envisions a world where there is development and application of technology that are climate sensitive and resilient (United Nations General Assembly and others 2015).

Uganda is among the countries adversely affected by climate change (Barihaihi and Mwanzia 2017; Barros et al. 2014). This is because most of its economic sectors are weather-climate dependent. Four out of five people in Uganda depend on agriculture for income and food security, and any threat to agricultural production degrades Uganda's socioeconomic status and puts 80% of the population at risk of poverty and hunger. Erratic rainfall seasons and the increased frequency of droughts and floods have led to failed harvests, food insecurity, insufficient intake of food for children and adults, and low household incomes, among others (Bamanya 2014; Barihaihi and Mwanzia 2017). These situations can be further aggravated by a lack of weather information. While considerable progress has been made in the collection, archiving, and analysis of weather and climate data, their transformation into information that can be readily used has lagged behind, especially in developing countries where such information needs are the greatest (Sivakumar 2006). The farmers, particularly, are interested in seasonal weather information, especially the onset and cessation of the rain and dry periods. Seasonal rainfall forecasts are particularly suited for rain-fed farming systems (Klopper et al. 2006). Farmers use this information to decide on when to plant their crops, weed, and harvest. They can also decide what type of crops to plant and what soil conservation practices to put in place, in case of flooding (Kanagwa et al. 2015). Barihaihi and Mwanzia report that

"empirical studies among African farmers have shown that usable climate forecasts can help them reduce their vulnerability to drought and climate extremes, while also allowing them to maximize opportunities when favorable rainfall conditions are predicted" (Barihaihi and Mwanzia 2017). Reliable weather information is therefore vital for informed decision-making (Sivakumar 2006; Weiss et al. 2000; Rijks and Baradas 2000).

ICT tools offer solutions for easing communication of information. For this study, we define ICT tools broadly as encompassing computing, communications, and digital technologies (Heeks 2008). These range from computer-based devices such as computers/laptops and mobile telephones to software systems including Internet services such as email, websites, and social network platforms, among others (Weiss et al. 2000; Ministry of Agriculture, Animal Industry and Fisheries n.d.). Globally, the most common means of dissemination are the mass media, mainly radio, television, and newspapers. Telephone and pagers are used to target specific users. The Internet is also increasingly gaining importance in dissemination (World Meteorological Organization n.d.; Uganda Communications Commission 2015). Specifically, these tools can be harnessed for the dissemination of weather information to farmers to improve agricultural productivity. Dissemination allows for clear communication of the results of climate science efforts (Barihaihi and Mwanzia 2017). However, despite the advances made in the field of ICT that have made the task of data manipulation, analysis, interpretation, and preparation of information easier, the challenge of communicating the right kind of information to meet the user needs remains even today (Sivakumar 2006; Weiss et al. 2000). There are challenges in getting weather forecast information to farmers (Barihaihi and Mwanzia 2017). User awareness of what information is available, where it can be found, and how it can be used in effective decision-making needs to be enhanced (Sivakumar 2006; Weiss et al. 2000).

This chapter presents results from a qualitative survey carried out to establish the level of ICT usage in accessing weather information by farmers in Uganda and to establish what modes of ICT-supported dissemination would be most effective and efficient to convey relevant weather information to them. We sought insights on the behavior of the farmers, their perceptions, and thoughts to using ICT tools and whether these tools would improve their livelihoods. The study is part of a larger project geared to addressing the problem of access to reliable weather information that meets the varying needs of stakeholders (Kanagwa et al. 2015). The project aims at improving the farmers' experience in accessing timely and personalized weather information to enhance their decision-making through the use of suitable ICT tools (Reuder and Sansa-Otim 2013).

This chapter is structured in seven sections. Section 2 presents the conventional methods of conveying weather information from the national meteorological authority in Uganda, the weather services provider, to rural farmers. We highlight some challenges to this flow of information. Section 3 presents related work that describes ICT tools, their advantages, and examples of projects where ICT has been used in Uganda. We then present our focus group and survey approach, tailored to the design science methodology, in Sect. 4; this is followed by Sect. 5 in which we pres-

ent the results from the survey, structured according to themes, as well as the limitations. We discuss the results from the survey in Sect. 6, presenting possible usage scenarios arising from the use of ICT tools; and we conclude in Sect. 7.

2 Challenges of Weather Information Dissemination in Uganda

Uganda is divided into 121 districts (Uganda National Bureau of Statistics 2009), with 13 climatological zones (Basalirwa 1995). The languages of the people in Uganda overlap across districts, but a total of 52 local dialects are spoken, with English as the official language. Swahili is being promoted as a national language in the spirit of regional integration within the East African Community (Uganda National Bureau of Statistics 2009; Barihaihi and Mwanzia 2017). Uganda has nine known farming systems (Mwebaze 1999). These farming systems, like the climatological zones, do overlap. The Uganda National Meteorological Authority (UNMA) currently disseminates weather information to different stakeholders in Uganda through electronic and print media, including news bulletins on radio and television (TV), email, newspapers, bulletins, magazines, websites, as well as tailored mobile weather alerts in the form of short message service (SMS). Information is also relayed through stakeholder workshops, the National Media Centre (NMC), non-governmental organizations (NGOs) charged with facilitating the access of weather information by relevant stakeholder groups, the Ministry of Agriculture early warning unit, and more recently through the Internet, specifically using social media (Facebook, Twitter, YouTube) (UNMA n.d.; Bamanya 2014; Barihaihi and Mwanzia 2017). The Ministry of Agriculture uses the extension service to disseminate agricultural and weather information to farmers. In this dissemination avenue, farmers acquire knowledge of new developments, technologies, and practices to improve their current practices through extension workers based at district local governments (Barungi et al. 2016; Gakuru et al. 2009). The weather information in Uganda ranges from weather alerts/warnings, daily weather updates, dekadals, and monthly weather updates to seasonal weather forecasts (UNMA n.d.). The weather information disseminated is further simplified by translating it into some of the local dialects to make it easier to understand by the relevant stakeholders (Bamanya 2014).

