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Abstract. Climate change and changing climate variability are pressing problems that need urgent solutions, now! Climate change has global consequences, and is already being experienced, mainly by the most vulnerable groups of people in the global south. Research shows that farming activities in the global south are being complicated by added uncertainties in weather. To mitigate the effect of weather uncertainties, there is a need for holistic mobile climate services. We have taken the first step towards the service by finding out the local information needs and current mobile usage patterns in Tambuu village, Tanzania. The results show that climate change is already complicating farmers' lives and therefore they have urgent need for information on how to prepare and adapt to changing conditions. From the technology perspective, the domination of voice calls and short messages in the current mobile usage limits the adoption of new services. However, modern uses of smart devices for farming activities were also found. Building on this ground, we propose designing climate service prototypes together with local farmers and other relevant stakeholders.

Keywords: Climate services Climate change Small scale agriculture Mobile technology

1 Introduction

Climate change is one of the most serious problems of the world today. It may cause uncontrolled sequences of fatal harms, and it directly threatens the future existence of humankind. The negative effects of climate change are already being experienced globally, but particularly in the Global South, mainly by the most vulnerable groups of people. Climate change and related change in climate variability already has a significant negative impact to small scale farming [19, 5, 11, 14]. This is important because small scale farming produces 70% of the world's food, and generates income and employment for a large number of people [13].

In dealing with climate change, two main tracks of response can be identified; The first and more important is preventing climate change from happening, to the maximum possible extent. The second is to determine actions that need to be taken in order to adapt to changing climate conditions. This paper reports the first stage of a project, which designs and develops climate services that assist smallholder farmers in adapting to climate change and will help steer their development in a sustainable direction.

In the first phase, the priorities and concerns are examined in a Tambuu community. This paper concentrates on answering two questions: What are the acute information needs of the Tambuu community? What are the current mobile usage patterns of farmers in Tambuu community? Regarding the first question, it is essential to determine the priorities of the Tambuu community. The second question is needed to design future mobile technology use cases.

Characteristics of Tambuu Tambuu village is located in Lundi ward, Matombo division, Morogoro district, in Morogoro region. Tambuu community is engaged mainly in farming related activities. The major farming activities include crop production; maize, rice, cassava, banana, sesame, potato, peas, pepper, cloves and oranges, among others. Tambuu and other villages in Matombo division, to some extent, feeds also the residents of Morogoro and some parts of Dar es Salaam region. According to the village chairman report, Tambuu village has a total population of 2,684. Morogoro region had a total population 2,218,492 in 2013, with a total land area of 70,624 km^2.

Project collaborators This project is implemented in collaboration between University of Turku (UTU), Turku, Finland; Sokoine University of Agriculture (SUA), Morogoro, Tanzania; College of Business Education (CBE), Dar es Salaam, Tanzania; and an NGO called Tanganyika Christian Refugee Service (TCRS), Tanzania[1]. All of the above mentioned Higher Education Institutes share a common research interest towards various aspects of the mobile applications for agriculture (ICT4Ag). TCRS is working on education of local villages and steering their development in a sustainable direction by building wells and houses among other things. The Tambuu village is one of the focus villages of TCRS, which means that TCRS prioritizes many of its development activities to Tambuu. However, the need for help and assistance is always initiated by people of Tambuu.

2 Background and related research

Climate services can be defined as a set of tools which provide climate knowledge from information producers (e.g. meteorological agencies) to end users (e.g. farmers). With the help of the climate services, end users can make better informed decisions and actions based on climate information, which often also includes expert advices on how to react to that information [22]. Crucial success factors for climate services can be defined as follows: understanding end-users demands, bringing climate forecaster closer to sector experts, co-producing the information to match user needs, reaching the last mile, and continuous assessment and re-assessment [22]. Climate services have many possible target sectors, such as agriculture, health, and disaster reduction. In designing climate services, one needs to pay attention to seamless and timely information flow between information providers and end users. This requires streamlining the traditional way on how information flows between different parties, since weather forecasts may take weeks to pass through various actors, such as meteorological agencies, regional experts, and district councils until reaching the end user [25].

[1] http://www.tcrs.or.tz

We can utilize learning's about the suitable content for climate services from many current climate service projects that have been launched, for instance, in Kenya, Uganda and Tanzania. In Tanzania, a project operating under the Global Framework of Climate Services was using participatory methods to train intermediates, which would spread climate information to rural farmers[2]. In Uganda, a project called Climate Change Adaptation and ICT (CHAI) reached 120 000 farmers, which receive weather forecasts and locally tailored agricultural advises by SMS. CHAI uses various technologies to collect weather data from 22 sub-country weather station[3]. The results of another project in Kenya revealed that farmers who received climate information were better in crop management and got higher yields, as compared to farmers in the control group [20].

