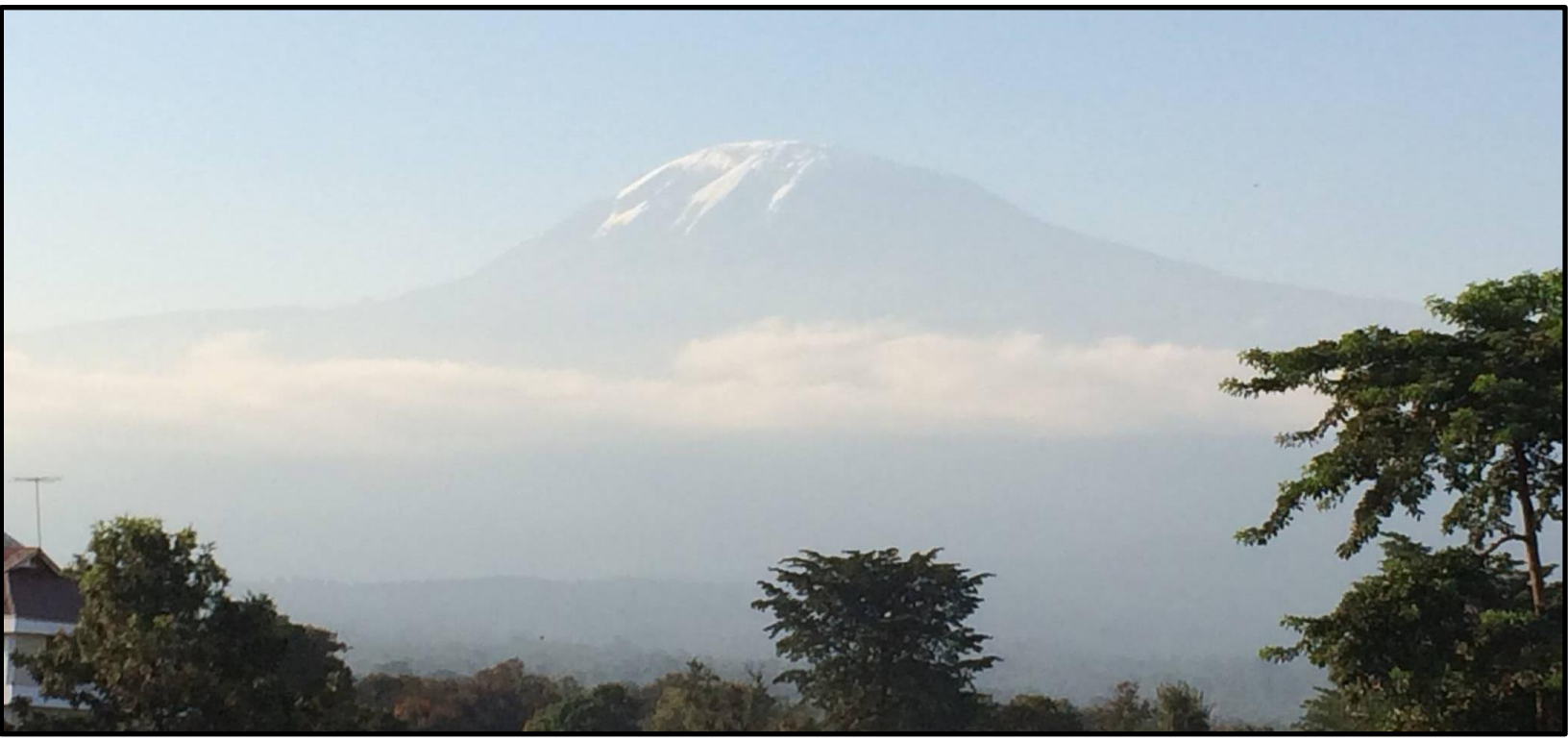
Disseminating Weather Information to Smallholder Farmers in Rural Tanzania



Academics for Development and Kukua B.V

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Final Report

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1. Introduction

Droughts, unpredictable rain and volatile weather patterns due to climate change are severely affecting the livelihoods of smallholder farmers in the Global South. Weather fluctuations with associated heavy rainfalls exacerbate flooding and soil erosion eventually impacting vegetative covers and soil water availability (Scherr, 1999). In Tanzania the effects of climate change are increasingly affecting yield. Tanzania is reliant on rain-fed agriculture (e.g. maize) and calculations show the average yields for maize dropped by one third due to increases in temperature limiting the length of rainfall (Agrawala et al., 2003). Research has shown that over a 100-year period around 33% of disasters in Tanzania were related to droughts; consequently these problems place a huge burden on farming families (Mongi et al., 2010).

The vulnerability of smallholder farmers is amplified by their inability to access reliable, precise and comprehensive weather predictions. Current weather predictions in Tanzania are very inaccurate and imprecise. Kukua estimates that to provide the whole African continent with accurate weather information, more than 7,000 weather stations must be installed. Without proper means of predicting the weather, the yield gap between potential and actual yields is widening subsequently exposing farmers to hunger and poverty (Mourice et al., 2014).

In order to increase food production, socially equitable and sustainable technologies are needed to increase crop yields and aid farmers with farming activities (Altieri et al., 2011). A 2012 study by Churi et al., in which 240 smallholder farmers were interviewed, found that up to 70% of the respondents considered climate information an important input to farming decisions in rain-fed agricultural systems of dry land areas, irrespective of socio-economic conditions. However, access and use of agricultural information in rural semi-arid areas in Tanzania is currently limited. The study concludes that crop production risk caused by climate variability cannot be managed in the absence of climate information.

The introduction of technologies in the wake of climate change can have a profound effect on the livelihoods of farmers. However, in order to effectively aid farmers it is imperative that local knowledge and needs are incorporated, by exploring viable solutions in the form of technologies whereby investments in local capacity building are necessary. Within the scope of this research, local knowledge or indigenous knowledge, refers to knowledge embedded between and within communities, namely with regards to local agricultural knowledge (DeWalt, 1994). Locating this knowledge is an important source in developing technologies based on the needs of communities; this in turn will contribute towards empowerment, as locals are part of the technological development (DeWalt, 1994).

The importance of including local knowledge in the wake of climate change is also investigated by Komba & Muchapondwa (2015). The authors studied to what extent Tanzanian farmers (534 households) adapted their agricultural activities based on their perceptions on climate change.

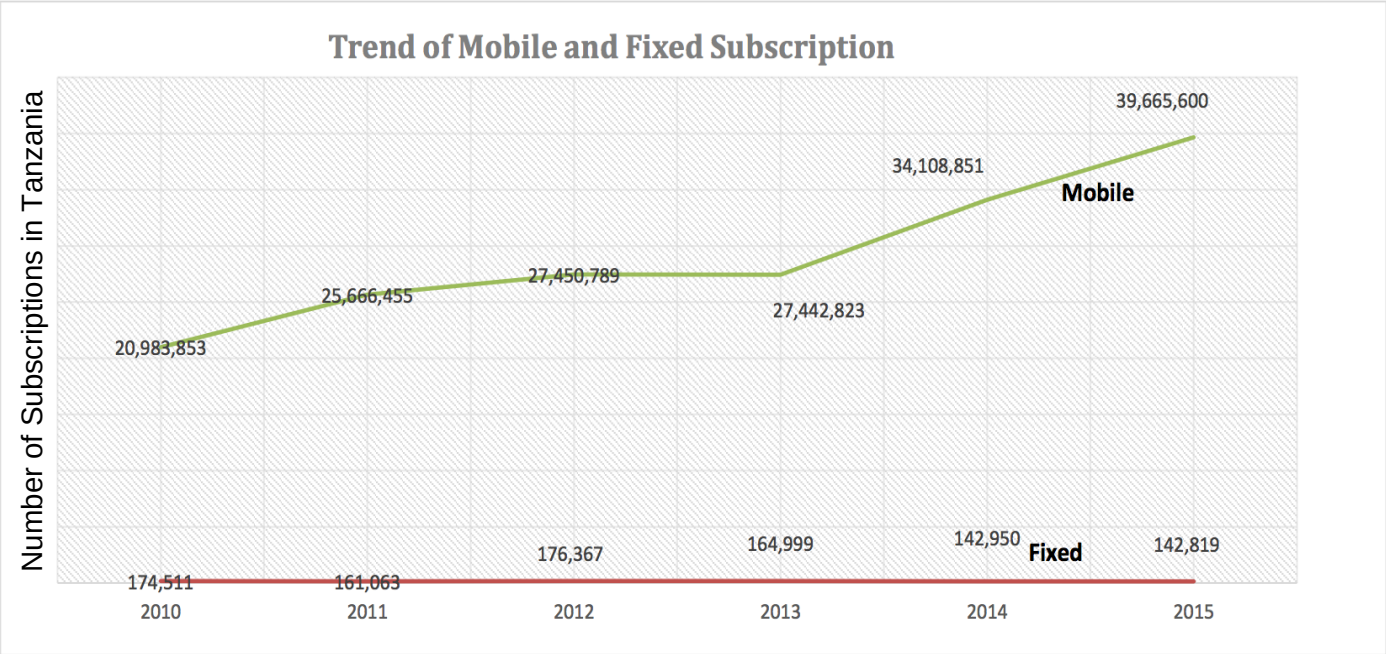
The study concluded that Tanzanian farmers use, "short-season crops, choosing crops resistant to drought, and [change] planting dates" (Komba & Muchapondwa, 2015, pg.25).