Most farming communities in Uganda are interested in seasonal weather information that indicates the duration of the rain and dry periods and the amount and distribution of rainfall to be expected. Given that most of the farming carried out in Uganda is seasonal, UNMA's main product for weather dissemination is the seasonal weather forecast, which typically contains a forecast for 3 months periods with accompanying advisories for different sectors. It shows the rainfall conditions for the four major regions of the country. The seasonal forecast is prepared for periods March–April–May (MAM), June–July–August (JJA), and September–October–November–December (SOND) (UNMA n.d.). The farmers can then use this information to guide their farming calendar and related agricultural decisions.

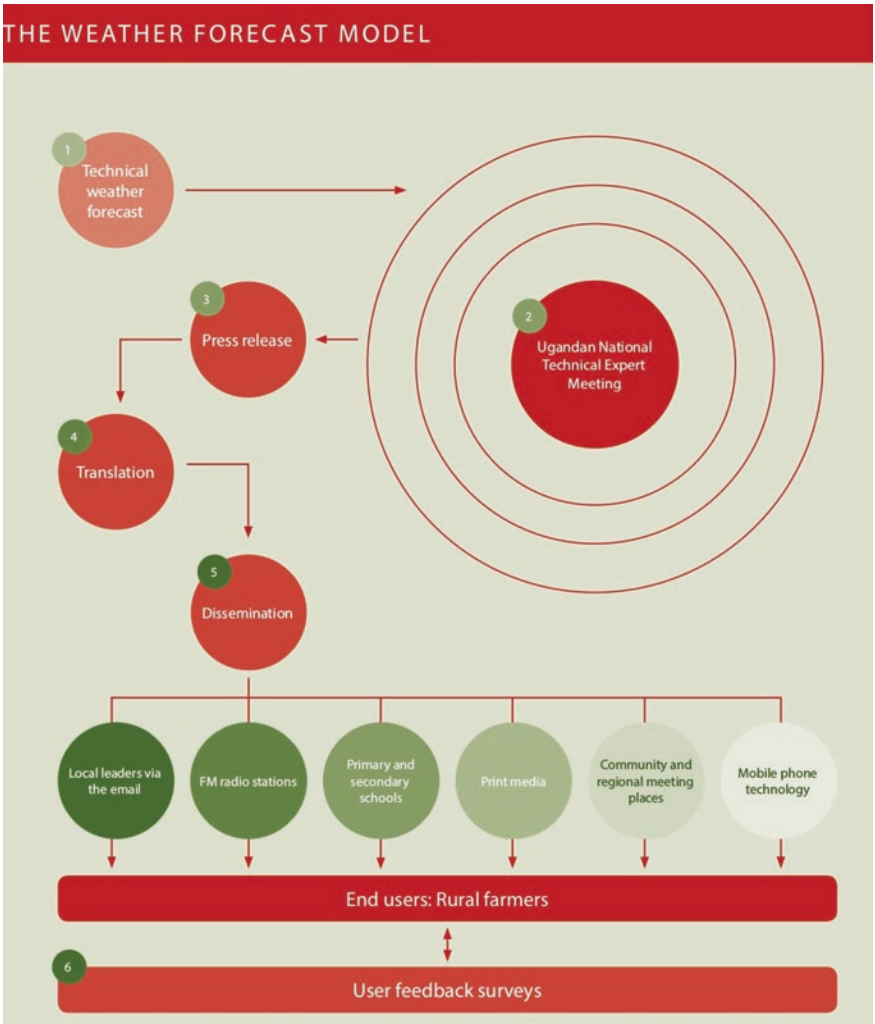

Fig. 1 Weather forecast model

Figure 1 shows the information flow from UNMA to farmers in the weather forecast model (Bamanya 2014).

In step 1, UNMA produces the seasonal weather forecast in relation to the regional consensus with other countries in the Greater Horn of Africa. In step 2, a meeting is held, where weather stakeholders representing various economic sectors discuss, simplify, and work out advisories for the seasonal forecast. At step 3, a press release is issued, and the forecast with advisories is also published in the national newspaper, the New Vision, and other newspapers. The forecast with advisories is then translated into local dialects by specialized translators trained in meteorology terminology. The translators work with UNMA to clarify any uncertain issues.

The translation takes 3–4 days in total, and the various versions are produced in electronic text soft copies and prerecorded audio CDs. This is shown in step 4. The forecasts are disseminated by various actors such as the government (through the local leaders), NGOs, and civil society organizations (CSOs) using distribution channels such as the Internet, local FM radio stations (and rural radio), primary and secondary schools, churches, mosques, markets, community and regional meetings, print media, and mobile phones (step 5). Rural or community radio is one of the communication approaches that targets and involves rural communities. It allows members of a community to gain access to information. It mainly takes on the form of a radio broadcast specially made for particular group of people, owned and controlled by them, or a radio station targeting a particular community operating in that community and managed by that community (Biraahwa Nakabugu n.d.; Heeks 2008).

To assess utilization and impact of the seasonal forecast, UNMA conducts rural community feedback surveys at least once per year (step 6). The surveys investigate the users' satisfaction with the weather forecast information provided. The surveys are yet to be extended to other users beyond the rural community. Future plans include institutionalizing the feedback mechanism as part of UNMA monitoring, evaluation, and reporting system.

Real-time meteorological products such as forecasts and warnings are highly perishable, and for them to be of any use, they must be disseminated rapidly in the most efficient way to the intended audience (Coelho and Costa 2010). Ideally, these channels should be sufficient and convenient for the stakeholders to receive weather information, but their uptake remains limited (Ziervogel and Calder 2003). Furthermore, according to the results from the population census carried out in Uganda in 2014, 85% of the agricultural household population that was sampled, totaling 19.3 million, received information on weather via FM radio. The census also reported an increase in Internet penetration from 29.5% in 2014 to 39.5% in 2015. The national literacy levels stand at 72.2% for adults of 18 years and above (Uganda Bureau of Statistics 2016).

