An Approach to a Sustainable Weather Information System for Farmers in Rural Burkina Faso

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Abstract

In the quest to improve the lives of farmers and improve agricultural productivity in rural Burkina Faso, a number of projects and initiatives have been implemented to collect meteorological data within the country. There is the urgent need to make use of this collected data to deliver meaningful information. It will directly help improve the lives of farmers and provide more food to the people in the country. Therefore, through this case study we designed a weather information system that collects this data and provides the farmers with weather and agricultural information for improving agricultural productivity and the livelihood of the people of rural Burkina Faso. Following the design science research methodology, we investigate the requirements for a weather information system, and the possible options for ensuring the sustainability of the system. Using a combination of methods, we developed a structured approach and methodology for developing and implementing a sustainable weather information system in the context of rural Burkina Faso.

This research follows all design science steps in designing a weather information system in the context of rural Burkina Faso, in a structured manner. Through this research, we explored and evaluated the design of systems in the context of rural Burkina Faso and rural Africa. We developed a sustainability model, where we examined different options for implementation and sustainability. We developed a simple prototype, which helped us discover that a voice interface plays an important role in a system when deployed in rural Africa.

1 Introduction

Information Technology for Development has gained momentum as quite a number of them have been implemented all around the world. In the context of rural Africa specifically, a lot of projects have been implemented to develop systems that address various issues within the area. These projects have employed various techniques and methods in implementing systems that have positively impacted the lives of people living with the rural communities. One of such projects is the work of de Boer et al[11], carried out in rural Mali. Our research bears some similarities with these ICT4D projects as it involves the designing of a system that aims to foster development in the rural communities.

This research was carried out as a continuation of initial work completed in 2016 by a group of researchers from the Vrije University and the company 2CoolMonkeys[5][6][4][7][8]. Initial field work was carried out from 2014 - 2016, and involved collecting a number of requirements for farmers in rural Burkina Faso. One of the main issues observed was the need for weather information that helps farmers make plans and manage their crops against unforeseen weather conditions. The farmers of the region were interviewed extensively and information was directly collected from them on their weather concerns, and how weather information can be of benefit to their agricultural productivity. In this paper, we evaluate this use case by further analyzing the situation of the farmers and we design a system that will help tackle the issues observed during the initial field research. The main aim of the system is to provide weather predictions for a few days, and to help improve agricultural knowledge and practices by providing weather-based agricultural advices. We develop a simple prototype which is evaluated by a small group of farmers in rural Nigeria.

In section 5, a full use case description is outlined using the format presented by Vrije University researchers, which was delivered as material in an ICT4D course at the Vrije University[1]. This use case description format is a mix of formal and informal techniques and methods. It consists of ten steps that help to provide a detailed description and understanding of the use case.

2 Related Work and Literature

2.1 Weather Information Systems for Agriculture

Yeboah[21] highlights the need for weather information for agriculture in rural Africa as 70 percent of the population rely on agriculture for food and income. The farmers lack the resources, and appropriate information systems that can help them improve their agricultural yield. They lack information on rainfall predictions, pests, and diseases that can devastate their crops and cause heavy loss[21]. With these prominent issues, there is the need for weather information systems that will deliver information that greatly impacts the lives and agricultural productivity of the farmers.

In a comparative analysis of agricultural systems for farmers in India, 60 percent of farmers were interested in an agricultural information system that provided weather forecasting information of rainfall, temperature and humidity. While 70 percent of soybean and wheat farmers were interested in a weather information system that provides information on the best practices for cultivating their crops[13]. They hoped that this information could help them manage and save their crops even during long periods of drought. The findings from this research show that in this specific context, the farmers find weather information systems that provide forecasts and agricultural information interesting. However, they have a higher number of farmers who prioritize retrieving agricultural information over weather forecasts[13]. One reason for this could be that the farmers already have access to weather forecasts, so they place more priority on having access to agricultural information. Our study will review and verify if this same findings are different or similar when reviewed in the context of rural Burkina Faso.

After the review of multiple literature, it appeared that only a few research have been carried out on weather information systems in the context of rural Africa. Asenso-Okyere and Mekonnen[2] however investigate how Information and Communication Technologies(ICT), and the use of a WIS can improve agricultural productivity in Africa. Countries in rural Africa have the highest concentration of food scarcity and poverty, all of which are due to low agricultural productivity[2]. However, in order to alleviate this situation and increase agricultural productivity, farmers need to have access to better information which can easily be achieved through the use of ICT[2]. Their paper however fails to provide any concrete result on how the use of ICT or a WIS have impacted the people of rural Africa.

2.2 ICT4D in Rural Africa

One of the main issues in rural African communities is the inability to access data over the Internet.[10] Which is mainly due to the lack of networking infrastructure in these areas and the lack of resources to purchase smart-phones or other technologies that could provide access to the Internet. These factors along with a number of others make it hard for people in rural Africa to share knowledge and information. Therefore to tackle this issue, a voice-based system was developed as a means for farmers in the rural communities to create a pool of information and share it amongst themselves[11]. The voice-based service uses mobile technology which is already easily available to farmers in rural Mali. Which allows farmers to get and share crop market prices. The use of the GSM technology is widespread and continuing to grow in rural Africa [1]. The technology was used to provide a voice interface that allows farmers interact with the system. This method provides an example of an innovative approach to providing individuals in rural areas with valuable information.

2.3 Sustainable Weather Information System in the Rural Context

An important issue to be examined is the economic sustainability of systems in rural Africa. Systems can be deployed in these areas as ICT4D projects or for other purposes. However, it is important to take into consideration what happens a few years after the system is implemented. What plans are there to ensure the system is still running and bringing value to the people. In this case, it is necessary to look into options that help to improve the chances of sustainability, for example, achieving some level of sustainability through a cost-effective system development approach. Which means developing the system in such a way that requires minimal costs, therefore increasing the chances of having enough funds to keep it running. Another option is to have it managed by

[1] https://www.gsmaintelligence.com/research/?file=7bf3592e6d750144e58d9dcfac6adfab

a third party who offers information from the system as a value added service[19]. For instance, a third party like an insurance company could manage the system, and offer weather information to the farmer as a value added service for buying insurance for their crops. In addition, a very recent study[16] discovered that out of 170 farmers interviewed in Northern Burkina Faso, 63 percent of them were willing to pay for some form of weather information. This means the system could also be commercialized and the farmers can contribute small amounts in ensuring the system stays up and running.