This study aims to correlate climate change variations, local knowledge and the use of technologies to explore the potentials of using SMS services to provide smallholder farmers in Tanzania with more accurate and reliable weather information.

1.1 Telecommunication in Tanzania

Communication channels and knowledge transfer across ICT mediums in rural areas in Tanzania holds potential for smallholder farmers in making farm-level decisions, as the use of mobile phones has dramatically increased despite relatively low levels of literacy and low income levels (Churi et al., 2012). The Tanzanian literacy rate in 2015 was 70.6% (UNESCO, 2013, p. 36).

According to the Tanzania Communications Regulatory Authority (TCRA) the number of mobile subscriptions has escalated between 2010 and 2015 (Graph 1):



Graph 1: Telecom mobile subscriptions 2010 - 2016 (Tanzania Communications Regulatory Authority, 2016).

In 2011, there were 157.025.351 mobile phone transactions valued at 6.75 trillion Tanzanian shillings (Genuchten et al., 2012, p. 6). The dominant telecom providers in Tanzania are: Vodacom, Tigo, Zantel and Airtel.

1.2 Research Aim

This report examines the extent to which ICT communication channels (in this case mobile phones) can distribute weather data to local smallholder farmers in semi-arid areas. The research team explored how Kukua can successfully deliver accurate weather information to the farmers in the form of an SMS. Through interviews with both smallholder farmers and experts, the research explored: local demographics, crop cycles, weather accuracy, locations where farmers receive weather forecasts, and the extent to which local smallholder farmers are willing to use and pay for Kukua's weather forecasting services (See appendix for questionnaire). The aim of the questionnaire was two-fold; on the one hand it provided information necessary to design SMS content based on the needs of farmers, while on the other hand the questionnaire explored the extent to which farmers were willing to pay for the weather information.

Willingness to pay was assessed for two main reasons. First, in order to enable Kukua to provide this service in a financially independent manner, income must be generated. In the exploratory phase of designing and developing the service, the viability of farmers paying directly for this service was assessed. Secondly, in light of changing climate conditions and the effect these patterns have on crop yields it is imperative to research to what extent farmers are willing to use the weather information. Their willingness to pay provides an indication the importance of weather information for farmers and the need for this service. Hence, the central focus of the research were the farmer's *needs* and *desires* in relation to weather services. With this information the research team devised an SMS format based on preferences from the farmer's perspective. The research team consisted of students from the organization Academics for Development Utrecht, recruited from different universities across the Netherlands.

2. Kukua Weather Services

Kukua B.V. is a Dutch company with the aim to have social impact by contributing towards increasing food sovereignty for small-scale farmers in amongst others Tanzania, Kenya and Nigeria. With the installation of Kukua's low-cost weather stations, Kukua currently gathers data, which is analyzed by Finnish forecasting, company Foreca, providing weather forecasts for the African market. These small, low-cost devices can create a monitoring network that is dense enough for accurate, localized predictions, which was hitherto not possible in Tanzania. One of the ways in which Kukua plans to use this data is to provide small-scale farmers with weather predictions through an SMS service at the lowest possible price. Kukua has currently installed 10 weather stations in northern Tanzania, which have been operational since August 2015. These weather stations are located in Lushoto and Moshi, shown in figure 1.

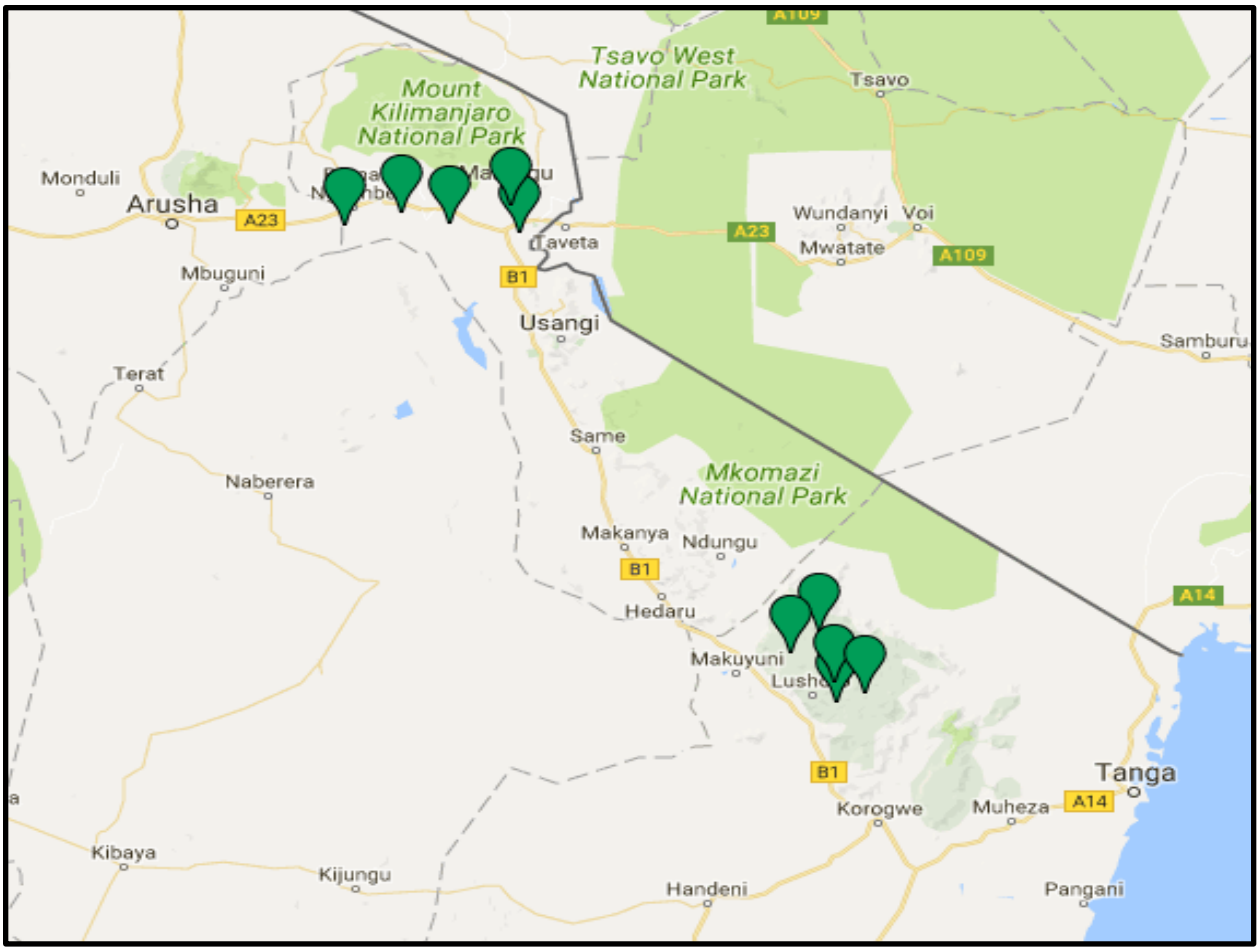


Figure 1.: Installed weather stations in Lushoto and Moshi

Kukua cooperates with several partners, including the International Institute for Tropical Agriculture (IITA), which is one of the world's leading organizations in finding solutions for hunger, malnutrition and poverty. Other partners are the aforementioned Foreca, the Dutch electronics design company SODAQ, global SIM Card provider Eseye and the owners of telecom towers. Kukua's main activities named by co-founder Ollie Smeenk are the design of weather stations, development of weather station roll out strategies, aggregating data from different parties, data sales, software development, fundraising and development research.

Kukua's value proposition is providing more accurate weather forecasts due to on-ground validation as they generate more insightful, clear and consistent data by installing weather stations in key areas (figure 1). The gathered data is processed in a weather model to predict weather patterns, which is outsourced to Foreca. With the installation of more weather stations, Kukua will have more available data sources, which will enhance the variety of inputs into the prediction model, in order to increase accuracy. The processed weather data is then distributed

by Kukua’s automatic software system based on name, location and phone number of the recipient.

Kukua focuses on the triple bottom line; people, planet and profit. In order to provide weather forecasts to smallholder farmers at an affordable price, Kukua plans to subsidize this service with the revenues they can generate through the sale of their data to commercial parties. Sales to commodity trading, crop insurance and hedge fund industries are sources of potential revenue streams in order to sustainably fund Kukua's operation and growth. The direct cost of providing an individual forecast SMS is up to €0.03. This excludes the indirect expenditures required to collect and process the weather data, and to operate the business.

3. Methodology & Planning

The AFD & Kukua team started desk research in March 2016, studying the socio-economic and cultural environment of Tanzania. As the research team began to understand the context in Tanzania and explore further Kukua’s business they narrowed down their research scope to the regions of Lushoto and Moshi.

The preliminary phase focused on existing research and data relying mainly on published articles and journals. The journals provided the team with extensive knowledge covering topics related to, but not limited to, how farmers understand climate and the diffusion of technologies. For example, Roncolli (2006) identified a range of opportunities and constraints when applying climate forecasts to agricultural decisions. Numerous studies have shown that forecast information is less likely to reach the rural poor, although radio programs are popular however, signals do not always reach remote areas. While another way to reach marginal communities is through mobile websites, the Internet is not always available for poor farmers. One effective method is participatory farmer workshops, which are building upon farmers’ own knowledge and experiences. This demands interaction with the farmers highlighting the way farmers understand and perceive the climate, subsequent uncertainties and the credibility and accuracy of climate information. These insights provided the research team with sufficient information to develop a research framework and to find key components and concepts from which a questionnaire would be created.