In spite of this, there are existing challenges to these weather information dissemination strategies. One major challenge is the delay in the distribution system of the weather information. This challenge arises at points 4 and 5 of Fig. 1. In the dissemination approach, local leaders receive the weather information and use agricultural extension workers to disseminate the information to farmers. According to the census report of 2014, 19% of the agricultural households were visited by an extension worker, and 63.3% of them were at a distance of 5 km to receive extension services (Uganda Bureau of Statistics 2016). Considering statistics from a district such as Rakai district, there are 22 sub-counties, with a total of 752 villages. In 2009, there were 25 registered agricultural extension workers for Rakai (Uganda National Bureau of Statistics 2009). That would roughly approximate to one extension worker for each sub-county, expected to cover an estimate of 35 villages. This makes it practically impossible to effectively disseminate relevant weather information to the farmers on time (Barungi et al. 2016; Gakuru et al. 2009). Some of the weather information is therefore received when there is no value for it. For

instance, seasonal weather information is first received in English by meteorological experts, translated into local dialects, and disseminated to the user communities (Bamanya 2014). Considering the time taken from the translation to final dissemination and the challenges of dissemination logistics, sometimes the end user receives it when the season it pertains to is either half gone or has ended, and sometimes he/she may not receive the information at all. This makes this information irrelevant to the users and not useful for decision-making (Barihaihi and Mwanzia 2017).

Another challenge is that the user has no control over the formats or of information they access or receive. For example, when weather forecast information is provided at the end of a news bulletin on radio or TV or presented in print media, it is clear that the user has not requested for the information. They cannot change the format in which they receive it. For weather information that is disseminated using print media, some of the consumers of this information may read it but not understand it and fail to apply it.

Owing to the diversity of the people in Uganda, in terms of dialects spoken, and the variations in farming systems, UNMA faces challenges in providing specific weather information that meets individual stakeholder needs due to a lack of computing resources.

A survey carried out to establish the status of the weather information dissemination system in Uganda found that many stakeholders do not receive timely and relevant weather information, with some stakeholders claiming that the weather information they receive is still complex in wording, making it difficult to understand. The nature of the forecasts provided, in terms of being probabilistic and using meteorological terms, means that they are not appropriate for all users (Ziervogel and Calder 2003; Barihaihi and Mwanzia 2017). The survey concluded that the current modes of communication used are not effective, and stakeholders have limited access to weather information (Kanagwa et al. 2015). This impedes the stakeholders' ability for making decisions that would lead to improved productivity. Other studies have identified similar challenges (Coelho and Costa 2010). To support the agricultural activities of farmers, the weather information needs to be timely, relevant, and packaged appropriately so as to lead to increased productivity (Rijks and Baradas 2000; Kanagwa et al. 2015).

3 ICT and Dissemination

Efforts are being increasingly made to provide disadvantaged people in rural areas with access to digital content and services using ICT tools in many developing countries (Pitula and Radhakrishnan 2011). These ICT tools collect, process, store, retrieve, and disseminate data and information (Weiss et al. 2000). According to a survey carried out to establish the access and usage of communication services across Uganda, ICT tools included radio, TV, cassette/DVD/CD, mobile phones, laptops, and desktop computers. Radio was the most widely owned form of communication device for both households and individuals, followed by mobile phones

for individuals, while desktop computers were the least owned by both (Uganda Communications Commission 2015). For our study, we investigated the use of mobile phones, laptops, and computers specifically.

Several pilot projects have been attempted over the past decades to integrate ICTs into the dissemination of information to stakeholders in developing countries, but few have managed to bring long-term sustained benefits to the people that they target. This is mainly because the projects tend to focus on technical success and not on the specific end users' needs. Most initiatives around rural ICT in agriculture are donor (or at least externally) driven. The majority of such projects are implemented by, or in partnership with, international organizations with local or national nongovernmental organizations (NGOs), private companies, or government institutions that play a large part in several projects. They remain at pilot or "proof-of-concept" phase which limits their impact, as the projects cannot be financially sustained beyond the funding of the donors (Barihaihi and Mwanzia 2017; Gakuru et al. 2009). Another challenge these initiatives meet is that they are largely institutional-based and product- and platform-specific (Gakuru et al. 2009). This tends to have the effect of several isolated and replicated "small" pilot projects that cannot be fully sustained as the resources to do so are scattered over a number of them.

One such project targeted the fishing community in Kalangala, an island of Lake Victoria in the south of Uganda. In May 2011, the Uganda National Meteorological Authority (UNMA) partnered with Mobile Telecommunications Network (MTN), World Meteorological Organization (WMO), Ericsson, and the National Lake Rescue Institute (NLRI) to provide tailored SMS information to fisherfolk about the weather conditions over Lake Victoria, so as to improve their safety. The information provided included daily weather forecasts and real-time warnings in the Luganda language. The fisherfolk received a color-coded message, using the traffic light color scheme, that described the daily weather condition over the lake, and provided advisories on how to proceed. The green color code indicated to them that the lake was safe, orange communicated that they should proceed to carry out fishing activity on the lake with caution, and red communicated dangerous weather conditions over the lake. The red code warned the fisherfolk not to venture out onto the lake for fishing activities. This information would also be displayed on the MTN website (UNMA n.d.; World Meteorological Organization 2012; Ericsson Corporate Public, and Media Relations, World Meteorological Organization, MTN Group, National Lake Rescue Institute, Grameen Foundation 2012; MetOffice 2012). The project demonstrated that mobile telephone solutions were suitable for disseminating weather and climate information directly to end users in Uganda (World Meteorological Organization 2012).