2.4 TAHMO Weather Initiative

An important addition to the related work is the TAHMO[2] weather initiative. TAHMO full name Trans-African HydroMeteorological Observatory initiative, is a weather initiative that was implemented to collect weather data in countries all around sub-saharan Africa. They set up sensors and weather stations all around sub saharan Africa, Burkina Faso included[3]. And for all these regions, they collect historic weather data like rainfall, temperature, humidity, etc. Therefore, when pondering on the idea of developing a system for weather prediction, TAHMO can be a model of how historic weather data can be collected at a local level. TAHMO can also be a source of raw weather data which can be mined and used in making weather predictions in rural Africa. Table 1 of the Appendix shows the number of TAHMO weather stations present in Burkina Faso.

3 Background

3.1 Rural Burkina Faso and Agriculture

Agriculture is a source of income for 80 percent of the population in rural Burkina Faso, with 45 percent of them living below the poverty line at €1.07 per day. In a population of approximately 20 million people, 16 million of them depend on agriculture as a source of food and income[17][18]. The crops they grow includes cowpea, maize, sorghum, and millet. However, due to poor weather conditions the country often is not able to harvest enough food to eat or generate revenue. The country experiences high numbers of unpredictable weather conditions,like floods and drought, which make it difficult for them to plant and harvest enough food to eat[17]. As a result, the country continuously faces high level of food insecurity for almost a decade now. The country turns to NGOs and other governments for support in alleviating the high level of malnutrition and food scarcity in the country[17][18]. The high level of food insecurity caused as a result of low agricultural productivity helps show that it is necessary for different options to be pursued in helping to improve agricultural productivity and tackling hunger in Burkina Faso.

3.2 Initial ICT4D Research in Rural Burkina Faso

Our project builds up on initial field research that was carried out in rural Burkina Faso[5][6][4][7][8]. This research was led by professors from the Vrije University, Amsterdam, in collaboration with 2CoolMonkeys, an IT company in Utrecht (both in the Netherlands). This project was carried out under an internship with 2CoolMonkeys, which provided access to all information collected during the initial field research.

The result of the field research provides a detailed description of the use case for farmers and the need for weather information in rural Burkina Faso. The need for a weather information system was identified. The farmers were interested in getting three main information: 1) Daily weather forecasts for 1 - 5 days. 2) Notifications on upcoming rainfall. 3) The amount of rain that will fall. And most importantly, it was observed that the farmers lack the necessary resources or infrastructure needed to access data over the Internet. They did not have smart-phones or Internet connection, and the people were mostly illiterate. They therefore require that they can have access to these information via their mobile (GSM) phones and in their local languages.

4 Problem Description and Method

The main problem discovered in rural Burkina Faso is the issue of low agricultural productivity. With 80 percent of the population depending on agricultural produce as a means for food and income, the lack of resources makes it hard for farmers to manage their crops and maximize their agricultural yield, leading to food shortages and starvation[17]. As a result of all the above problems, we are proposing a system that is able to provide these farmers with resources like weather predictions and agricultural advice, and

[2]http://tahmo.org/weather-stations

[3]https://school2school.net/stations/?siteCode=TA00169

information for knowledge building. In designing this system, we are therefore interested in the question of 'What is a good methodology for developing a sustainable weather information system for farmers in the context of rural Burkina Faso?' and 'Through what channels can the farmers have access to the information provided by the system?'. We are interested in these questions because most systems are currently developed for individuals who are technology literates, can read and write, and have access to the Internet with connected devices like laptops and smart-phones. However, in the context of rural Burkina Faso, the vast majority of people are mostly illiterate (cannot read or write), lack technological skills, and access to the Internet[11]. Therefore, there is the need to deliver a methodology that takes all these factors into consideration when building a system for farmers in rural Burkina Faso.

In answering this, we implemented the design science methodology. We made use of a combination of methods, including an ICT4D Use Case Description Format, the e-3 Value model[9] for sustainability, and a user evaluation setup in rural Africa. The reason we have adopted these methods is that they help paint a clear picture of the context and how the system fits into it. For instance, the use case description format helps to place the system right at the center, and shows how each actor in the given context interacts with the system. The e-3 value model on the other hand provides an approach for modeling different value exchange options that can exist between the system and the various actors in the context. The models help to give a good visualization of this value exchange.

In the next sections, we have investigated the requirements for a weather information system using survey data and information collected from the previous field research and structured them using formal and informal methods. We developed and analyzed models and options on how the system can be implemented and made sustainable in the rural context. And lastly, we conducted an evaluation with farmers in rural Africa in order to explore their response to the weather information system.

5 Weather-Based Agricultural Information System

We have designed a system that provides weather predictions for farmers in rural Burkina Faso. The system will make use of weather data that collected locally(using weather sensors) to create accurate weather predictions and make them available to farmers via a simple interface. The system will also act as an advising system by providing farmers with advice on activities that can be performed based on the weather and the type of crops they plant. The next section will provide a detailed use case description for the system, providing more contextual information, and highlighting the various system actors and the technological infrastructures for the system. Using the use case format presented by Akkermans and Bon [1], the next section will include ten steps that aim to paint a clear picture of the system.

5.1 Name

For the first step of this use case description, a clear and understandable name is required for the system. The name 'MonsieurMeteo' has been selected, which is the French word for 'Mr Weather' . This is a straightforward name that should be easy for users in Burkina Faso to understand as their official language is French.

5.2 Summary Of Key Idea

This step involves providing a summary of the central idea of the system. The main idea is to develop an application that provides weather predictions and information using weather data that have been collected locally in Burkina Faso. Farmers, especially those living in rural areas will have access to these forecasts and information via a simple interface or an easily accessible communication channel. By making use of locally collected weather data, more accurate predictions can be created, allowing farmers to make better plans in response to predicted weather conditions. The system in addition, will be a weather-based agricultural advising system. It will be a platform that provides farmers with crop advice in relation to the predicted and current weather conditions. By making use of the weather information and predictions, the system can advice farmers on activities that they can perform to help them protect their crops or increase their agricultural yield and productivity.

5.3 Actors And Goals

This section provides a list of the main actors/stakeholders of the system, and a brief description of their goals for the system. Based on the previous research and some additional background research, we obtained a list of actors who each have active roles to play within the system. Table1 below presents these actors and their corresponding goals:

Actors	Goal
Farmers	- Collecting weather predictions for the next 5 days. - Collecting agricultural information to help manage crops.
MonsieurMeteo	- Providing weather predictions for farmers. - Providing crop information for farmers
Forecast Service	- Collecting raw historical weather data. - Providing MonsieurMeteo with weather predictions for the next 5 days (at least).
Data-Entry User	- Providing farmers with up to date agricultural and crop information.
Radio	- Broadcasting weather information to farmers over the radio.
NGO	- Providing financial support for MonsieurMétéo. - Providing support to farmers by making weather prediction information available to them.