3.1 Understanding the Farmers and Crops

In order for the team to understand the research context in Tanzania, different aspects were taken into account: Firstly the beliefs, knowledge and understanding the farmers have of the weather, followed by a systematic plan to estimate expected sample size in each location by using farmer density. Similarly, to identify primary crops, stages of the agriculture cycle, types of seasons and

stages important for farming were evaluated. Finally, research was conducted by looking at the socio-economic state (income per capita, purchasing power of farmers, etc.) for each location.

The second phase was to determine the cell phone usage amongst rural/farming communities: These included queries such as how many farmers use cell phones, the types of phones, whether they trust information provided by telecommunication companies. Additionally the research team aimed to identify key cell services providers, prominence of mobile payment services. Part of Kukua's goal was to understand the willingness of smallholder farmers to pay for the provision of accurate weather information, as a service. Thus in order to incorporate this within the study, the research team dove into identifying key factors that affect consumer's willingness to pay for a new service. This was amalgamated together with the findings of the traditions and perceptions of smallholder farmers to operationalize concepts and questions used in the preliminary questionnaire. This first draft was used to interview smallholder farmers in both Lushoto and Moshi in order to develop a template design for the SMS service.

3.2 Constructing the Survey and Semi-structured Interviews

The research team opted for a mixed methods approach for the field research. This approach was deemed the most holistic and efficient within the allocated timeframe to extract detailed information from a smaller sample and general information from a larger sample. Qualitative elements of the research project centered on interviews with open questions. In order to gather more quantitative information closed questions were integrated into the interview. Based on the literature review, the team constructed a preliminary questionnaire. As the questionnaire was an important component for the research the team presented their findings to an audience of students, academic staff and professionals during their midterm presentation. The research team asked the audience to provide them with feedback, which was analyzed and used to improve the questionnaire.

The majority of the survey consisted of closed questions: this was to ensure that the interview time was short and data could easily be codified and stored in a spreadsheet format. In addition, an adjusted Likert scale (a 1-5 scale translated into nominal categories) was used to measure respondents' attitudes to a topic. The gathered information was recorded in a spreadsheet and tallied; the data was analyzed using statistical programs (Excel and SPSS).

The structured interviews (following the questionnaire format) were conducted according in order of general information; i.e. age, name (etc) followed by household information such as size and role in the household, and main type of income and types of crops grown. The second section was on weather perception and lastly was information on the Kukua weather SMS pilot. Ultimately the goal of the questionnaire was to gather the following information:

I. The individual farmer's perception of the weather

II. How weather forecasts influence them (as proposed in research question 1. Sub-questions (e.) and (f.)).

At the end of the survey, the team introduced the farmer to Kukua's products. This was done after I and II, and therefore did not influence the farmer's responses to those questions.

3.3 Feedback Phase Survey

The first phase of the research consisted of interviewing farmers regarding perceptions of weather and interest in additional weather information. The farmers were asked whether they would like to participate in a pilot phase, in which they would receive a daily SMS with weather information for their location, free of charge. During the pilot phase Kukua sent out text messages to farmers (those that indicated that they wanted to receive text messages) for a total of 10 days. After the pilot phase was completed the team visited the villages again for the feedback interviews. Due to time constraints only four villages for both Lushoto and Moshi were sampled. During the pilot phase a separate survey for the feedback rounds was constructed. The main aim of the feedback sessions was to quantify the experiences of the farmers. Using a scale variable between 1 and 5, whereby 1 was the minimum and 5 the maximum response, the overall satisfaction rate of the text messages during the pilot phase was quantified.

Additionally, to measure the perceived accuracy of the weather information, the respondents were given 4 possibilities: Not accurate (1), sometimes accurate (2), mostly accurate (3) and totally accurate (4). These options are translated into a 4-point scale.

3.4 Expert interviews

Besides the structured interviews conducted with smallholder farmers in Lushoto and Moshi, in order to gain knowledge of farming practices in the regions the research team interviewed key informants to strengthen existing knowledge.

The key informant interviews were conducted with a number of selected respondents. The focus of these additional interviews was to construct crop-cycle calendars; to acquire practical information concerning the weather patterns and to ask what the respondents believed would be the most beneficial weather information for the smallholder farmers.

3.5 Research Ethics

Determining the local context behind the research in Tanzania was a significant component of the research. As the team was collaborating with local smallholder farmers in very remote locations, it was particularly important for them to understand the local context in which the research would be conducted. During field research, interviews with farmers were only to be conducted in the presence of both a representative from IITA or N2Africa and an AFD & Kukua team member to ensure consistent surveying.

3.6 Planning Field Research in Tanzania

Together with the IITA staff based in Dar es Salaam, the field research plan was reviewed and adjusted to meet the standards and expectations of both parties. This meeting highlighted key aspects to consider when conducting the research; such as important farmer holidays and weekly harvest markets. With the help of Dr. Frederick Baijukya, the assigned IITA contact person and the N2Africa Country Coordinator for Tanzania, the team reviewed the entire questionnaire and adjusted the questionnaire to be shorter and more precise. The final questionnaire was translated into Kiswahili with the help of the extension officers and tested out with an initial sample of farmers randomly selected in the first village (Lushoto).

In each location the team met with a local IITA staff member also known as an extension officer, often a trained agrarian familiar to the weather and farming practices of the area, who introduced the team and the project. The farmers were informed about the aim of the field research and the AFD & Kukua research team. After the briefing each team member was paired with a translator and then interviewed the farmers.

3.7 Sampling the Farmers

The locations from which the farmers were chosen were based on Kukua's presence in the area. These villages were selected based on proximity to Kukua's weather stations. These locations were important because IITA extension officers could reach farmers close to these stations. This amounted to a total of 14 villages in both Moshi and Lushoto. The villages spread across low and highlands therefore having distinctly varied climatic conditions.

The research team had no influence on the selection of smallholder farmers that the team could interview per village due to the sample contacted through village chairs and extension officers. The team targeted to interview only between 15-20 farmers per village, but IITA extension officers contacted a total of 350 farmers (of which 310 responded). The extension officers acted as a medium through which the farmers could be interviewed; in collaboration with the village chair they contacted farmers and asked them to come to a central location at a specific time.

4. Research Findings

4.1 Demographic Characteristics of the Respondents

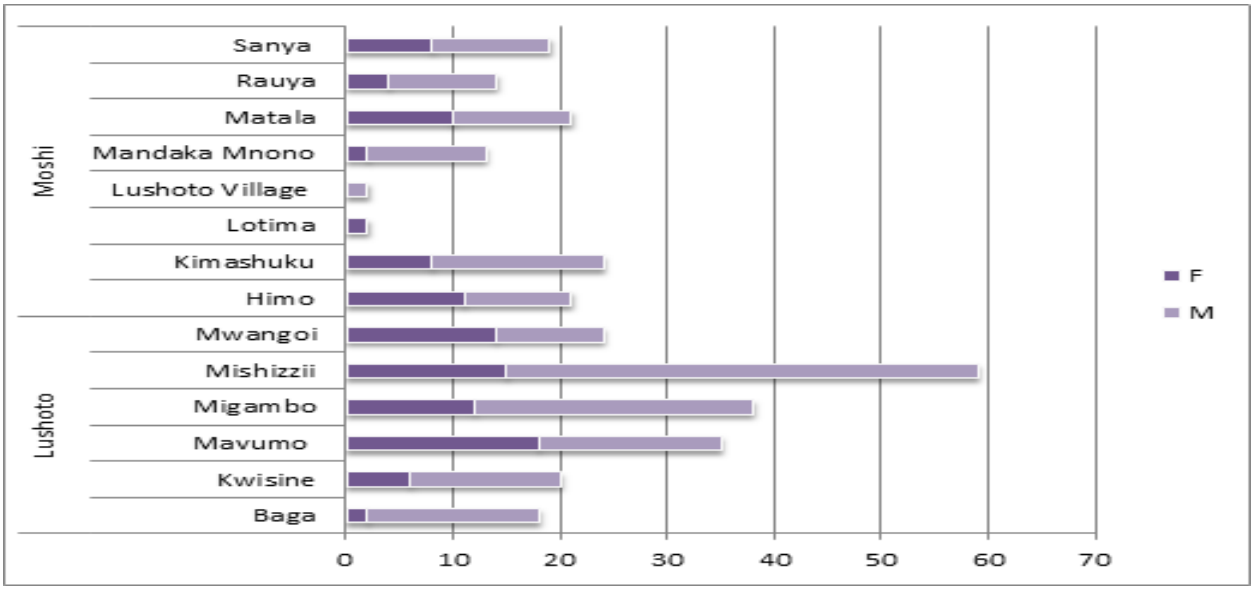
The following table (table 1) shows that our total sample size consists of 310 farmers spread over 14 villages close to Lushoto and Moshi, all in the vicinity of the installed weather stations. Of these farmers, the vast majority (97%) depends on farming for their livelihoods. The average farm size is 3.14 acres, indicating that these farmers classify as smallholder farmers. Of the interviewed farmers, 62% had seen or heard about the Kukua weather stations. Additionally, 92% of the farmers in the sample owned or had access to a cell phone. As aforementioned, the number of Tanzanians who has access to a mobile phone is rapidly increasing and therefore it is not surprising that there are a significant number of farmers who own a phone. Some respondents who did not own a phone did express that they would be able to share information with neighbors or shared a phone with their spouses. The village of Mavumo had the lowest number of respondents who owned a cellphone (77%).