Another pilot project targeted farmers in Kasese district by providing weather information through SMS. The project provided the dekadal, monthly, and seasonal forecast with related agricultural advisories to farmers, to answer their questions on when the rains would come. The project covered a total of 22 sub-counties in the district and covered two crop growing seasons (World Meteorological Organization 2012; Byarugaba 2014). Over a single-year period, from November 2011 to December 2012, the project showed that providing timely and accurate weather

information to farmers could mitigate the increased risks of weather and climate variability that they faced and by boosting agricultural production, food security, and poverty reduction would be enhanced (Byarugaba 2014).

The effective dissemination of weather data and forecasts also demands close coordination between the meteorological and user communities – cooperation that notably has often been lacking (Mass 2006). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) noted that one of the determinants of adaptation efforts to cope with the impacts of climate change is the need to increase access to resources (including information and technology) (Yohe et al. 2006). Furthermore, the challenges of climate change in Africa can be addressed by more effective engagement with climate variability through better integrating climate science and user communities (including in early-warning and disaster management systems), improving the dissemination and communication of information, and developing seasonal and intraseasonal information (Washington et al. 2006).

Other studies have investigated dissemination of information using ICT, especially over the World Wide Web and the Internet, and shown the impact of economic development as a result (Sivertsen 2000; Aker and Mbiti 2010). These have shown that ICT has the ability to support graphics, animations, and simulations (demonstrated live and/or in three-dimensional aspects), which is not possible with presentations on print media. Computer-based ICT tools are able to filter relevant information for a user and deliver it in a timely and appropriate manner (Sivakumar 2006). This would contribute to efficient dissemination of relevant information to stakeholders.

4 Data and Methods

To optimize the efficiency of the weather forecast information, the presentation techniques of the information including content, format, language, and style must fit the chosen means of dissemination as well as the target audience (World Meteorological Organization n.d.). There is need to take advantage of the respective features of the various dissemination channels so as to present a product in a way that will be appreciated by users and encourage positive response. Specifically, aspects of weather forecast information that appeal to stakeholders' interests need to be noted, so that the relevant content is prepared. The presentation of the weather information should attempt to arrest and retain the users' attention. It should be concise and easy to understand and interpret; but when necessary, emphasis should be placed on the most important meteorological phenomena and their impacts (Sivle et al. 2014).

One approach to identifying appropriate content for dissemination is to elicit forecast information that agricultural decision-makers desire, often done in the context of exploratory surveys designed to characterize perceptions and perspectives on a range of related issues. For this reason, we chose a qualitative strategy (Miles et al. 2013) which is person-centered to understand the process involved in weather

information dissemination. We set out to understand the weather information services which agricultural stakeholders in Uganda are interested in, so as to allow us to generate a list of requirements for an effective and efficient weather information dissemination system.

First, we carried out a stakeholder analysis to identify the key stakeholders. We identified these as the farmers, agricultural extension workers who aid in weather information dissemination to farmers, and the weather service providers (UNMA). For the information gathering, we chose to interview the farmers first, as the immediate end users, then agricultural extension workers, and finally UNMA personnel. Farmers provide a representative sample of stakeholders that consume weather information. The targeted farmers were involved in either or both of crop production and animal rearing for subsistence and commercial purposes. UNMA is the only institution mandated to provide weather forecasts and advisories in Uganda.

We used focus group discussions (FGDs) with the farmers. We chose focus groups because of the resources available to us, and they are productive. To improve the responses, the FGDs were conducted in the local dialects of the farmers to ensure that they understood and answered the questions appropriately. We followed up with interviews using guided questionnaires with the agricultural extension workers and UNMA personnel, to address arising follow-up questions.

The information gathering techniques were chosen in line with the design science methodology. The main goal of design science is to create artefacts from an understanding of an environment (Von Alan et al. 2004). Tremblay, Hevner, and Berndt propose focus groups as an effective technique to improve artefact design and to provide evidence of its ability to solve a real problem (Tremblay et al. 2010). Focus groups provide a cost-effective and fast way to obtain experiences (Kontio et al. 2004) and obtain specific type of information from a clearly identified set of individuals (Stewart and Shamdasani 2014).

4.1 Setup of the Focus Group Sessions

We conducted one pretest focus group discussion to practice the discussion and evaluate if the questions were clear (Stewart and Shamdasani 2014). The feedback from the pretest session was also used to improve the clarity of some questions (Kontio et al. 2004). The study focused on two districts in Uganda: Mbale and Rakai. Mbale and Rakai are two of the districts in Uganda that have been affected by the weather changes. Choosing Mbale and Rakai provides us with varied user input because the districts are in different climatological zones (Basalirwa 1995) and the farmers in the two districts grow similar crops. This provides a basis for comparison, for instance, in terms of the weather requirements for the crops and arising decisions that can be taken.

To focus our research, we considered farmers dealing with two categories of crops. The National Development Plan (NDP) II 2015/2016 to 2019/2020 identifies these as subsistence and cash crops (Ministry of Agriculture, Animal Industry and

Fisheries n.d.). In Rakai, we conducted four focus group sessions and, in Mbale, six focus group sessions. Mbale is divided into three major regions the upstream, midstream, and downstream areas. We conducted two focus group sessions in each of these areas so as to enrich our findings. As we progressed with the focus group discussions, we realized we were getting the same responses. This confirmed that the ten focus groups were enough. This has also been supported by literature, as the point of saturation (Tremblay et al. 2010).

The extension workers and UNMA personnel completed structured questionnaires with the researcher(s) present or had an oral interview. The questionnaires were used as tools to guide the interviews. The extension workers were found at district level and represented different sub-counties in the two districts.