Table 1: System Actors and their Goals

5.4 Context And Scope

This step provides a more detailed description on some of the main actors, including their surrounding background, and their related goals. In addition, the scope of the system and what it should provide is briefly described.

Based on information collected from the farmers, we gathered that farmers in rural Burkina Faso depend on rain to grow their crops. Within the country, they experience two seasons; wet season (also known as the rainy season), and dry season. The wet season lasts for a period of 9 months, which is when the farmers experience heavy to mild consistent rainfall in the region. While the dry season season comprises of little to no rainfall, and lasts for a duration of 3 months. During the rainy season, the farmers mostly plant the following crops:

Crop	Season
Millet	Wet
Sorghum	Wet
Maize	Wet
Cowpea	Wet
Peanuts	Wet
Onions	Dry
Tomatoes	Dry
Cabbage	Dry
Potatoes	Dry

Table 2: Crops Cultivated by Farmers

It is common practice for the farmers to make preparations and prepare their land before the wet season and upcoming rainfall. They make sure that necessary seeds and fertilizers are available for the upcoming season, and that the soil is properly prepared. However, the farmers do not currently have access to weather forecast information so they rely on traditional methods to help them predict when it will rain. This method involves observing the atmosphere and making use of old knowledge and experience to forecast upcoming rain. However, due to the recent occurrence of climate change, this method has proven to not be as effective. The farmers are experiencing unpredicted rainfall, and are therefore unable to properly prepare their farms in advance. The system in this case will be a source that provides farmers with accurate weather predictions using local weather data. In addition, farmers will also be able to get agricultural information and advice based on the type of crops they plant.

The scope of the system is to provide weather forecasts for the next 1 - 5 days, provide crop advice based on the weather, and also provide general agricultural information. All information provided by the system will be collected from various actors in this use case. The weather forecasting service will provide weather predictions, and the agro data-entry user will provide crop advice and information. All these data will be collected by the system and provided to the farmers via an interface.

Due to the low level of income of the farmers, and the lack of access to Internet, an interface that allows the farmers to access weather information from the system without needing an Internet connection will be included. For instance, using a voice interface, and a USSD/SMS interface, the farmers will be able to access information from the system using their simple GSM phones. On the other hand, in order to add new agricultural information and crop advice, a web interface will be implemented that allows the agro-data entry users add new data and agricultural information to the system. The local radio stations in addition, are a current source of weather prediction information for farmers. They are involved in broadcasting weather predictions to the farmers, and with the system the radio stations can collect weather information for their broadcasts.

5.5 Use Case Scenario Script

This section provides descriptive scenarios for different types of users and their interaction with MonsieurMeteo. It provides some details on the background of each target user, and how they can interact with the system.

5.5.1 Scenario I - Voice

Yaméogo is a farmer that lives in rural Burkina Faso. Yaméogo speaks his local language Mòoré but he is illiterate and is unable to read or write. He has a GSM mobile phone which he uses to make calls to his family and friends. He has a small hectare of land where he plants cowpeas. He is quite new to farming, and is interested in getting some planting information in addition to information he received from his other local farmer friend. He wants to prepare his soil for planting, but he is unsure when to do this because he does not know when the next rain will fall. So in order to get this information, he calls MonsieurMeteo with his GSM phone. He selects Mòoré as his preferred language and requests weather forecasts for the next 5 days. He also requests some information on how he can plant cowpeas. MonsieurMeteo provides him with all requested information and Yaméogo listens to the information over the phone and ends the call when done.

5.5.2 Scenario II - USSD/SMS

Mariam is a farmer that lives in rural Burkina Faso. She has elementary level education and is able to read and write a little in French. She has a GSM mobile phone which she uses to send text messages once in while. She has a small hectare of land where she plants maize and cowpeas. She is interested in getting weather forecast information on a daily basis to help her plan her activities on her farm. So in order to collect this information, she contacts MonsieurMétéo via a USSD code. She reads through the forecast options provided by the system, and selects a preferred weather option. The system responds with the forecast information via text.

5.5.3 Scenario III - Radio:

Souleymane is a farmer that lives in rural Burkina Faso. He is illiterate and cannot read or write. He cannot afford a phone but he has a small radio where he listens to programs and news in his local Dyula language. He has a small farm where he plants a few crops and is interested in getting weather forecasts to properly manage his farm and make plans. In order to get this information, he tunes in to the local radio station, which provides weather forecast information collected from MonsieurMeteo. He listens to the radio presenter who reads out the weather forecasts in Dyula.

The scenarios above provide a storyline of three types of users. Each user with varying levels of education and resources, and how each one of them interacts with the system. Farmers who are educated but lack Internet access and resources can access the system information via a USSD/SMS interface using their GSM phones. While farmers with resources like the GSM phone but with low education level can access information from MonsieurMeteo via a voice interface. And lastly, farmers with no GSM phone and who can neither read nor write can access the system via radio broadcasts.

5.6 Interaction and Communication

This step provides information on how the system and the users interact. MonsieurMeteo will have two groups of interfaces, the first group thats allows farmers and users collect information from the system. And the other group is for admin and data entry who continuously provide new and up to date agricultural information and crop advice to farmers. As shown in Figure 1, the system requires a login for the admin user to log-in and create new users. These users are the agro data-entry users. They are responsible for adding new agricultural related information to the system. In addition, they provide new and updated crop-weather information for the system, so that based on the weather, the system knows what advice to give to the farmers.

5.7 Information Concepts

Here, further information is provided on the flow of information within the system. Figure 1 in Appendix shows a UML activity diagram that presents the flow of processes when using the web interface of the system. As shown in the image, the farmer/user (this could also be a radio representative that accesses the system for information) visits the MonsieurMeteo website, and the system collects the user's location and sends a request for weather predictions for that location. The weather forecasting service receives this request and retrieves the forecasts for the location. This information is sent back to MonsieurMeteo, and is displayed for the user to view via the web interface.