	Number of respondents	Dependent on Farming	Average Farm size (acres)	Aware of Kukua weather stations	Owns or has access to a phone
Lushoto	**196**	**97%**	**3.52**	**74%**	**90%**
Baga	18	100%	3.64	50%	100%
Kwisine	20	95%	3.49	35%	85%
Mavumo	35	100%	4.23	66%	77%
Migambo	38	100%	4.14	63%	89%
Lushoto Village	2	100%	6.25	0%	100%
Mishizzii	59	98%	3.28	97%	92%
Mwangoi	24	88%	2.04	100%	100%
Moshi	**114**	**97%**	**2.50**	**41%**	**96%**
Himo	21	100%	1.57	19%	100%
Kimashuku	24	96%	2.18	33%	88%
Lotima	2	100%	3.00	0%	100%
Mandaka Mnono	13	100%	2.31	31%	92%
Matala	21	90%	2.30	19%	100%
Rauya	14	100%	1.96	79%	100%
Sanya	19	100%	4.21	89%	95%
Total	**310**	**97%**	**3.14**	**62%**	**92%**

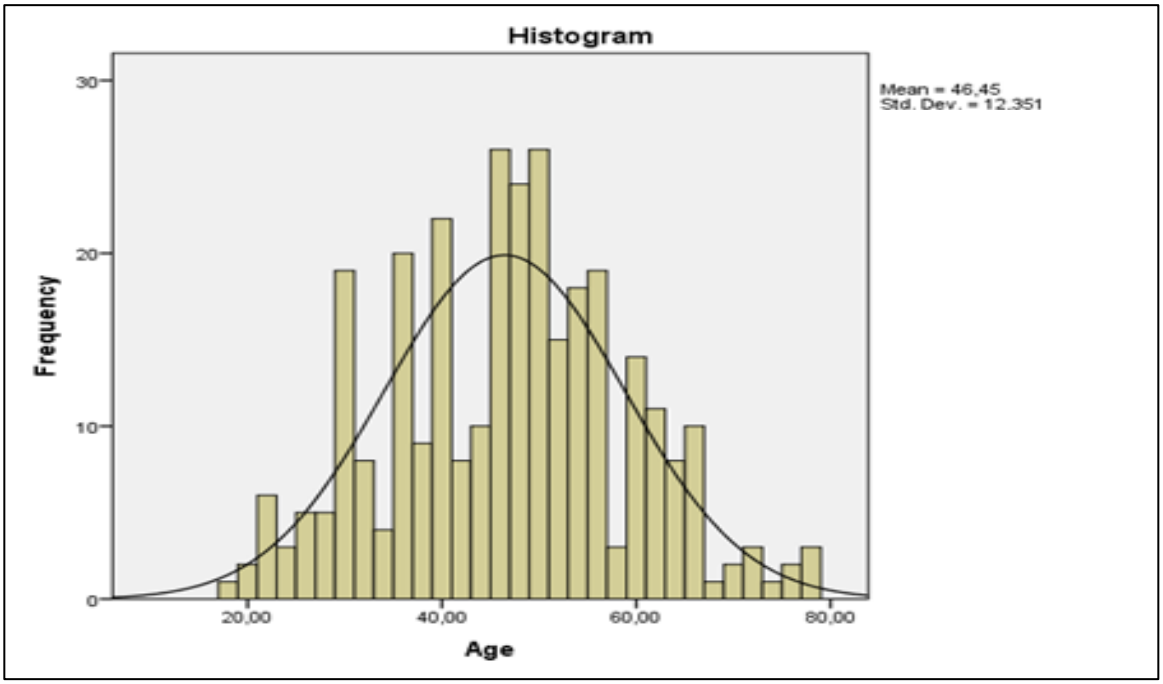
Table 1: Demographics and awareness

The respondents in Table 1 from Lotima traveled to Himo to be interviewed. Another noteworthy subset are the number of respondents who were aware of the Kukua weather stations, the discrepancy being due to the fact that at times the interviews were conducted near to the local weather station (hence the high percentage in some villages as a pose to others).

The following graph (graph 2) depicts the age distribution of farmer respondents per village and gender. The oldest respondents were from Mishizzii and the youngest from Rauya. The distribution of gender among the respondents varied per village. The average age of the interviewed farmers was 46 years (graph 3).

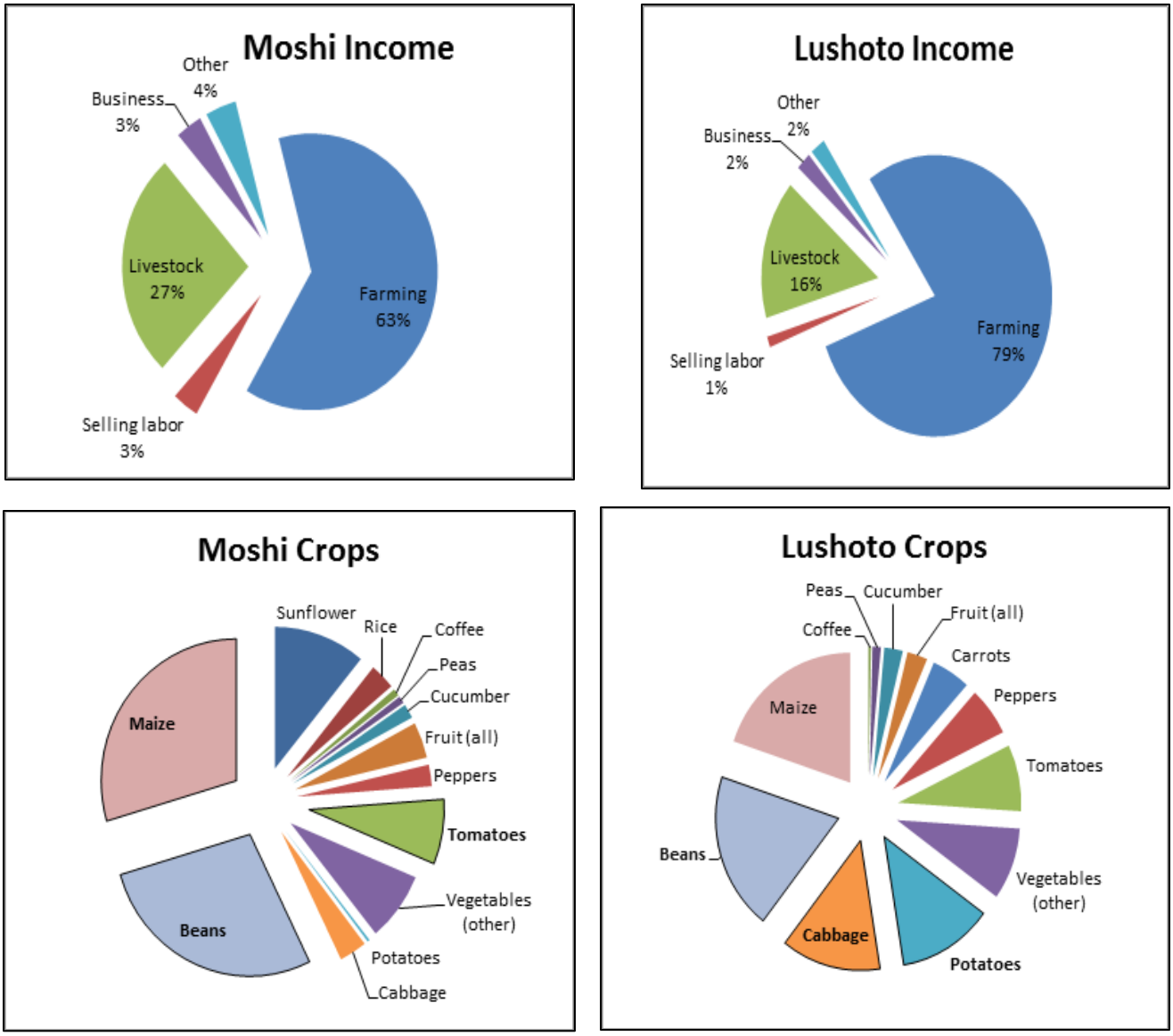


Graph 2: Age distribution of interviewed farmers per village differentiated for gender.



Graph 3: The age distribution of farmers

As seen in graphs 4-5 below, there is a higher income from farming crops in Lushoto than Moshi. However, raising livestock was more prevalant in Moshi than in Lushoto. Regarding crop types, graphs 6-7 show that maize and beans are clearly the most popular crops yielded in both Moshi and Lushoto. Although these are popular, many farmers shared that these crops have produced less yields in the past due to changes in weather patterns.