Selection of Participants

The district leaders involved in agriculture supported us in identifying the specific farmers. These officials are local experts and can identify farmers with suitable profiles (Meyer and Booker 2001). In Mbale, these were the Chief Agricultural Officer (CAO), Community Development Officer (CDO), and the District Environment Officer/Natural Resources Officer and extension officers. In Rakai, the District Production Officer (DPO), the District Natural Resources Officer, the Sub-county Chief, the Local Council Chairman, and the District Police Commander were contacted. We selected farmers based on their experience and insight into weather information for farming activities (Kontio et al. 2004). We considered both farmers who have experienced the effects of fluctuating weather conditions and those who were knowledgeable of the changes in the weather conditions and had taken measures to adjust accordingly. The farmers selected were part of farmer groups and were familiar with the farming domain. We sent out invitations to 12 farmers per focus group (Tremblay et al. 2010; Stewart and Shamdasani 2014), targeting the preferred 6–8 (Kontio et al. 2004). For nine of the ten focus groups, there were at least ten participants. One focus group however registered 15 participants because some of the invited farmers invited other colleagues. The farmers chosen were of similar socioeconomic standing, as similarities in abilities, knowledge, and intelligence facilitate communication (Stewart and Shamdasani 2014). After the sessions, we discovered that some (at most three in one of the groups in Rakai) of the farmers belonged to the same farming group and were familiar to each other, but most were unfamiliar. This, in our view, did not affect the group cohesiveness.

We observed during the pretest that there were cultural hindrances attached to mixing the farmers by gender (if a husband and his wife were in the same session, the interviewers had to coerce the wife to respond), so we disaggregated the sessions by gender, to allow for free interactions. Some studies have shown that men and women behave differently in group settings (Stewart and Shamdasani 2014). Of the four sessions in Rakai, two were composed of female-only farmers and the other two of male-only farmers. The six in Mbale were equally divided into three male and three female groups (one group of male-only and another of female-only farmers from each of the upstream, midstream, and downstream areas).

We also selected farmers by age with ranges of 15–25, 26–35, 36–45, and above 46. The age ranges begin at 15–25 because most of the people in Uganda are the youth, with 21.13% within this age group (Uganda Bureau of Statistics 2016). This was done to include farmers of all age groups and determine if ICT tools are more proficient for a particular age group. The National Analytical Report shows that generally ICT usage increases as an individual's age advances (Uganda Bureau of Statistics 2016). We considered exposure (none, some, high) to ICT tools and mechanisms of information dissemination ranging from radios, televisions, computers/laptops, and mobile telephones; and the applications that run on these, including Internet services such as email, and social media platforms (WhatsApp and Facebook); and the use of SMS.

The district leaders also identified the extension workers who filled out the questionnaires and participated in interviews. These were randomly selected from the sub-counties they oversee in working with the farmers. The UNMA personnel were also randomly selected from the directorates in UNMA. A total of 17 questionnaires were given to the extension workers from both Mbale and Rakai districts and ten questionnaires to UNMA personnel. The structured questionnaires and key informant interviews for the extension workers and UNMA personnel were all administered in English.

FGD Session Management

A moderator, an assistant, and an observer (part of the authors) were in charge of each session. We recorded each session using an audio recorder, and the participants were notified about the recording before the sessions. The average session time was 1.5 hours, with the longest taking 2 hours. The moderator provided ground rules including assuring the participants of privacy and confidentiality, respect for differing viewpoints of participants, and handling of mobile telephone interruptions. Pictures were also taken at each of the sessions, as a way of data capture. The pictures show participants raising their hands to answer some of the questions, for instance, to answer "how many people have a smart mobile phone?" and some showing the mobile phone they have. We obtained consent from the participants for both the audio recording of the sessions and taking of pictures.

Meeting Venues

The district leaders identified meeting venues easily accessible to the farmers. These included homes of village Local Council Chairpersons, churches, and schools. These sites turned out to be excellent as they were comfortable for both the farmers and researchers and allowed proper recording of sessions. Participants from hard-to-reach areas of the upstream region of Mbale traveled to the midstream areas for their sessions. The researchers also traveled by car to one such meeting.

Question Guides and Themes

We categorized the questions in four themes: agricultural activities of the farmers; agro-meteorological information pertaining to the farmers; ICT aspects and dissemination channels; and indigenous knowledge forecasts. Each of the themes was designed to capture a different aspect of weather information dissemination. Each theme consisted of three open-ended questions structured from general to specific (Stewart and Shamdasani 2014). We translated the questions from English into the farmers' local dialects using translators. We conducted the Rakai sessions in Luganda and Mbale sessions in Lugisu, the local dialects for the districts.

4.2 Analysis

We conducted the focus group sessions with a cross section of farmers chosen from the sub-counties in the districts of Rakai and Mbale. Focus groups are not self-contained by themselves, so we used a limited content analysis (Morgan 1996). We targeted thematic analysis since the interviews were structured into themes. Each focus group session and interviews was transcribed in form of a simple descriptive narrative (Stewart and Shamdasani 2014). The transcribing was done verbatim, and no corrections were made to the participants' grammar to preserve the responses. The results from the pretest session formed part of the analysis. Questionnaires from the agricultural extension workers and UNMA personnel were coded using spreadsheets.

4.3 Limitations

Some of the participants were not as active as others, particularly those younger in age, and the moderator directed individual questions to them to capture their responses (Stewart and Shamdasani 2014). The sessions were conducted in the participants' local dialects, and the participants tackled complex questions, rephrasing them for counterparts, with the guidance of the moderator. However, we cannot rule out that there may have been some information lost in translation. One limitation of focus group research is generalization (Tremblay et al. 2010) arising from the way participants are recruited and the number of groups sufficient for a correct sample. Basing on the fact that after the ten sessions, we reached a point of saturation and received the same responses, we suggest that our findings are useful for further research.

5 Results

This study sought to establish the level of ICT usage in accessing weather forecast information by farmers in Uganda and establish what modes of ICT-supported dissemination would be most effective and efficient to convey relevant weather information to them. We sought insights on the behavior of the farmers in light of climate change and existing mechanisms of information dissemination, their perceptions, and thoughts to using ICT tools and whether these tools would improve their livelihoods. We present the results from the focus group sessions according to the themes in the survey.