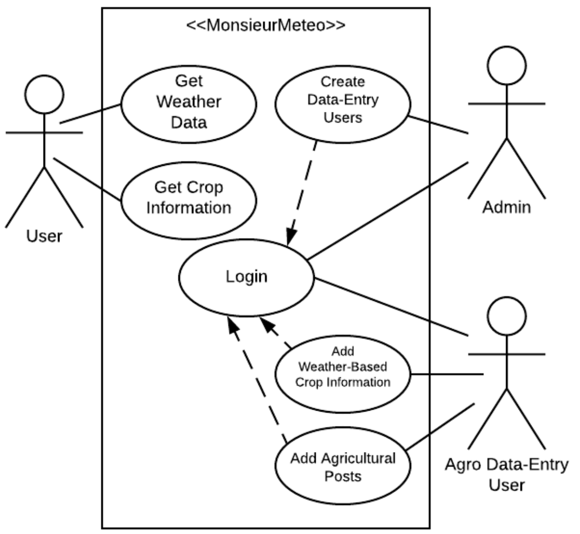

Figure 1: Use Case of User Interaction with System

On the other hand, Figure 2 in the Appendix shows the UML activity diagram that represents the flow of processes when using the voice interface. When a farmer calls the application, they are asked to first select a language from a list of languages available in the system. This choice determines what language the system will use in communicating with the user. The user then has the choice to select a location. The system collects the user's choice, and retrieves the weather forecasts for the selected location. Due to limited resources for supporting text-to-speech in local Burkina Faso languages, the system will make use of pre-recorded audio files, stored as WAV. The system will select the matching wav files for the predicted weather and play this out to the farmer. The user can therefore listen to this information in their local languages. More details on this will be discussed in Section 5.

The UML class diagram in 5 shows what type of information is stored for the system, and how they relate to one another.

5.8 Technology infrastructure

The necessary technologies like hardware or software required by the system is explained here. The information generated by the system can be made available to farmers and other stakeholders through various channels. Figure 2 shows an architecture for the system.

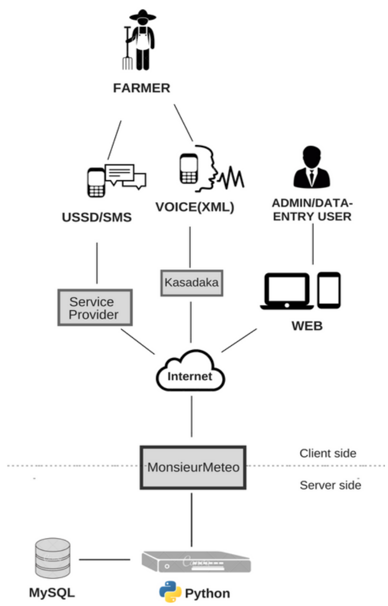

Figure 2: System Architecture for MonsieurMeteo

The users of the system can make use of different technologies in accessing the system. The admin users and agro data-entry users require access to the Internet in order to make changes to the system. They can make use of Internet connected devices like a PC, tablet, or a smart-phone in accessing the system. On the other hand, the farmers can make use of non-internet connected devices to access the system. As shown in the image below, farmers can either use USSD/SMS or Voice interfaces in accessing the system. With the use of USSD/SMS, the user dials a code, which sends a request to the user's network service provider, the service provider connects with MonsieurMeteo, collects a response to the user's request, and sends it back to the user's GSM phone. As an alternative, when using the voice interface and the farmer calls the designated number for the application, the call is directed through the Kasadaka[3] platform which helps connect the user to application hosted on the web. The user is thereby able to interact with the system without needing to be directly connected to the Internet. MonsieurMeteo will be hosted on a web server allowing access over the Internet. It can be built using python, and a MySQL database.

5.9 Cost Considerations

A brief review of some costs associated with implementing the system are outlined in this step. The costs were calculated using values gotten from the websites of the service providers. These costs are as presented in Table 3 below:

Item	Description	Cost
Hosting	This is the cost associated with setting up a server for hosting the system. The system can be hosted on a third party server while paying a monthly subscription fee. 4GB, 4 Cores, SSL Certificate.	€5.61
Domain	The cost of getting a domain name for the system. e.g 'monsieurmeteo.com'.	€0.99
Bulk SMS	When implementing the USSD/SMS this cost is associated with sending SMS to various users. The cost to the right is user based, so it has been calculated assuming that the system expects 200 users per month.	€€45

Table 3: Estimated costs for the System

The table gives a total cost of €51.60 per month. Assuming that there are 200 users making use of the system per month, the cost per user is approximately €0.26 per month. In developing the costs for the system, careful considerations have to be made in keeping the costs as low as possible considering the low level of income of the farmers, and low level of resources. As mentioned in Section 3, 45 percent of the population live on €1.07 per day, which means the cost of the system has to be considerably low. More details on why this is important will be discussed in Section 8.

5.10 Key Requirements

In developing a more detailed system design, it is important to have a concrete list of requirements for the system. The table below provides brief outlines of these requirements using information that was collected in the previous research, and from additional research on weather information systems. The table below lists out these requirements using the so-called MoSCoW list of requirements as shown in Table 4 and Table 5

Must Have	- Web interface for users to access the system over the Internet. - Weather predictions for 5 days. - Provide Weather-based crop information. - Provide general agricultural information. - Back-end account for agro data-entry users to add and manage crop information.
Should Have	- Voice interface for farmers to access information via their GSM mobile phone. - USSD/SMS interface for farmers to access information via their GSM mobile phone. - Farmers can select multiple locations. - Multiple local languages for the voice interface.
Could Have	- Farmers can give feedback on information provided. - Farmers can share their own agricultural information. - Collect raw weather data from farmers.
Won't Have	- Ability to work without Internet connection.

Table 4: MoSCow List of Functional Requirements

Must Have	- Ease of Use: System is easy to use. - Understandability: Content must be easy to understand. - Portability: Must be easy to implement on multiple platforms like web, voice, SMS.
Should Have	- Scalability: Should be able to accommodate growing number of users and additional languages. - Speed: Quick response time. - Maintainability: Should be easy to maintain codes.
Could Have	- Security: Make the system more secure.
Won't Have	- End user authorization levels

Table 5: MoSCow Non-Functional Requirements

6 Conceptual System Design

Based on the requirements collected during the research, this section details a design for the MonsieurMeteo system. It includes the various functionalities for the system and how it can be implemented.

6.1 Local Weather Forecast

The farmers are mainly concerned with having access to accurate weather forecast information. These forecasts are important because they help the farmers decide what actions to take for the benefit of their crops. For instance if a farmer knows that a storm is on its way, the farmer can set up protection for his plants that are prone to damage from the storm. The farmer will thereby be safe from loss that he would have otherwise incurred. It is therefore important that the forecasts are not only available, but that they are accurate.

To attain accurate forecasts, a weather prediction model will be created using weather data that is collected locally[14] in the rural areas of Burkina Faso. From previous work carried out in Burkina Faso like TAHMO, weather stations are already set up, and they collect data on various weather conditions like rainfall and radiation. Appendix 3 shows a sample of the data collected in Ouagadougou, Burkina Faso. With the use of this data, there are options for weather prediction models that can be created[20][14][12]. These models will provide the system with accurate weather forecasts.