Graphs 4-7: Farmer income and specific crops farmed among interviewed farmers in Moshi and Lushoto *(Crops marked in bold and outlined indicate the crops that provide farmers with the most income).*

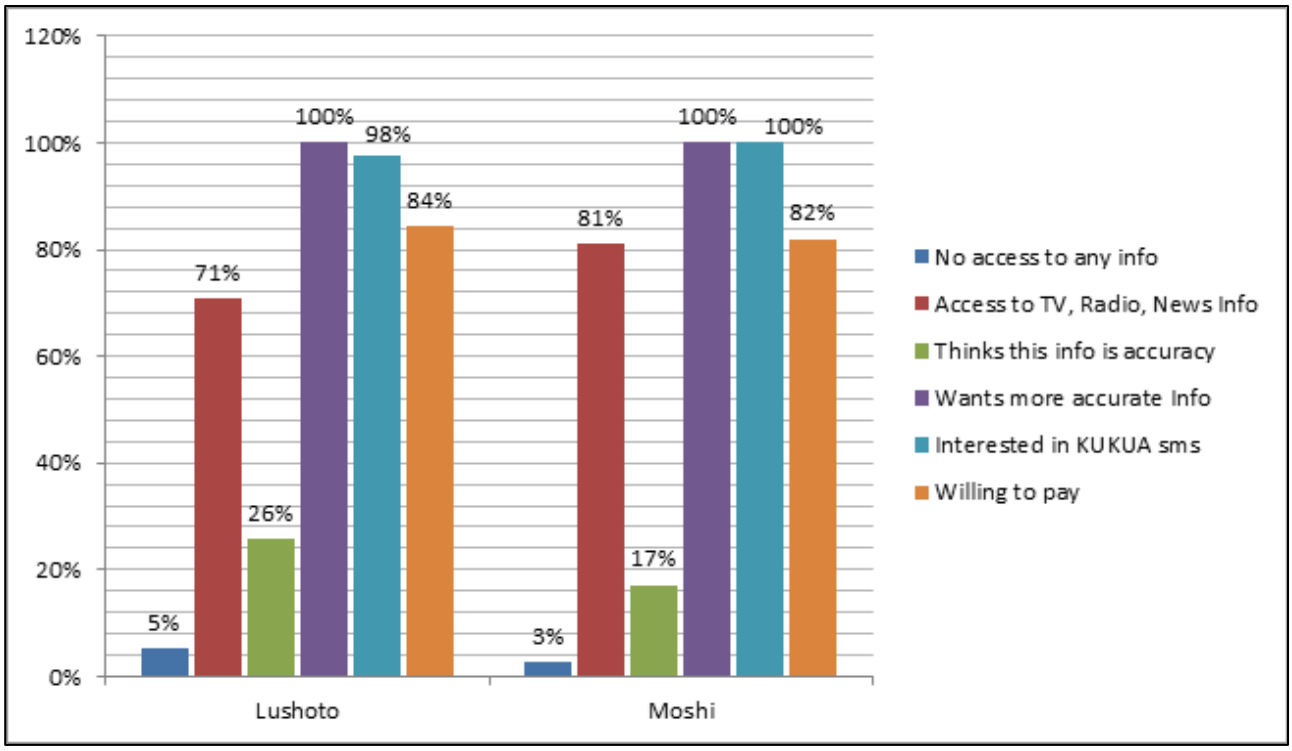
4.2. Changing Weather and Farming

Graph 8 on the following page summarizes the key findings regarding local weather and the adoption of the SMS service, for farmers who have access to a mobile phone (N=285). Currently, the majority of the respondents (75%) have access to weather information through TV, Radio or Newspaper. However, only 22% find the weather information to be accurate. Some respondents claimed that at times when rainy periods were forecasted, it ended up not raining. Subsequently, one respondent shared that she would be willing to invest in irrigation pumps but that it would not necessary as more accurate weather alone would help to plan rain-fed irrigation practices. It is currently not possible as the available forecasts are generalized for large regions and are not village specific (table 2). As a result in both Moshi and Lushoto, 100% of the respondents (N=310) indicated they wanted access to more accurate weather information. A small percentage (4%) claimed to have no access to any weather information. Furthermore, from the group of farmers who had access to a mobile phone, 99% of farmers indicated they would be interested in receiving an SMS with weather information. Out of these farmers, 84% were willing to pay 64 TZ shillings per SMS containing weather information.

	No information access	**Access to information**	**Thinks this info. is accurate**	**Wants more accurate info.**	**Interested in Kukua forecast SMS**	**Willing to pay**
Lushoto	5%	71%	26%	100%	98%	84%
Moshi	3%	81%	17%	100%	100%	82%
Total	**4%**	**75%**	**22%**	**100%**	**99%**	**83%**

Table 2: Weather information accuracy and willingness to pay respondents for both Lushoto and Moshi

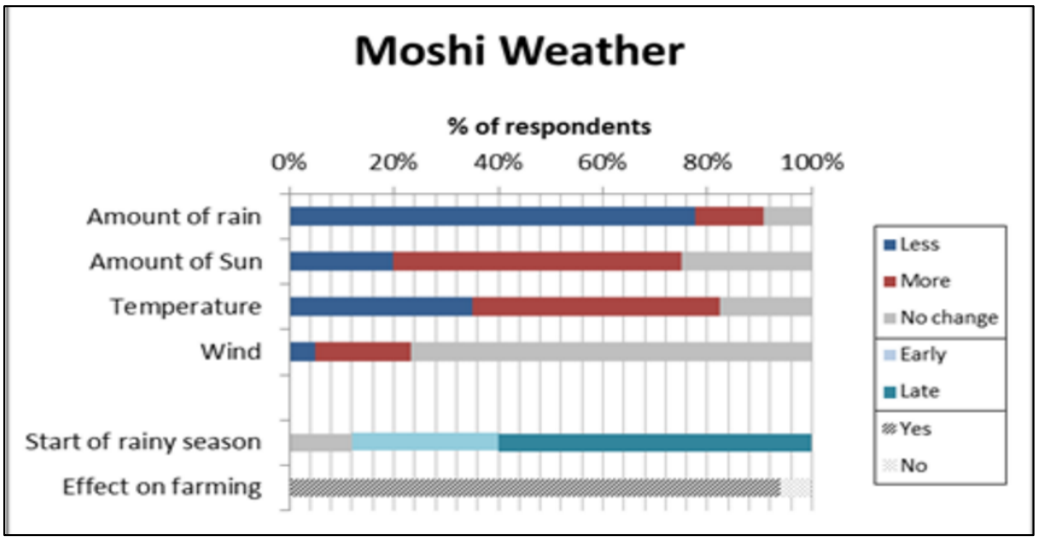
The indicator 'willingness to pay' was prompted through the following question: *Would you be willing to pay for the cost of a text message for this information? (average around 64 shillings)?*. This closed question was asked to allow the research team to gain an indication whether the interviewed farmers would be willing to pay the average cost of a text message for each daily weather forecast.

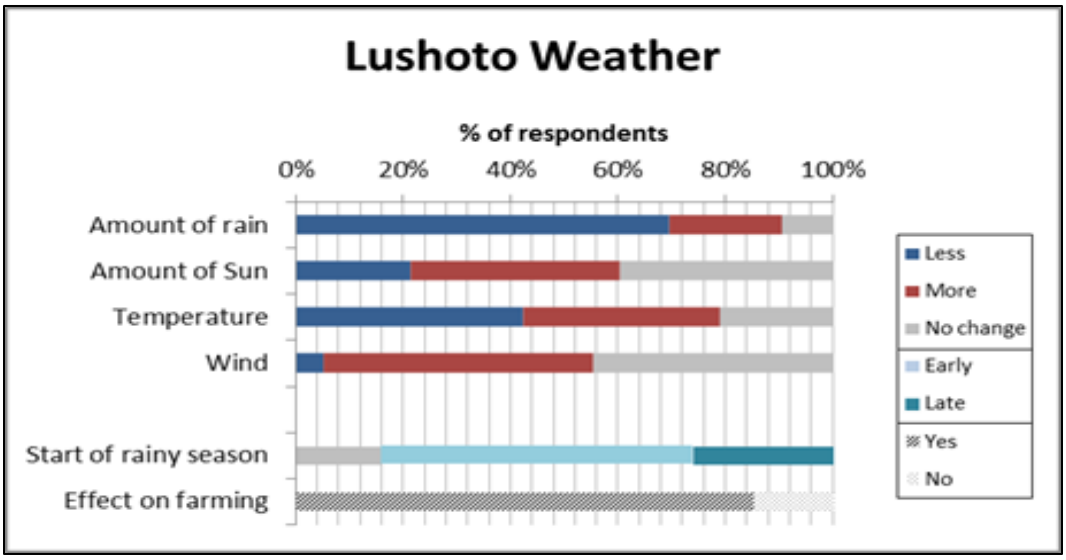


Graph 8: Respondents weather information access for Lushoto and Moshi.

In order to determine if smallholder farmers were willing to pay for weather information through a text message it was important to determine the knowledge gap between the weather information available for smallholder farmers and the desired weather information. Therefore, in graph 9-10, an illustration is shown of the varied weather patterns experienced by the interviewed farmers for both Moshi and Lushoto. During the interview, the team asked the respondents: '*How has the weather been for the past season?".* After which, a more specific question was asked focusing on changes in weather patterns for: rain, sun, temperature and wind. An open-ended question allowed the farmers to express any perceptions and differences in weather patterns experienced during the past season.

It was imperative that the AFD & Kukua team gained an understanding of changing weather patterns experienced by respondents. According to the responses, rainfall levels decreased compared to previous years in both Lushoto and Moshi (Graph 9-10). In addition, the number of sun hours has increased. However, there were also a number of 'no change' responses from Lushoto. The responses correlate with our findings from scientific journals alluding to the increase occurrences of droughts in Tanzania (Mongi et al., 2010).





Graph 9-10: Changing weather patterns in the past indicated by respondents Moshi & Lushoto

What is particularly interesting is the positive correlation between weather patterns and farming practices. A change in farming practices was highlighted with the question: *How have these changes affected your farming practices?* This question aimed to denote any changes in farming activities that resulted from changing weather patterns. Interviewed farmers clearly communicated that there have been various negative effects on their crop yields due to the changing weather patterns. One of the many recurring problems faced by the farmers due to the weather was the drying out of their crops. Subsequently, farmers harvested lower yields than

previous years. Another noteworthy response was that many farmers shared they were unable to irrigate, in order to counteract dry crops and that they did not have enough water for irrigation.