Other relevant studies about information needs of the farmers especially in Tanzania are [12, 3, 6]. Bernard et al. studied the information needs of the rice farmers in Kilombero interviewing in total 80 people in four villages [3]. Lwoga et al. studied the information needs of the rice farmers in seven districts, interviewing in total 181 farmers [12]. Coulibaly et al. presented in [6] climate information needs of the farmers in the Longido and Kiteto districts based on interviewing in total of 360 households. A relevant study to comprehend local needs, understanding of climate change and availability of different information sources in Tanzania is the latest Afrobarometer [21], which interviewed 2400 Tanzanians in May 2017. Out of the 2400 interviewees, 2/3 were rural residents, out of which 71% where farmers and 5% were from Morogoro region.

3 Methods and data

There is a constant change in crucial systems such as cultivation practices, agricultural education, technologies in the local communities, climate, and climate variability. Therefore, to address the growing need for resilience and agility in development work, we use the System Action Design Research framework (SADR) and Epistemic Implementation Delphi model (EID) [8] in project implementation. SADR is an extension to Design Science Research (DSR) [10, 16]. EID is a scientific model for project implementation that is based on building a mutual agreement between stakeholders [8]. DSR is different from "routine design", where existing knowledge is applied to solve problems by using "best practice" knowledge and theory [9]. In SADR and EID, rigorous research methodology is brought to back up the design process in situations, where the end-user demands, contextual and sociocultural factors, and many other important issues in the design process are not understood well enough to use a linear design process [8]. SADR and EID are specifically designed to fit well into the developing country contexts [8].

[2] https://www.wfp.org/stories/climate-services-farmers
[3] https://www.fhi360.org/projects/climate-change-adaptation-and-ict-chai

3.1 Data collection protocol

The data was collected in a two-week period in April 2018. The actual interviews took place in three different days during which the researchers interacted with farmers in the Tambuu village. The first two days were dedicated to qualitative data collection. In total, 17 farmers participated in the research. From these 17, deep interviews were arranged with a total of 13 farmers (6 males, 7 females).

The recruitment of interviewees was done with the help of our local NGO cooperation partner TCRS, which has been operating in the Tambuu village for nearly a decade, and therefore have good connections to village elders/leaders and local farmers. TCRS selected suitable farmers to participate in the project. We requested that half of the interviewees would be women and half men, and that they would also represent different ages, education and mobile literacy levels. TCRS also ensured that interviewees where present on the right day in the village house, where we conducted the interviews. This selection process naturally affected the final outcomes of the interviews, and therefore full range of views and ideas of the local farmers might not be reflected in the results. However, we believe that the selected group represented well the village and that the selected interviewees where free to express their thoughts without outside monitoring or other limitations. Considering the local context, such as trust and communication barriers, this method was the most feasible way to arrange the interviewees' selection.

The interviews were conducted using the interviewee's mother tongue, Swahili. We had two interview teams, each of which had one Swahili speaker and two researchers from UTU. Each interview lasted between 40 to 70 minutes and they were also video-recorded. In each interview, we used a set of beforehand agreed questions. The questions were originally written down in English and then translated into Swahili during the interviews. During the interviews, interviewees answers where summarized in English, so that the UTU researchers could also get an idea on the answers and have change to ask additional questions. This practice was noted to be working well in this kind of context. Later the interviews were also transcript in Swahili and then translated into English, in order to make more detailed data analysis. This paper reports a preliminary analysis of the collected data.

4 Information needs

4.1 Socioeconomic characteristics

The socioeconomic characteristics of the interviewed farmers were found to be as follows. (1) out of the 17 farmers, 10 were males, and 7 females; (2) the household sizes ranged from 3 to 9, with an average household size of six (6) persons, and average age of 42 years (min=23, max=58); (3) the main sources of income for all of the interviewed people were farming, and farming-related activities. Work in agriculture ranged from growing crops to managing livestock, as well as related production services and agricultural marketing. Fourth, the most commonly grown crops were maize, cassava, rice, banana, vegetables, potatoes, tomatoes, and oranges. The live-

stock included chickens, goats, and cows. Also, ponds were actively used for growing fish for nutrition. Fifth, the typical total farm plot size was around 2.5 acres per family. Only very limited amount of active co-operation with extension agents was reported. The reading and writing skills of people in Tambuu varied, but in general it was found that most were able to read distinct words and short sentences.