Based on the local weather data collected, the system will provide daily weather forecasts on 1) Rainfall, 2) Temperature (how hot or cold the weather will be), and 3) Wind-speed (will there be a storm or not) as represented in Figure 3 below.

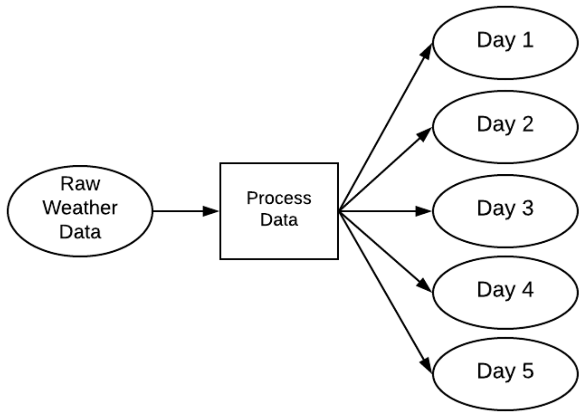

Figure 3: Weather Data for Weather Forecasts

Using the weather model, the system can provide users with 2 - 5 days of weather forecasts. The longer the days the forecasts are for, the more time the farmers will have to prepare in advance.

MonsieurMeteo will be provided with weather forecast data which will be displayed to the user via a simple interface. Farmers can choose to get all available weather forecast information, or they can select a specific day from the range of available forecast days.

6.2 Weather-Based Agro Advice

MonsieurMeteo will provide advice on activities that the farmers need to perform in response to the predicted weather patterns. For instance, a farmer could be asked to select a crop they intend to plant or have currently planted, then based on the current weather, the system will provide some tips on what activities can be performed. The system will have a stored list of crops that are commonly grown in Burkina Faso which includes cowpeas, maize, millet, sorghum, etc. The farmers can select one of these crops, and the system checks the weather forecast data and checks for corresponding advices, which is then displayed to the user.

6.2.1 Adding Advice to the Database

The advice provided by the system will come from a stored list of information that comes together to form some sort of crop-weather knowledge base. The stored information will be a list of different crops, different weather conditions, and various advices. The information will be stored as represented in Figure 4, and a statement could be, 'if the Crop is maize, and rain(weather) is greater than(condition) 5 millimeter(value), advice is "protect your your young plant from flooding"'.

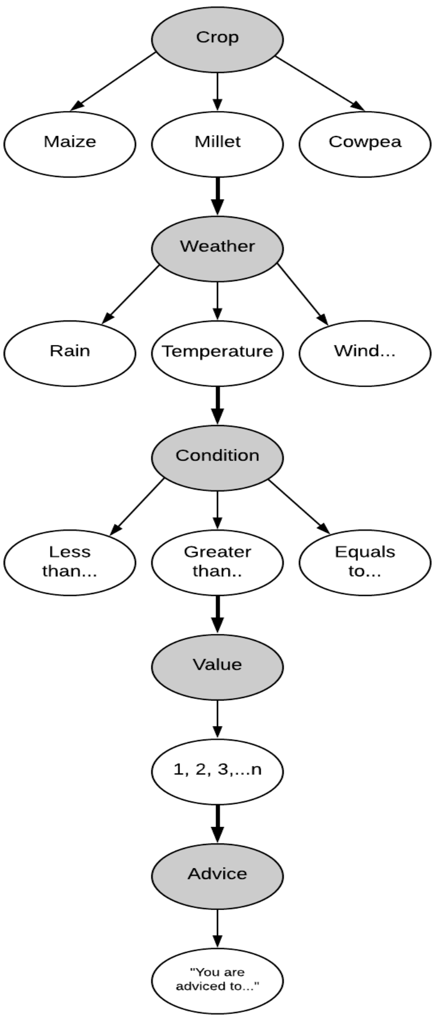

Figure 4: Crop Advice

This information will be stored in a database and fed to the system. So each time a user selects a crop, the system gets the weather predictions, searches through the database for a match, and displays any available advice to the user. Figure 5 shows a UML class diagram of the data model for the system.

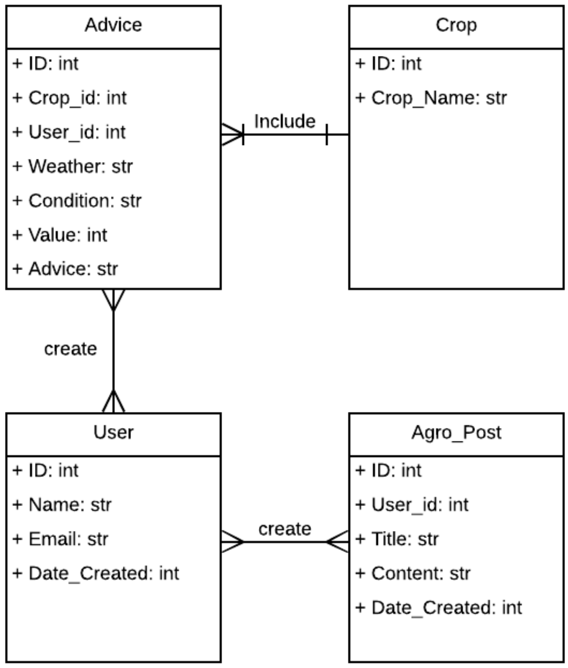

Figure 5: UML Class Diagram System Data model

6.2.2 Managing Advice

In order to ensure the growth and expansion of the system to accommodate new information, and include new crops, it is important that the system has a management module that allows some set of authenticated users to make changes. For instance they can add new crops , new information on weather or information on new crops. The system will allow the users add new crops and add new advices to the system.

As mentioned in previous sections, this is where the agro data-entry user comes into play. This user will have an authentication-based access to the functionality on the system via a web interface. The user can choose to add new information, or edit existing information. Figure 5 in the Appendix provides a representation on the flow of activities that can be performed when the user wishes to add new advice or edit an existing one.

6.2.3 Agricultural Information

The system will provide general agricultural information in addition to weather-based crop advice. The system will provide a platform for agricultural information to be shared to farmers who have no formal education in agriculture. This information can help benefit them in terms of getting knowledge on diseases, pests, or how to properly plant certain crops. The system will include a module that allows the agro data-entry user to add information to the system in form of blog posts. User can add texts and images to the posts. These information are stored in the database and can be viewed by the user via the web interface.

6.3 Voice Interfaces

Developing some functionalities of the system for a voice interface will require a few additions to the system designs. A voice interface can be designed using VoiceXML, and when hosted on the web and ported to the Kasadaka platform[3], farmers can call the application and get information that they need.