5.1 Agricultural Activities

We established that the farmers engage in either or both of subsistence or commercial farming. Most farmers practice crop production, with livestock rearing done for purposes of supplementing household incomes and food supply. The farmers in Rakai and Mbale noted that the pricing of agricultural produce is not consistent. This leads to unanticipated losses from their sales.

The crops grown can be categorized as either short-maturing crops such as market fruits and vegetables (onions, carrots, tomatoes) or long-maturing crops such as coffee, bananas (matooke), maize, and cassava. Animals reared included cows, pigs, poultry, and goats. Mbale farmers grow more market fruits and vegetables than Rakai farmers. Farmers in both districts reported that they rarely have food left over from one planting season for storage and use in the next season, as any surplus is sold for upkeep. One of the participants from a male group in Mbale proposed that each household stores about 50 kg of food with government, which could be later redistributed in hunger time.

The farming activities are carried out on average on an acre of land. In Mbale, the land is fragmented according to the size of one's family, and this determines the kind of farming activity undertaken. The more children in a family, the more land is fragmented. For this reason, farmers in Rakai rear more animals compared to the farmers in Mbale, as the land is less fragmented. The farmers in Mbale rear a maximum of five cows, most of them zero-grazed, while the cows in Rakai are kept free-range. Some farmers in Mbale pay for grazing their animals in areas with pasture.

The farmers in both districts make comparable decisions including when to prepare the land, plant, apply fertilizers (mostly from the animal waste of cows, goats, and chicken) irrigate, harvest rainwater, and apply pesticides to both crops and animals (cows). Notably, only farmers who grow market vegetables invest effort in irrigating their crops. Water for irrigation comes from streams, swamps, rivers, harvested rainwater, boreholes, and piped water from the National Water and Sewerage Corporation (NWSC) and Lake Wagagai, a crater lake in Mbale. Residents who have NWSC water installed sell a 20 L jerrycan on average at 0.2USD (600UGX).

To be able to pay for the water bills, these residents sell water to their neighbors who come from different places to fetch the water. Irrigation is generally not practiced because the distances the farmers have to travel for water are prohibitive. The decision to use fertilizers is also dependent on the type of soil; participants in Mbale claimed that fertilizer is not helpful on sandy soil. This information is useful for understanding the factors that farmers consider before planting, during planting, harvesting, and post-harvest stages. In order to disseminate weather forecast information that is relevant to the farmers, their farming decisions must be considered.

5.2 Agro-meteorological Information

Most of the farmers receive weather information, especially via the radio (handset or mobile phone radio) from farmer program broadcast at designated times. Radio has been found to be the most widely owned form of communication device (Uganda Communications Commission 2015). Some farmers pointed out that they are not available at broadcast times and miss out on the disseminated information. Some areas of Mbale have poor radio signal strength, and participants here do not have access to radio. Other areas do not have access to electricity, so the participants do not have televisions. For the areas where electricity is available, televisions are prohibitive because of costs attached to buying set-top boxes after digitization of broadcasting.

The farmers acknowledged the change in seasons and unreliability of weather information received, because it is general information, noting that it would rain in one village, for instance, and not in the neighboring village. Most farmers claimed they would plant their seed after experiencing one shower of rain in a season when the rains were expected and then wait expectantly for the crop to grow. In this particular season (January), the rains had not come as expected resulting in a severe scarcity of water to the extent that many animals died in Rakai. Some farmers noted that when the rains are heavy (above normal), there are more pests to deal with.

The government provides the farmers with agricultural inputs such as seeds and fertilizers, but most farmers complained that these arrived late in season to be useful. Some NGOs have given the farmers nonlocal heifers, and the farmers found that they have no pastures to feed the animals. The animals are exotic and require more specialized care than local breeds, as they are not adapted to the local conditions, which makes them more prone to diseases.

The extension workers chose information on crop development, plant disease reports, and food security reports as parameters relevant to aid farmers in making decisions. Crop development included information on planting seasons, rain periods, prolonged droughts, and harvesting aspects, while food security encompasses food usage, storage, and hunger forecasts. They cited that some weather element parameters are unpopular, including soil temperature and moisture, relative humidity, and air pressure, and yet these have been cited to be some of the main variables of interest for an effective growth season in farming (Coelho and Costa 2010).

The prepared weather forecast does not aid the farmers in understanding this particular information, and therefore they do not have any motivation toward understanding and using it. There is a need therefore to bridge this information for the farmers.

The extension workers also cited challenges in accessing and distributing agro-meteorological information including unavailability of the information, low literacy levels among the farmers, and high poverty levels (farmers cannot afford modern equipment such as radios, mobile phones, computers). Some of the farmers are in hard-to-reach areas and therefore inaccessible. Many of the farmers do not believe in the accuracy of the seasonal weather forecast information and rely more on their own experiences. Agro-meteorological information here provides insights into what channels of dissemination to use, appropriate times for availing weather information, providing location-specific information, and structuring meaningful advisories for the expected weather conditions.

5.3 ICT and Dissemination Channels

We found that over 95% of the farmers own a mobile telephone, those that did not have one were of school-going age and therefore unable to afford one. These, however, expressed the desire to own a mobile phone. Despite the high poverty levels, the farmers prioritize acquiring a mobile phone, also as Heeks points out (Heeks 2008). The 2017 National Analytical Report reports that 52.3% of the population owns a mobile phone, and this is projected to increase as the population gets more exposure to ICT tools (Uganda Bureau of Statistics 2016). The majority of the farmers had the simple feature phone (the "button" type), while a few of the farmers had smartphones (commonly referred to as "touch"). Many of the farmers argued that the smartphones were not practical considering the nature of their work. "You cannot be in the garden digging and use your dirty hands to slide on the phone!" This can be considered a needs assessment for improving the quality of smartphones, for instance, by designing more resilience in waterproofing phones.