4.2 Impacts of climate change in Tambuu

During our discussion with the farmers it became obvious that they have experienced significant changes in the local climate during the last few decades, and those changes have affected their lives and agricultural practices. The farmers also reported to have received training about the impacts of climate change; how to identify the impacts and how to partly mitigate to them. The local farmers have witnessed changes mainly in temperature and rainfall. In regards of temperature, there have been an increase of hot days and nights, but also increase of periods when temperature is lower than usual. Rainfall variability has also increased: heavy rains at one moment and prolonged dry periods in the next, as well as increased variability of the starting day of the seasonal rains. Regarding to that, farmers reported a need for more credible weather information and skills to use such information for more productive agricultural practices.

4.3 Good agricultural practices

Farmers reported that they need better information about productive agricultural practices. The most urgently needed agricultural practices in the Tambuu community were found to be techniques for cultivation of maize and rice crops. Information about agricultural practices includes knowledge on planting the right crops on the right soils, how to use fertilizers, how and when to irrigate, how to control pest, and how to harvest efficiently.

4.4 Production inputs and other issues

Farmers in Tambuu suffer from a lack of production inputs: improved seeds, and proper fertilizers and pesticides. Farmers reported that they use locally grown seeds which are low in productivity and are obtained from the stock of the previous year, neighbors or other nearby people. Chemical fertilizers are typically not available at the local markets, and if they are, they might be counterfeit, expired or otherwise spoiled.

Other issues revealed from the interviews included the following: (1) timing of harvesting was found to be a challenge. For each different crop, there is an optimal time for planting, sowing, and harvesting. Credibly documenting these in a crop calendar was reported to be sometimes challenging; (2) proper marketing after the harvesting to get the best value, was found to be a challenge; (3) insufficient financial services were reported to be a major concern for all the members of the Tambuu community. Lack of education, conflicts between farmers and pastoralists, and forest fires were also reported as challenges; (4) in relation to fertilizer use, soil management was found to be a concern. Proper soil test could help to insure the proper application of

fertilizer, by considering the nutrients already present in the soil, as well as the pH level and the salinity of the soil.

4.5 Sources of information

It was found that Tambuu community depends on a number of sources for farming information. These include extension workers, radio, television, film shows and agricultural pamphlets. However, it was found that access to agriculture information in regards of the available sources was constrained. The study revealed that a significant portion of information was domestic, and based on indigenous knowledge, such as inferring from the appearance of certain species of birds on the field. A small amount of information was reported to be gained through television, radio, and internet. In regards of weather information, sources included radio and television. However, those methods were not regarded as fully trustworthy. In addition, proper interpretation of the available weather information was perceived as a challenge. Intuition was reported as a common method for decision making.

4.6 Information needs matrix

Table 1 summarizes the findings by listing the acute information needs of the Tambuu community. In regards of near future, taking into account the climate change and change in climate variability, credible and trustworthy weather information is extremely important, but currently only available to some extent. In addition to future climate services, general agricultural education, seed information, marketing data, soil management tips, soil testing service, financial services, and marketing skills are of extreme or high importance.

Table 1. Information needs of Tambuu

Acute information and other needs
Credible and trustworthy weather information
Knowledge in best uses of weather information
Education about best farming practices
Farming inputs (seeds, fertilizers, equipment)
Soil management tips and soil testing service
Financial services and marketing skills

5 Mobile device usage in Tambuu

5.1 Ownership of mobile devices

Out of the total 17 study participants, 14 owned a basic phone and 3 owned a smartphone. Study participants explained that each one owned the mobile phones they used, and that they were typically not sharing mobile phones with others. On the other hand, some participants were unable to distinguish the difference between a basic mobile phone and a smartphone. Smartphones were sometimes referred as “Touch”, and feature phones as “Sim”. Regarding the mobile internet connectivity, we found that out of three largest operators in Tanzania, only one had G3 mobile data coverage in

Tambuu, which was also rather weak. Two other network operators had G3 mobile data coverage around 5 kilometers away from Tambuu.