6.3.1 Weather Forecasts to Voice

The system will provide weather forecasts via a voice interface. Due to the current limited resources and lack of technology that supports text-to-speech in local Burkina Faso language, voice files will have to be pre-recorded as WAV and stored on the system. Hence, when the system gets the weather forecast data, it can select the matching audio files and play them back to the user. For instance, if the weather for 'tomorrow' is predicted as 'heavy rain', and 'very cold', an audio recording of 'heavy rain' and 'very cold' can be stored in the system in the local Burkina faso language. And once user calls the application, the user is able to listen to the audio recordings.

The audio files will be stored in pieces and grouped together to give complete sentences. For instance, 'the-current-weather-for.wav' + 'tomorrow.wav' + 'is-heavy-rain.wav' will output "The current weather for tomorrow is heavy rain". The day changes and the weather changes, so based on the weather or the day, a matching WAV file should be created, stored, then played back to the user. Audio files for all days of the week, all weather conditions, etc, will be stored and played back to the user.

6.3.2 Crop Advice and Agricultural Information

With the use of the voice interface, users can also get crop advice based on the weather and general agricultural information. In order to have this information accessible to the users, audio recording of each advice and crop information will be saved, then users will have the option to listen to these information. Figure 6 in the Appendix, provides a representation of how the user can interact with the system and collect weather forecasts or agricultural information. In addition, when the agro data-entry user adds new agricultural information or crop advice, the user will be required to upload the audio recordings of this information. Once saved, the farmers will be able to listen new information.

7 Prototype Implementation

We built a simple prototype for the web interface of the system. A voice interface was however not developed due to time constraints. But further iterations must include a voice interface. With more time and access to audio recordings in a Burkinabe local language, a functioning voice interface can be developed.

The purpose of the prototype was to provide a simple proof of concept for some of the main functionalities of the system. We developed the prototype using the Flask Python framework, and MySQL as a database. The app is hosted on Heroku[4] for free, and the codes are available publicly on GitHub[5]. A demo showing the main functionalities of the prototype has been uploaded online[6].

The prototype provides weather forecasts for the user's location, provides crop advice to user based on the predicted weather condition, and provides the user with general agricultural information. The section briefly discusses the main functionalities implemented in the prototype.

7.1 Weather Prediction

We made use of the OpenWeatherMap API in collecting free weather predictions for the next 5 days. We collected this data and made some formatting of for instance, converting date and time to day of the week. This is because farmers will be more concerned with the day of the week, they might not be familiar with date and time formats. The next formatting was to rank the temperature. As farmers have low level of literacy,so most of them will not be familiar with terms like 20 degrees celsius or fahrenheit. Therefore rather than use this values, we categorized the weather from cold to warm, to very warm, to hot, and to very hot. So rather than display only numbers, it tells if the number is categorized as

[4]monsieurmeteo.herokuapp.com
[5]https://github.com/armydah30/monsieurmeteo
[6]https://youtu.be/QdhTVwuo-U8

warm, hot, cold, etc. Fiqure 6 shows a screenshot of this functionality.

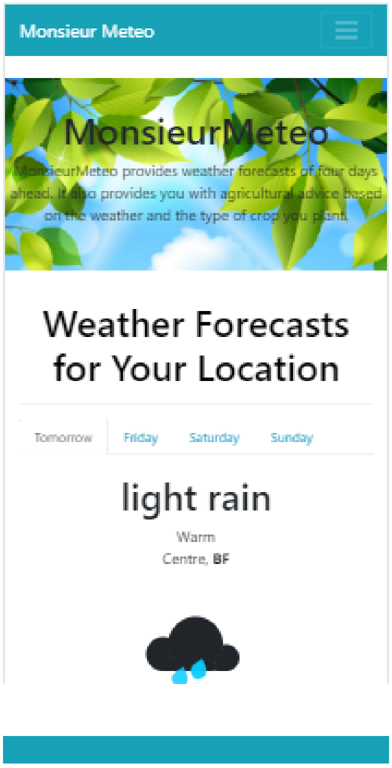

Figure 6: Weather Forecast

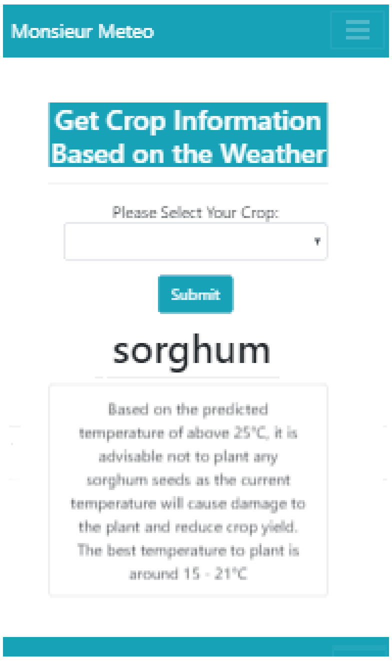

Figure 7: Crop Advice

7.2 Crop Advice

For this prototype, an important functionality was for the system to provide crop advice based on the weather condition. Two crops of Sorghum and Maize were implemented in the prototype. We collected information on the two crops and how they are affected by wind and temperature weather conditions, as can be found in Table 2 of the Appendix. We added this information to the database of the system terming them as 'Rules', and allowed it to be displayed to the user via the web interface, such that when the weather forecast information is provided, and the user selects a desired the crop, the system provides the user with an advice (if any) for the crop. For instance, if the predicted temperature is greater than 30 degrees, the farmer is advised not to plant any new seeds as the temperature might be too harsh and cause damage to the seed. The Figure 4 in the Appendix presents an activity diagram that represents how the system interacts with the database and weather forecast information, and gives the user a response. Figure 7 shows a sample of this information for the prototype.

7.3 Advice Management

We implemented a data-entry functionality that allows a user add and update advice/ rules in the system. The user can add more advice to the system specifying the weather condition, and the associated values. This was termed as 'rules' in the prototype because in order to give a certain advice, the specified weather weather condition has to be met.

These were the main features implemented in the prototype on a simple interface that allows us to demonstrate some components of the system. The evaluation of this prototype will be discussed in Section 9.

8 Sustainability and Implementation Plan

While building a weather information system in this context, it is important to consider how the system can be sustained over time. This section outlines four options that can be implemented, in ensuring sustainability over time.

8.1 Government/NGO Sponsorship

At the initial stage, there will be need for financial resources for implementing the system. We therefore propose that for this stage, the system is supported by an NGO or the NGO in collaboration with the Government of Burkina Faso. The government of Burkina Faso has for a long time been involved in managing the impacts of weather conditions in Burkina Faso. It has worked with various NGOs in developing initiatives that are channeled towards benefiting farmers and improving agriculture and food availability in Burkina Faso.