One male focus group in Mbale explained that there was an ongoing project that was teaching the farmers how to use computers. Most of the farmers, however, did not have exposure to a laptop or computer. These have been shown to be the least owned ICT devices (Uganda Communications Commission 2015; Ministry of Agriculture, Animal Industry and Fisheries n.d.). Those who could access the Internet used their mobile phones to do so. These were the minority. The more youthful participants had knowledge and access to social media (particularly WhatsApp). 77.2% of the population is signed up for social media (Uganda Communications Commission 2015).

The farmers had good command of how to operate their mobile phones and could use short codes, e.g., for loading airtime, checking account balance, accessing mobile money, and calling customer care lines, among others. This shows that the farmers would know how to utilize various applications on a smartphone. If, for

example, farmers ask for SMS information with parameters of language, district, and farming practices, they could get back a text message, audio recording, or a toll-free line to call for related weather information.

Overwhelming majority were willing to pay up to 0.14USD (420UGX) for weather information services, as long as they initiated the request and received pertinent information. This is due to the volume of unsolicited for messages telecommunication companies normally send, particularly for advertisement. Some of the farmers felt that they should meet part of the costs for receiving weather information as individuals, and other companies such as telecommunication companies top up as part of their corporate social responsibility. The majority voted to receive weather information using their mobile phones, via SMS, because they have access to their mobile phones all of the time. This is positive since the farmers realize that the service has to be funded somehow.

One focus group of male farmers in Mbale suggested the introduction of a weather call center, sponsored by the government, where they can call in for the weather information at no cost. Another group proposed that they receive audio phone messages directly from UNMA, just as they received audio political campaign messages.

All of the women groups vouched to receive weather information in communal settings such as places of worship, at weddings, or funerals, organized demonstration sessions among others. They reported that radios, televisions, and mobile phones are controlled by the men, and the women have to listen or watch programs prioritized by the men, such as football. A greater percentage of men own mobile phones and radios, listened to radio, watched TV, and used a computer and Internet than women. Men have been shown to have more ownership and control of ICT tools than women (Uganda Communications Commission 2015; Ministry of Agriculture, Animal Industry and Fisheries n.d.; Barihaihi and Mwanzia 2017).

The farmers in Mbale vouched for receiving weather forecast information in Lugisu, and those in Rakai in Luganda, or be given the option to choose a preferred language, with a bias for audio messages than any other format. They reasoned that the government had carried out mass registration of citizens, so one's local language could be determined through their identity. However, English and Swahili should also be maintained as general national languages.

The extension workers advocated for the use of mobile phone capabilities, especially SMS (as most of the farmers own or at least have access to a mobile phone) and Internet resources, particularly social media be used for dissemination. However, radio and the services of extension workers must be maintained, to cater for those who cannot read but can listen. Aspects of the Internet such as email and websites are currently not being used for dissemination to the farmers. This is in tandem with the results from the Uganda population census report that showed that the Internet stands at 7.3% among the sources of information for households in Uganda (Ministry of Agriculture, Animal Industry and Fisheries n.d.). Acceptable formats of information chosen for dissemination of weather forecast information were audio, text, and pictorial/graphical. The extension workers also advocated for trainings for themselves, to be able to provide better services to the farmers, and sensitization workshops for the farmers for increased uptake of meteorological products.

We established that UNMA mainly provides seasonal weather forecasts, accompanied with advisories, to the public. These take the form of PDF (portable document format) reports mainly. They also provide alerts in form of warnings and updates which may be daily, dekadal, and monthly. All of the services they provide are public (common good) services. For the services provided to the farmers, there is a demand for location-specific advisories for specific crops, which they are unable to cater for at the moment. UNMA is currently unable to provide regular and timely updates on seasonal climate outlook (due to late collection of the data to generate the product), and forecast of dry spells, due to a low computing capacity. Information that is not freely available to the public is weather and climate information tailored to particular transactions, historical data, and raw climate data.

UNMA personnel also agree that there is a need to understand the weather information needs of the farmers, so as to create tailored products and services. They concur that to complement existing dissemination efforts, SMS should be fully adopted and promoted, and a strategy for a crowdsourced feedback mechanism established. One of their recommendations to improve the weather information dissemination strategy is to mainstream forecast dissemination in government programs, so that effective policies can be structured, and to promote integrating traditional weather forecasts in order for the stakeholders to appreciate scientific forecasts.

From this information, we can deduce the proficiency of the farmers in the use of ICT tools such as the mobile phone, computers, and Internet services. We also noted the availability and access to these tools; the need for a demand-driven service where the farmers initiate the request for weather information; and willingness to pay for the services provided.

There was also a clear need for language-specific weather information services, packaged in different formats for different people.

6 Discussion

This study allowed us to interact closely with farmers and enabled us to understand their weather information needs, as well as their impression in using ICT tools for dissemination of this information. The farmers expressed interest in receiving weather forecast information because it affects the productivity of their small-scale agricultural efforts. More targeted weather information will lead to improved productivity. They unanimously agreed that the mobile phone be harnessed in the dissemination strategy.

We believe that an ICT-based dissemination system will provide the best solution to complement the existing weather information dissemination strategies, as reaching a majority of farmers requires special targeted communication efforts. ICT can provide user-friendly access and cost-effective solutions. ICT tools can effectively manage information delays, foster interactivity, and provide services palatable for all.

ICT however cannot be a stand-alone solution in the effort to ease dissemination of weather forecast information but can be effectively used to boost existing solutions. Gakuru et al. Argue that since users cannot be forced to accept a product, they are to be enticed and convinced by the benefits of the product. If they are satisfied with the product, they will give it better publicity than anyone else (Gakuru et al. 2009). If the farmers fully appreciate the benefits of using ICT tools, they will embrace their usage and will convince their counterparts to do the same. Training sessions can be held for all the stakeholders to ease the uptake of enhanced dissemination.