5.2 Usage patterns of mobile devices

Several usage patterns for mobile devices were found. First, it was found that the most common smartphone applications used were short messaging services (SMS), and voice calls, followed by calendar, clock, and calculator applications. In regards of other, currently unused smartphone applications, some study participants were unaware of how to use them. One participant noted: *"I see those applications but when I touch the features icon, I cannot go to the next steps because I do not know what the next outcome shall be and sometimes, I feel like stopping the use of most applications."* In regards of information domains, the participants explained to use smartphones for communicating with relatives, friends, and other groups about social, economic, but not for political aspects. The leading practice was explained to be social inquiries, followed by economic information seeking. Social inquiries included, in typical cases, family affairs that are geared in traditional taboos. Inquiries for markets in regards of product prices were common. For example, one study participant said: *"I am coming from faraway (pause) the hilly areas (pause) and before coming along the roadsides (Main road) with my product, I must communicate with my relatives and friends to know the prevailing market price of a bunch of a banana, peas, yams."*

In all these cases, short messages, voice calls, calendar, clock, and calculator were the most used features. In addition, rare usage of WhatsApp, internet, camera, and Facebook for communicating with relatives was mentioned. For example, one respondent was taking photos of a crop plant affected by insect and sent them to more experienced relative for advices on how to use pesticide to safe-guard the plant. Thus, more "modern" information technology usage patterns were also found.

5.3 Cost of using mobile devices

The question of how much money farmers spend for usage of their mobile devices was also one part of the interview questions. We found out that interviewed farmers were spending between 1000 TSh to 2000 TSh (from 0,45 USD to 0,9 USD) per week on buying phone credits for their phones. Smartphone users were also buying data credits for their phones, however in small quantities since relatively high cost of data limited their willingness to use mobile data. One other important aspect is the charging of the phones. Since there is no connection to electrical grid at the Tambuu village, people use generators and small solar panels, which are becoming more affordable and thus more common. Few of the interviewed farmers owned their own solar panels, rest where paying for their neighbors or friends to charge a phone. Common charging fee was between 200 TSh to 300 TSh (from 0,09 USD to 0,13 USD) per charge, and farmers where charging their phones between every few days to once a week.

5.4 Challenges encountered

The challenges in mobile usage were divided to the following six categories. First, weak network coverage was found to prevent effective smartphone usage. One study participant noted: *"I rarely use my touch because of poor coverage and weak signal.....*
My ordinary mobile phone has very strong signal and powerful than touch almost everywhere in the village, even if I am in the field work (farming business activities) I still communicate fluently. I enjoy using my touch when in town than being in the village."

Second, technical competence was regarded as limited. One respondents said, *"I am not familiar with many features and operations that make touch not very usable to me, I do not know anything on them, some of them have nice pictures and music that attract my young daughter when crying."*

Third, high prices of smartphones was reported as a problem. Although the village produces farming related products, the market price was low compared to city centers; sometimes prices could be even six times higher in the cities. In regards to smartphone prices, based on the researchers visit to a local mobile phone retailer in Morogoro, common low end smartphone models were costing between 85 000 to 90 000 TSh (37 to 39 USD). When taking into account that Tanzania per capita GDP was 2 131 299 TSh (934 USD) in 2016[6], and our interviewees were reporting relatively low incomes, ranging from 95 000 to 650 000 TSh (41,6 to 284,7 USD) (however these figures should be taken with certain uncertainty, because of issues relating to lack of bookkeeping, memorizing and differences on what is counted as an income). Therefore, it can be noted that these smartphone prices would represent a big part of their income. As one respondent noted: *"We produce a lot of farm products, but the prices are too low, the middlemen traders are exploiting us, we cannot afford transportation costs (Too high) to municipalities. I bought my touch on performing extra duties (Building construction) apart from farming."*

Fourth, usability was reported as a challenge. For example, the touch screen in smartphones was explained as too delicate thus inconvenient to handle with farmers' hands that are constantly at work holding farming equipment and tools and doing rough work in nature. Thus, participants said touch screen was unfavorably to users. One respondent noted: "While in my fish pond feeding the fish my phone was ringing and I could not pick it up because the touch screen does not like wet and rough fingers, does not like water on the screen and my daily activities involve touching water throughout."

Fifth, language was found to be an issue. Participants noted English language was discouraging as it was a strange and were not ready to adopt a new language.

Sixth, education and training was found to be an important issue. During the sessions the participants noted that paying for any training and education is impossible. One participant noted: *"I have five children, two in secondary school, two in primary school and the last born is yet to start school. That is headache to me."* Participants were also unaware of any of the existing mobile-based agricultural information services. However, participants were interested about possible future services.

Table 2. Table of Mobile Usage Patterns and Challenges

Ownership
14 out of 17 owned a normal featurephone Mobile phones are typically not shared 3 out of 17 of participants owned a smartphone
Usage patterns
Voice calls, short messages, calendar, clock, calculator Social and economic inquiries Some WhatsApp, Internet, camera, and Facebook usage Both typical and modern information usage patterns
Money usage patterns
1000 - 2000TSh per week for airtime (0.43 - 0.86USD) Batteries are charged by using generators and solar panels Charging cost between 200 - 300TSh (0,09 - 0.13USD)
Challenges
Weak mobile network, Technical competence, High prices Usability: too delicate touch screen, English language

6 Discussion

Tambuu community has a number of positive aspects including good soil quality, favorable climate, variety of fruit trees that can grow in the area, and availability of water. Therefore, Tambuu is a suitable area for further agricultural development. However, a number of challenges are still blocking the prospering of Tambuu farming community. Unpredictable climate variability, caused by climate change, is probably the most serious challenge for the near future.