A programme on climate information for Burkina Faso was proposed in 2016 by an NGO called the UNDP (United Nations Development Programme) in collaboration with the Burkina Faso government. The project named "Promoting Index-Based Weather Insurance for Small-Holder Farmers in Burkina Faso" was proposed at USD19 million in financing. The project was aimed at assisting small-scale farmers in minimizing risks associated with damages caused by weather conditions. This project along with several other initiatives have been developed in order to improve the conditions of farmers and the citizens in Burkina Faso.

With an organization like UNDP willing to help development in countries like Burkina Faso, it is therefore possible to propose that the development of the system is sponsored by an NGO or by the Burkina Faso government. The initial implementation and startup costs will be borne by these parties. They can also actively work on making the farmers aware of the system, and providing them with assistance on how to use it. At this stage, farmers will become more familiar with the system, and the benefits it brings.

According to the e3-Value model in Figure 8 below, the NGO/Government funds the system, and in exchange, the system provides support for the farmers. The farmers get the information from MonsieurMeteo without any fees being paid in exchange. The farmers can however provide observed weather data in exchange. According to the previous field research carried out in Burkina Faso, the Government and some NGOs are interested in locally observed weather data. The farmers can provide this observations in exchange.

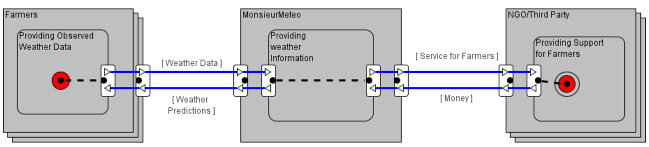

Figure 8: e-3 Value Model for NGOs

8.2 User Subscription

In the event that the NGO or Government stops sponsoring the system, as most NGOs tend to do after a while, the next option is to commercialize the system. The continuity of the system can be ensured by providing a subscription based service, that allows the farmers subscribe to the system and get weather information for a small fee. Users who wish to use the system can pay for a weekly to monthly subscription in order to have access to the system.

As mentioned in Section 2, a significant amount of farmers are willing to pay for weather information[16]. By providing weather information at a small fee, farmers can pay a small fee on a weekly to monthly basis in order to have access to the system information. Therefore careful consideration needs to be made when implementing the system, to ensure that costs are kept at the minimum. Based on the calculation in the previous the section, the total monthly cost per user of implementing the system is at €0.26. Then when compared to the minimum cost of living at €1.07 per day - €32.1 per month, this option seems more feasible. .The users can afford a fee of at least €0.26 per month. This fee will allow the user generate revenue that can sustain the system economically. The Figure 9 below shows an e-3 Value model for this option. The user pays money to the system, in exchange for weather information.

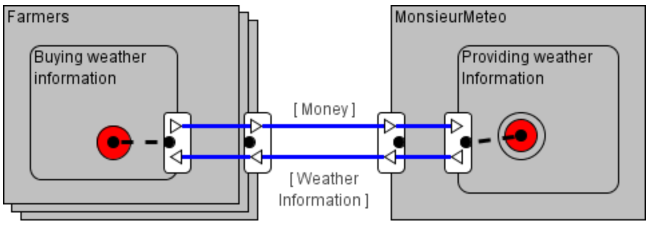

Figure 9: e-3 Value Model for Farmer Subscription

8.3 Middleman Subscription

The next option is the use of middle-men. As a way of further reducing the fee farmers have to pay to get weather information, another option is to make use of middle-men. Figure 10 below shows an e-3 Value model that represents the exchange of value between the farmers, middlemen and MonsieurMeteo. According to the figure, the middlemen subscribes to the system and pays a fee for accessing the weather information provided. The middlemen in return gives this information to the farmers in exchange for a smaller fee. By using this approach, the farmers can buy the weather information from the middleman who acts as a vendor for information, at smaller costs. For instance, instead of having to pay as much as €0.26 per month, farmers pay 50 - 60 percent lesser.

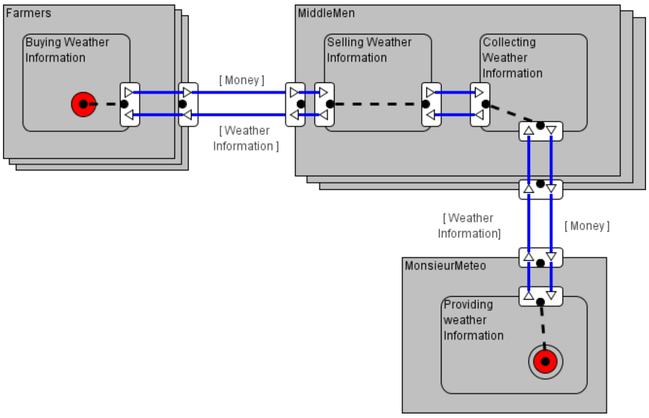

Figure 10: e-3 Value Model for Farmer Middlemen

8.4 Radio Stations Subscription

The last proposed option for sustainability is for radio stations. As mentioned previously, radio station are also actors involved in the system. In order to ensure some sustainability, the radio stations can have access to the system however, this access and are charged a certain fee. By having access to the system and the weather information provided, radio stations can broadcast more accurate weather information. However, in considering how this can benefit the radio stations or seem like a useful investment to them, we have proposed some benefits that the radio stations can get from subscribing and providing weather information to farmers.These benefits can act as incentives for radio stations to subscribe to the system:

8.4.1 Increased Audience Share

By having access to accurate weather forecasts that are beneficial to farmers as well as other stakeholders, radio stations will be able to acquire a more steady listeners and increase their audience share. Radio stations in rural Africa generate a certain percentage of their revenue by selling airtime slots to companies or individuals who wish to advertise or have programs hosted on the radio[22]. The largest radio stations with higher rates of listeners tend to have a higher demand for their airtime slots, and are thereby able to charge a higher fee per airtime. This means that once a company is able to increase its listener base, such a company will be able to generate more revenue. Therefore, it can be proposed that radio stations should make use of the weather system in providing a unique value to individuals, thereby increasing its listener base, and generating more revenue.

8.4.2 External Fundings

Another benefit for the stations includes potential for increased funding. The majority funding for radio broadcast stations in Burkina Faso come from external donors such as NGOs[22]. As mentioned above, there are a number NGOs and organization interested in the development of agriculture and food security in Burkina Faso. By providing weather information that benefit farmers, radio stations can position themselves to receive additional funding from such NGOs and organizations involved in agricultural development.