All of the interviewed farmers (100%) expressed that they wanted more accurate weather information (table 2). As weather patterns are changing, data shows that the farmers desire more accurate weather information, which can be provided by Kukua through text messages. A discrepancy between responses in the two region's changing start of the season shows the importance of location-specific forecasts.

Although it was outside of the scope of this study, respondents shared the need to receive additional information besides weather forecasts to increase the yields. For example, respondents were eager to learn more about seed quality, irrigation advice and learn more about how they could change farming practices to complement the use of weather forecasts and counteract the impacts of climate change.

4.3 Key Informant Interviews

Interviews with experts in the agricultural field were especially important as the indicated that most of the farmers are only interested in weather services during the rainy season, altering the potential earnings that can be expected at the levels of willingness to pay that were found.

In Lushoto the main informers were John Mdoa, Mr. Ayuba and Sophia. The first two were working at the district council and concerned with agricultural practices. Sophia aided with well-appreciated translations of extensive knowledge of agriculture in the region. In Moshi the informers were extension officers who had worked with IITA in the past.

5. SMS Design

In addition to conducting the interviews and questionnaires, the team worked on a design for the SMS that was sent out during the pilot phase. The design was based on a system in which the SMS had a set structure, with multiple variables changing depending on the predicted weather. The system is explained below in English, however during the pilot the messages were sent out in Kiswahili.

The message consisted of the following text and was sent out early in the morning with predictions for that particular day:

Hello. The weather for [today]: [daytemp]. [nighttemp]. [Rain.x]. [Wind.x]. Have a nice day, Kukua.

The variables were determined automatically according to the incoming weather information with the help of Kukua's software. The variables were filled with the following parameters:

Variable	Parameters (Optional)	Values
Day		
day		Monday
		Tuesday
		Wednesday
		Thursday
		Friday
		Saturday
		Sunday
Temperature		
temp.day		Temperature during the day (maximum)
temp.night		Temperature during the night (minimum)
daytemp	If temp.day>20	The heat during the day will be [temp.day]
	If temp.day<20	The cold during the day will be [temp.day]
nighttemp	If temp.night>20	the heat during the night will be [temp.night]
	If temp.night<20	the cold during the night will be [temp.night]
Rain		
rain.0	0-10% chance	No rain
rain.1	11-50% chance	Minimal chance of rain
rain.2	51-70%	It is likely to rain
rain.3	71-100%	It will rain
Wind		
wind.1	< 5 km/h	Normal wind
wind.2	> 5 km/h	Strong wind

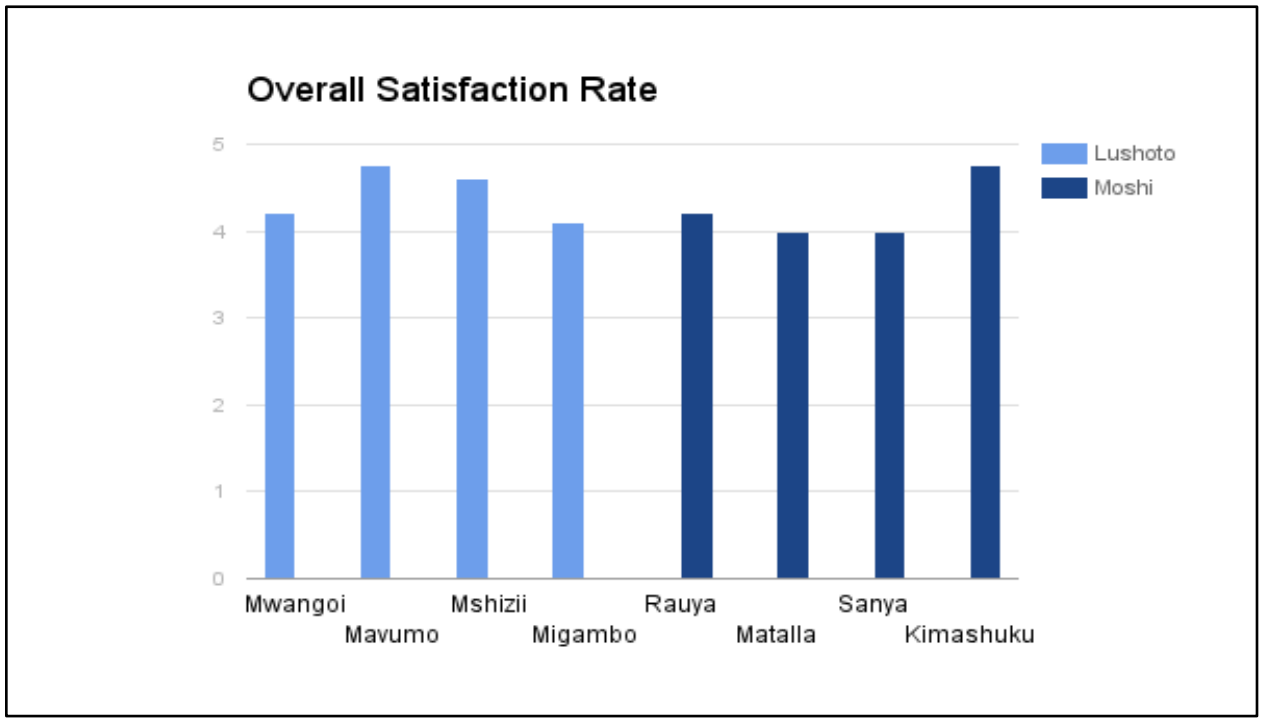
Table 3 – variables and parameters for SMS

6. Pilot phase and Feedback

The total number of respondents in the feedback phase (N) is 61, 6 farmers did not receive any messages, and therefore did not rate the weather services of Kukua. They did not receive any messages because they did not own a cellphone, or because they provided the phone number of a relative/neighbor in the first interview stage. Therefore, they were not considered in the overall satisfaction rate for the SMS service. They are part of a group of farmers who are interested in the service, but do not have the means to participate.

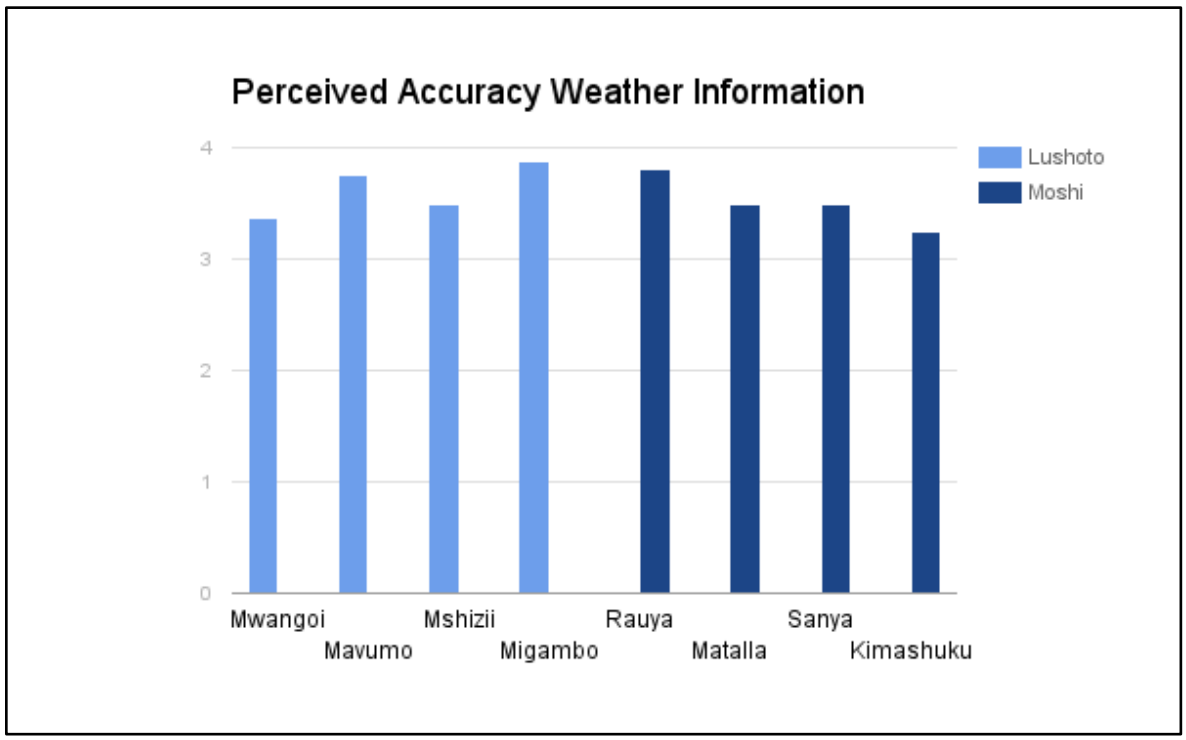
The satisfaction rates (graph 11) in Lushoto are 4.22 in Mwangoi, 4.75 in Mavumo, 4.6 in Mshizii and 4.11 in Migambo. The satisfaction rates in Moshi are 4.2 in Rauya, 4 in Matalla and Sanya, and 4.75 in Kimashuku. The overall weighted satisfaction rate is 4.29 out of 5, with a sample size of 55. This result illustrates that farmers were pleased with the text messages they had received. This group of participants is however positively biased; all participants took the effort to provide feedback. This effort to give feedback can be explained by the fact that they

were satisfied, and therefore contribute to the service, so the service can be continued in the future.