6.1 Information needs

It was found that in the Tambuu community, the impacts of climate change have been experienced by farmers, and that they are also knowledgeable about climate change. The farmers' observations of changing climate patterns are well backed up by measurements and analysis done by both the Tanzanian Meteorological Agency (TMA) [5], and Berkeley Earth[4]. Farmers regarded their climate information needs as urgent and something with a high impact to their crop yields. Findings are rather similar to those reported by Coulibaly et al. [6]; in both cases farmers expresses mistrust to current weather forecasts and where requesting weather information to be connected with agricultural tips on how to adapt to those changing conditions.

These results can also be compared to findings of the latest Afrobarometer, where 32% of the surveyed rural Tanzanians had heard about climate change and 52% of respondent thought that conditions for farming where "worst" or "much worst" due to climate change now than ten years ago, while 26% thought that they very either "better" or "much better". However, same figures for respondents in Morogoro region where 39% and 40% respectably, stating that they see their region agricultural conditions being slightly better in terms of climate change effects compared to the whole Tanzania [18].

[4] http://berkeleyearth.lbl.gov/regions/tanzania

In regards of rainfall, future scenarios concerning it vary a lot. Rainfall may increase or decrease in the future [23]. What is certain is that the uncertainty will increase. This uncertainty is related to a starting times of the rains, duration of the rains, and durations of dry spells between the rains. The uncertainty will make it hard for farmers to make decisions about when to start planting or when preparing for drought period. There is also a rather strong variety in annual and monthly rainfall year by year and month by month [5].

Several other information needs were found as well. The most important ones are the knowledge of agricultural practices, such as techniques for cultivation of maize and rice crops, and need for production inputs, not to mention general agricultural education and training needs. In regards of information sources, it was found that current means for weather information was not regarded as that trustworthy or reliable. Typical sources were extension officers, radio, television, pamphlets, friends, relatives, and neighbors. These results are mostly in line with the findings of Benard et al. [3] and Lwoga et al. [12].

6.2 Current mobile usage patterns

In regards of the current mobile phone usage patterns, it was found that the most popular applications are voice calls, short messages, calendar, and clock. However, more ”modern” uses were also found, when, for example, farmers took photos of insects and sent them for analysis to a relative. Smartphone ownership was found to be relatively low, but estimated to increase. Social inquiries and economic information seeking were found to be the typical smartphone usage patterns. Usage of short messaging services and social media applications was also found, to a relatively small extent, though. Although for some smartphone owners, the main reason for the purchase seemed to be the access to WhatsApp, which would reduce the communication costs when compared to using airtime credit for calling or sending SMS.

A number of technical challenges were revealed also. These included weak network coverage, low technical competence, high prices of mobile devices and airtime and data credit, usability issues of smartphones, especially relating to the touchscreen, and English language. These observations are similar to the findings of Medhi et al. [15], Wyche et al. [24] and Aker et al. [1] about the usability issues of phones in the rural areas of developing countries.

An important technological aspect is the user experience of the proposed service. Therefore, we conducted technology prototyping and icon design session, which results will be presented in other conference paper [17]. Future phases of this research will include developing advanced prototype based on the user needs and our experiences, which would allow us to test how users respond to different layouts, navigation and information presentation types. Final aim of the project is to conduct through user-test to verify the benefits of the climate service app.

7 Conclusions

In developing countries, the impact of climate change is already being experienced as uncertain weather patterns, which seriously complicate the life of small scale farmers. How to provide farmers with accurate predictions to assist them in farming decision making is a crucial problem. However, smartphone ownership is rapidly increasing in developing countries, and smartphones provide an excellent platform to run future climate service applications that may assist small scale farmers in their daily practices.

However, as multiple research [2, 4, 7] have pointed out, is not only about providing the information, but also providing infrastructure related developments (such as improving road quality and access to electricity), that can improve farmers livelihoods. Based on our findings, we can fully agree on that statement.

Limitations of our study was the rather small sample of 17 farmers, in a village with 2 684 inhabitants. Also, when generalizing results from one village to be fit for population of Tanzania (around 55 million, out of which 75-80% are related to farming), it is clearly that they are not representing all the various issues that the farmers encounter in different climate areas and cultural contexts.

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