We found that the mobile phone is the most prevalent ICT device the farmers have access to, and there is some access to computers and laptops. Mobile penetration rates continue to increase, as the costs of handsets decrease (approaching 10USD per unit). The mobile subscribers also continue to increase as shown by the increase in number of active subscriber identification module (SIM) ownership. Many mobile subscribers own one or multiple SIM cards without actually owning a phone set (Ndiwalana and Tusubira 2012). Mobile phones require basic literacy, making them accessible to a large portion of the population. This means that more people have access to mobile phones, including women, and the number will continue to increase. Availability of Internet-enabled mobile handsets (smartphones) is also enabling access to mobile Internet (Ndiwalana and Tusubira 2012). The current state shows a progression from a period when there was a lack of access to mobile phones to date when mobile phone possession is widespread. We anticipate that in the near future, smartphones will be more common among the farmers. We assume that progressively, more farmers will own or have access to a mobile device, and this will reduce the gender gap over ownership of the mobile phone. This should also open up dissemination of information in a nondiscriminatory manner. There is ready access to ICT tools, and the weather forecast information to be disseminated is also available. What remains is to find seamless ways to use these existing ICT tools to disseminate the information.

Internet coverage is also on the increase, with access and speeds projected to keep increasing as the infrastructure to support is harnessed (Uganda Communications Commission 2015). This implies that ICT usage and use of social media will increase. Mobile phones can therefore be harnessed to disseminate weather information and reduce on the proverbial delays by eliminating any third-party actors. The information can be provided in the audio and SMS formats.

The farmers are somewhat familiar with mobile phone user interface aspects such as the use of short codes, and this familiarity can be harnessed to enhance usability. The recent introduction of tax on over the top (OTT) services in Uganda (MTN Uganda 2018), that include the popular social media platforms Facebook and WhatsApp, may humper the uptake of weather forecast information. However, availing a nonsocial network weather information application for download would promote dissemination. UNMA can take the lead in the development of such applications. ICT tools support such a venture for farmers with smartphones.

Using the mobile/smartphone, the farmers can subscribe to receive SMS weather forecast information at a small fee. They can also make a call to listen to an audio

recording, in a language of their choice, or download an application that provides the forecast information. In responding to a query made by a farmer, the information to be sent back can be filtered appropriately to fit the request. Using these channels allow tailored and relevant information to be sent to the farmers. Because mobile phones offer mobility, weather forecast information can be accessed anytime, anywhere.

The requests made by farmers for weather forecast information can be studied, and corresponding profiles can be derived. For instance, if several farmers make requests for information on soil temperature and moisture in their locality, this can provide an indication to UNMA of what other services and/or products to provide to the public, aside from the seasonal forecast. UNMA can also receive feedback on the services they offer directly from the farmers, for example, on simplifying the meteorological terminology used. This will foster understanding and application of the weather forecast information.

ICT tools can offer UNMA the needed computing resources to be able to offer and organize tailored and relevant information needed by the farmers to meet their individual needs. ICT tools can also offer relief to the overstretched and under-resourced extension service. If every extension worker is equipped with a smartphone, they can receive the weather forecast information directly. They can then either pass on the information by SMS to farmers or organize communal gatherings to share the information. We have also learned that attention should be paid both to the technical solution and to the workflow as information trickles down to the farmer. Some of the processes involved are not computerizable. They need to be organized more efficiently for a smooth flow of information from one human being to another. For instance, the need to provide an extension service that can positively contribute to the weather information dissemination. The nontechnical solution requires a change in attitude of the farmers, policy changes at the level of weather information service provision, for instance, in instituting a designated team of stakeholders that participate in weather information break down into meaningful advisories. Also, the incorporation of the farmers' feedback, and the further refinement of the disseminated information, would create more ownership of the resultant system.

7 Conclusion

This study presented the need to utilize ICT tools to improve livelihoods of farmers in Uganda, in the face of climate change, and the variations in seasonal weather. We listened to farmers voice their concerns and give ideas and suggestions for weather information dissemination using ICT tools, particularly the mobile phone.

We found that mobile phones are generally available to the farmers, and the farmers are open to the use of them for accessing weather forecast information. We posit that solutions built around the mobile phone will receive more ownership and have greater impact, as long as they are developed in close interaction with the farmers.

We also presented the several capabilities of ICT to enhance weather forecast information dissemination, particularly in targeting a larger population than the conventional dissemination channels. ICT tools allow for tailoring of the weather forecast information so that it is relevant for the farmers, including parameters such as the language of interest, the locality of the farmer, and any other related constraints, such as specific advisories. The farmers can receive the information in text form on SMS or in audio form from a recording.

However, ICT solutions cannot be stand-alone; linking them to other dissemination channels, especially those which are more accessible to farmers, will create a multiplier effect. A multichannel weather dissemination system which must be accessible, anytime, anywhere, with requirements structured from the interactions with the farmers needs to be developed. The envisaged system is an integrated system online (web) and mobile (USSD, SMS-based) platform that provides voice, textual, graphical, and analytical weather information. The information provided by the system can also be used to create advisories for the farmers, and be language-specific, making it simple to read and interpret.

To provide an efficient weather forecast information dissemination system, issues of technology, location, policy, pricing of services, politics, and training/sensitization, among others, cannot be ignored. We anticipate that the dissemination system to be developed should be of low cost, as a number of existing dissemination channels already are in place, and can lead to successful implementation.

A deeper investigation should explore how to foster the use of services such as email and websites in weather forecast information dissemination to farmers. An open challenge to address is assessing the impact on agricultural productivity after disseminated weather forecast information has been used by the farmers to take agricultural-related decisions. We also propose structuring a business model to ensure sustainability of the weather information dissemination system, so that its impact among stakeholders can be fully realized.

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