Graph 11: Satisfaction rate of received SMS during feedback phase for Lushoto and Moshi

Displayed below in Graph 12 illustrates the perceived accuracy of weather information. In general, the weather information was perceived as accurate.

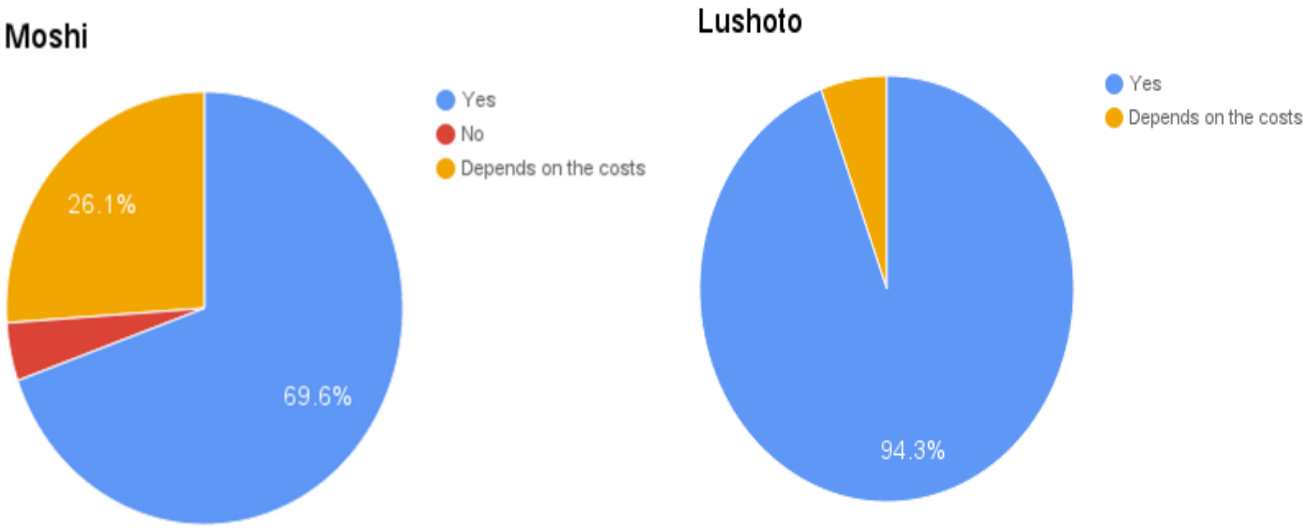


Graph 12: Accuracy weather information received in SMS for Lushoto and Moshi

When asked whether farmers would prefer to automatically receive the weather information or on demand, 68.75% of the total respondents preferred the automatized SMS service. An automatized SMS service means that Kukua automatically sends the SMS with weather information, instead of farmers contacting Kukua to receive the SMS with weather information. As shown in table 3 respondents prefer receiving messages during rainy seasons only.

As the research aimed to find the willingness to pay for the text messages with weather predictions respondents were asked if they would be willing to pay for the texts after the pilot phase. Willingness to pay for the feedback round was not prompted but simply asked if the respondents would still be willing to pay for the service in the future if it would cost money. This was asked because it was important to know *if* and not *how much* the respondents were willing to pay.

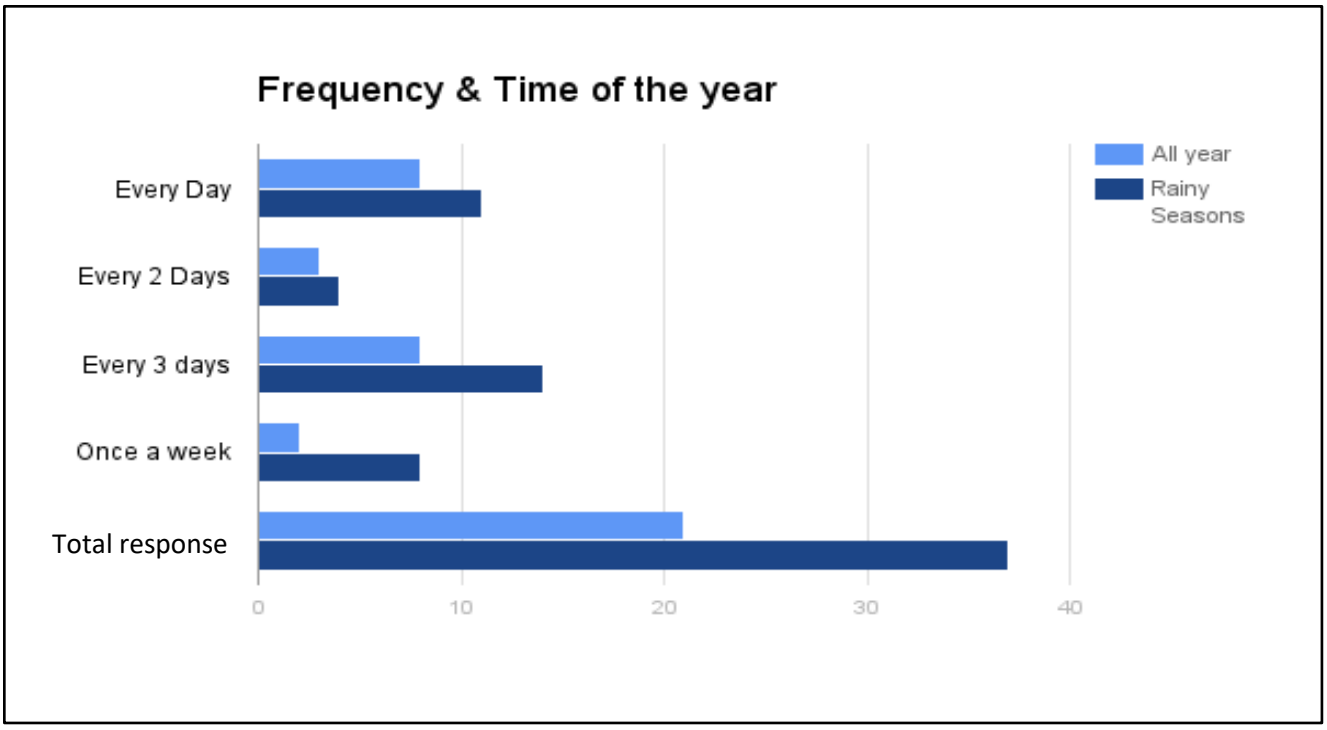
Previously, before the pilot phase, around 80% of the respondents would be willing to pay for weather forecasts. The results in the feedback phase show that there is a significant group of consumers in Moshi whom are mostly affected by the SMS price (as is shown in graph 13-14).



Graph 13-14: If respondents were willing to pay for the SMS in feedback phase.

Also, it was mentioned by the key informants in Moshi that many farmers in that area are unable to pay for text messages multiple times a week. More than 25% would let it depend on the costs, which will be a significant part of Kukua's potential customer group, but clearly shows there is sufficient demand to continue with the service.

Graph 14 below shows the result of a further analysis into the willingness of farmers to use the service and combines two variables. Firstly it shows the farmers' preferred frequency of receiving text messages with weather information, and secondly the time of the year to receive this messages. 19 out of the 58 farmers who would prefer to receive a text message every day, of which 8 all year round, and 11 would prefer to only receive text messages during the rainy seasons. There are 7 farmers who prefer to receive a message every other day, 22 who would prefer to receive it every 3 days, and 10 who would prefer to receive a message every day.



Graph 14: Time and frequency at which respondents' preferred to receive SMS

In total, only 19 out of 58 would like to receive a text message every day. This shows that 39 out of 58 respondents would like weather information spread across multiple days. It also shows that the weather should be accurately predicted and delivered multiple days in advance. This has major implications in the design of the text message. Another finding is that the majority (37 out of 58) of the farmers would prefer to receive the text messages only during the rainy seasons. See the section 'recommendations' for further elaboration.

7. Conclusions

The preliminary desk research conducted identified the changes in weather patterns due to climate variability as one of the major causes for crop production risks (Churi et al.,2012). It is the lack of access to weather information that can therefore lead to decreased food security as droughts cause for crops to deteriorate (Agrawala et al., 2003). This was later confirmed in the field research where respondents indicated huge crop losses due to unexpected weather changes throughout the different villages. Whilst a low percentage (4%) had no access to any weather information the majority (75%) received weather information from newspapers, TV or radio broadcasting. The research identified accuracy of these alternative sources of weather information as the major issue as 100% of the respondents indicated a need for access to more accurate weather information. It can thus be concluded that there is indeed a need for Kukua's weather services amongst local smallholder farmers in these semi-arid areas.

In conclusion, the lack in accurate weather information providers within the eastern regions of Tanzania provides an opportunity for Kukua weather services to have a positive impact on those most vulnerable to the effects of decreasing food security – smallholder farmers. The overwhelming interest in more accurate weather information and the SMS, and the measured willingness to pay indicate that there exists a viable market for the Kukua SMS product.

8. Limitations

To interpret the results of this study, the research team highlights a number of limitations.

Firstly, it is likely the use of non-trained translators provided by N2Africa and IITA had implications for the elaborateness and type of answers that were given by the interviewed farmers. When comparing the answers after the interviews in each village the team found that a lot more information was gained from the interviews conducted by Sandra (native in Kiswahili and thus acting as an additional translator during the interviews) in cooperation with another team member than from the interviews in which one of the two extension officers or an additional translator translated. Team members noticed an elaborate answer to a question was often translated as a simple 'yes' or 'no'. This implies the data collected reflects the translator's interpretation of answers rather than the team member's.

In addition the nature of the questionnaire (namely, investigating whether a certain product is desired) and N2Africa stake in successfully launching this product - N2Africa installed and maintains the weather stations - gave the team members the impression the extension officers sporadically influenced answers by looking to pull farmers towards to positive side when in doubt. When the team noticed this was happening, the issue was addressed and the translators were reminded that there were no good or bad answers. However, the team acknowledges that answers might have been influenced towards a more positive view of Kukua's service.

Secondly, the team recognizes the farmer's sample is biased to some extent. The sample group have previously collaborated with IITA, which indicates their interest for farming innovations is already high, potentially leading to a higher interest in the SMS product when compared to the general farming population. This bias is inherent to the research. For further research it is imperative for the target population to be approached by several leading actors in order to create a more diverse sample in order to achieve conclusions that can be applied to the larger farming population.

Thirdly, lacking the time and resources to investigate willingness to pay more elaborately, the team assessed willingness to pay by simply asking farmers whether they would be willing to pay a certain amount for the messages. As gained from the desk research, this method has a low reliability because individuals may try to manipulate the survey to their selfish ends or fail to assess the larger cost of the product over time (Whittington, 1990). Kukua will have to re-

evaluate the willingness to pay when determining the actual price they will charge for their service.

Fourthly, it is important to note that for weather accuracy there are several factors, which play a role in the accuracy of the weather information for a particular village, such as the exact location where the weather station is installed. Additionally, weather patterns for the months July and August are relatively stable with no extreme daily fluctuations, this may influence perception of the accuracy and value of the service, as predictions are not as difficult to develop.

Finally, the team discussed possible ethical challenges as a result of the introduction of Kukua's product. Existing (income) inequalities between farmers may be increased if Kukua's information is not able to reach every farmer. If a subset of the farmers does not have access to or is not be able to pay for Kukua's service, the introduction of Kukua's service could increase inequality by raising the yields of those farmers that do have access to the information.

9. Recommendations

The results in this paper provide a framework from which further research can be conducted. Primarily, farmers indicated that they would like to have additional information pertaining to how the weather stations operate. These trainings could convince farmers to collaborate with Kukua.

It would be beneficial to combine weather predictions in an SMS format with a risk reduction strategy; this could provide the farmer with mechanisms to improve their crop yields. Risk reduction strategies can come in the form of adapting planting and harvesting patterns, better quality seeds, soil fertilizers or irrigation pumps. Further research will be required for this. The end product of this research would entail collaboration with other companies. An additional risk reduction strategy the team already recommends is sending out weather alert SMSs. Such a service will send out messages in case of extreme, and perhaps dangerous, fluctuations in the weather within a day's notice.

Although the system of weather forecasts through SMS is embraced by a majority of the respondents, the team encountered instances where farmers were illiterate. In villages such as Matala (Moshi area), a number of illiterate respondents indicated the need for communicating weather information through alternative media. Further research into alternative ways of communicating the weather information such as Interactive Voice Response (IVR) are therefore recommended.

Regarding the timing of the SMSs in the service, a business model based on a service that sends out SMS automatically only during rain seasons (as prefered by respondents) is suggested. This

is based on interviews with the key informants, in which they indicated that this is the most pressing time for farmers to know more accurate information. On top of this, farmers are generally not able to pay for several text messages a week. The team considered the possibility of designing a text message that includes multiple days, however found this was difficult regarding formatting and the constraint in the number of characters sent in one SMS. As this recommendation is solely based on the interviews with key informants the team recommends further research into which stage of the agricultural process most requires specific weather data.

10. Appendixes

Questionnaire:

Introduction

Hello, thank you for speaking with us. We are volunteers for IITA, working on a project about weather forecasting. This project is set-up together with Kukua, who have installed weather stations in the area. They collect information on the weather.

1. Do you know of these weather stations?

This project is about how this accurate weather information can be used. If you want to answer some of our questions it would greatly help the project and IITA.

2. Do you want to participate?

Background

3. What is your name?
4. What is your age?
5. How many people are in your household?
6. What is your role in the household?
7. How big is your farm (in acres)?
8. What is the main source of income for your household?

Farming practices

9. What crops do you grow? (list)
10. What crop gives you the most income?
11. For which crop do you use fertilizers?
12. What fertilizers do you use?
13. For which crops do you use pesticides?
14. What are the most important crops you grow?

Weather

15. How has the weather been for the past season?
16. Do you think the rains, temperature, amount of sun and wind have changed over the past years?
17. How have these changes affected your farming practices?
18. How do you predict the weather?
    a. Do you also get information from other sources (TV, Radio, Newspaper, Other)?
19. Have these weather predictions been accurate?
20. Would you like more accurate information in the future?
21. What aspect of the weather would you like more accurate information about?
    a. Specifically, what about [this aspect] would you like to know?

Kukua Weather Services

As we mentioned, Kukua has installed 5 weather stations around Lushoto. These weather stations measure the weather and send this information to machines. This information is then studied to make accurate predictions about the weather for up to a week in advance. These predictions can be sent by SMS message to mobile phones.

22. Do you own a cell phone? If not: what other way would you like to receive the weather information?
23. Do you use mobile banking?

24. Would you be interested in receiving messages with more accurate weather information on this phone?
25. When would you want to receive this message?
    a. A day before or early in the morning on the same day.

Costs

Because it costs money to install and operate these stations and send the information, this service will not be free in the future after the test. For test you do not have to pay anything.

26. Would you be willing to pay for the cost of a text message for this information? (average around 64 shillings)

Test project

We are organizing a test to see how the sending of these messages can be done. This test will be free of charge. You can participate in this test, and you will receive text messages with weather information for a short period. With this test you will not have to pay and you will receive 5 – 10 messages in total. After the pilot, you will receive a message that the test has ended.

27. Do you want to participate in this pilot?
    a. If so, what is your number on which you would like to receive the messages.

28. After the pilot phase, we are going to evaluate, can we come to visit you again after the pilot phase to ask you some questions?

Conclusion

29. Dou you have any questions or remarks about the test or the questions we just asked?

Answer sheet for Questionnaire:

Date: Interviewer: Translator:
Village
Coordinates

Elevation

1. Yes / No 2. Yes / No
3. **Name:_____ 4. Age:_____Gender:** M/F
5. **No. of people:_____**
6. **Role: _____**
7. **Size of farm: _____**
8. a)Farming b)Selling labour c)Livestock d) Other:
9. **What crops do you grow?**
   o Peas o Maize o Beans o Cucumbers o Tomatoes
   o Cabbage o Carrot o Potatoes o Other:
10. **What crop gives you the most income?**
    o Peas o Maize o Beans o Cucumbers o Tomatoes
    o Cabbage o Carrot o Potatoes o Other:
11. **For which crop do you use fertilizers?**
    o Peas o Maize o Beans o Cucumbers o Tomatoes
    o Cabbage o Carrot o Potatoes o All: o None
12. **What fertilizers do you use?**
    o Manure o DAP o NPK o UREA
13. **For which crops do you use pesticides?**
    o Peas o Maize o Beans o Cucumbers o Tomatoes
    o Cabbage o Carrot o Potatoes o All: o None
14. **What are the most important crops you grow?**
    o Peas o Maize o Beans o Cucumbers o Tomatoes
    o Cabbage o Carrot o Potatoes o Other:
15. **How has the weather been for the past season?**

_____
_____
_____
_____

16. **Do you think the rains, temperature, sun hours and wind have changed over the past years?**

Rain	Sun hours/ Temperature
Wind	Other

17. o Changes_____
o No Changes
18. o Indigenous o Previous experience o TV o radio o Newspaper o other people o None
19. o Yes o No, why:_____
20. o Yes o No
21. o Rain o amount of sun o Wind o Temperature o Other:
Aspect:_____
_____
22. o Yes o No, how: _____
23. o Yes o No
24. o Yes o No
25. o A day before o Early in the morning o Other_____
26. o Yes o No
27. o Yes o No **Phone no.**_____
28. o Yes o No
29. Comments:

Feedback questionnaire:

Village: Date: Interviewer: Translator:

1. **Name:**_____
2. **Phone number:**_____

Thank you for participating in the test phase and speaking to us again. Currently, the service is still in development, and it will take some time before it will be available. In order to make the service as useful as possible we would like to ask you some questions.

How satisfied are you with the text messages on a scale of 1 to 5?

- o 1 Not
- o 2
- o 3
- o 4
- o 5 Very

Would you want to use this service in the future if it costs money?

- o Yes: Why?
- o No: Why?

_____

_____

How many Kukua text messages about the weather did you receive in the last week and how often?

- o None
- o One every day
- o More than one a day
- o Less than one a day
- o Total:_____

How accurate did you perceive the weather forecasts to be? (1-4 scale)

- o 1. Not accurate at all
- o 2. Mostly inaccurate
- o 3. Mostly accurate
- o 4. Completely accurate

Would you prefer to have the SMS sent automatically, or only when you ask for it?

- o Automatically
- o Only on demand

If automatically: How often would you like to receive the text message?

- o Every day
- o Once every 2 days
- o Once every 3 days
- o Once a week

Which time of the year would you want this weather information?

- o Always
- o During the rainy seasons
- o Other seasons

What would you like to add or take away from the SMS?

_____

_____

_____

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