The e-3 Value model in Figure 11 provides a simple representation for this option. It shows how the radio station provides revenue to the system in exchange for weather information. And the station provides this information to the farmers in exchange for increased audience share.

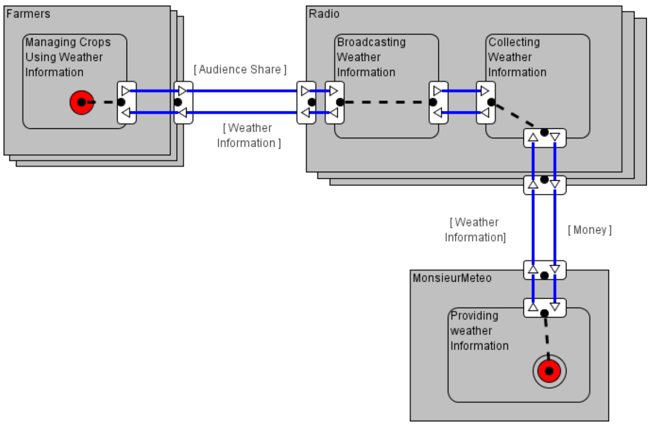

Figure 11: e-3 Value Model for Radio Subscription

8.5 Implementation

The first model is the ideal option for implementing the system. Where the NGO pays for the start up costs of developing, implementing, and maintaining the system. However after a few years or even months go by, and the NGO is no longer willing or able to support and fund the system, the other three option can be set in place. By commercializing the system and allowing the three types of users to subscribe and pay a certain fee, the system can be kept running. The last three option could be utilized simultaneously. The farmers can either subscribe directly by paying for a subscription, or the radio can subscribe broadcast, or lastly, a vendor can subscribe and re-sell the information. The system can generate funds from all three sources or from one source at a time.

9 Evaluation and Discussion

We conducted an interview to evaluate the prototype that was developed. The aim was to test the response of farmers to the system, and get a verification on the need for an appropriate interface that fits this specific context. Due to the lack of access to farmers from Burkina Faso, the test was carried out using users from a similar context. The evaluation was conducted with 10 farmers from a rural area in Northern Nigeria called Nasarawa.

9.1 Setup

As our research was conducted in the Netherlands, the evaluation and interviews was conducted by two contact persons we had in Nigeria. One is a farmer who had access to other farmers. He contacted the farmers and requested their participation in the evaluation. His help was also needed in providing translations as the farmers mostly spoke 'Hausa', and he understood the language well. The other contact person is a Software developer from Abuja, Nigeria. We contacted him for his help in conducting the evaluation over there, because of his knowledge of software applications and how they operate. Moreover, we expected that most of the farmers will not be literate enough to use the application themselves, or understand the questions from the questionnaire, so it was important to have someone that could properly demonstrate and explain things to them, and also conduct the interviews. We prepared an evaluation questionnaire which has a few questions about the farmers, and about the system. It also included the System Usability Scale questions intended to evaluate the usability of the system. The content of the questionnaire is as shown in Figure 7 of the Appendix. The questionnaire was sent by email, and all other communication with the contact persons was done by phone call and text messages.

9.2 Evaluation

During the evaluation, a total of 10 farmers were interviewed. Comprising of 8 male farmers and 2 female farmers. We hosted the prototype on Heroku so that the application could be accessed using a mobile phone. The interviewer made use of an android 'Samsung Note 8' phone for testing the application in the evaluation. However, it turned out that most of the farmers did not have knowledge on technology or on how to use a smart-phone, so a demonstration was conducted as an alternative. The farmers were given individual demonstrations on the functionalities of the app, and were also given translations on some of the content as needed. Most of the farmers could not read or write, so the questions from the questionnaire had to be read out to them, and their responses were transcribed.

9.3 Result

70 percent of farmers did not have access to the Internet or a smart-phone, while only 30 percent of the farmers could access the Internet and had smart-phone devices. Only 3 farmers could provide an evaluation on the application's usability using the System Usability Scale. The remaining 7 farmers could not provide any information as they were not familiar smartphone devices and applications, and how they can be evaluated. However, all farmers found the information provided by the system very useful. 10 out of 10 farmers were interested in the weather information provided, while 5 out of 10 were explicitly interested in the crop advice given by the system. A farmer who was new to farming found the crop advice and information useful as it will provide him with some information on what to do. And other farmers felt that the weather forecasts will let them know when they have to visit their farms, and how to plan their farm activities. Table 3 of the Appendix provides a summary of the information collected during the interview. The farmers provided suggestions such as:

- Should be available in GSM mobile phone
- Should include more crops
- Should include more options for locations

While all farmers found the weather information useful, 70 percent of them requested that the information will better serve them if it were available on their normal GSM phone. Figure 8 of the Appendix shows a sample response that was transcribed from one of the farmers. The majority of the farmers suggested that the information provided by the application should be made accessible to them via non-smart or internet connected phones. Therefore, it is perceived that a voice interface is needed for the next set of evaluation.

9.4 Discussion

We carried out this evaluation as we were interested in getting some feedback from the farmers who have a similar background with farmers in Burkina Faso (in terms of rural infrastructure and agriculture as a means of sustenance). We are however aware that the validity of the results collected are still questionable because the evaluation was carried out in a situation that we could not really control. For instance, most of the farmers could not read or write, or speak English, so their response had to be translated, then transcribed on paper by the interviewers. Which could have some level of influence on the results collected, as the information collected depended on how it was translated by the interviewer and how it was written down. We concluded that this approach might not be the ideal way of testing the system, as most of them had no idea how to use an android phone or a web-based application. However, the evaluation was still able to provide some valuable results which can be applied when planning for a next phase of evaluation. In the next phase, it will be crucial that a voice-interface is tested, and that a different format for testing usability is used. For instance the clarity of the voice used in the interface will be evaluated, the grammar used in the local languages will be evaluated for correctness and understandability, etc. In conclusion, this was a simple evaluation setup to explore the response of the farmers to a weather information system, and lay the groundwork for future evaluations. In other future work, the scope should be broadened, and multiple iterations of the system should be evaluated progressively. All data collected during our research and evaluation were uploaded online[15].

10 Conclusions and Future Work

The aim of our research was to investigate the requirements and options for sustainable weather information system in the context of rural Africa and deliver an approach for developing and ensuring the sustainability of the system. We have through this study, delivered an approach for developing the system, and have achieved this by combining different existing methods like the ICT4D use case description format, the e-3 value model for sustainability, etc. In addition, based on our review of previous work and literature, we failed to find any existing works or designs for a weather information system done specifically for rural Burkina Faso. As mentioned in Section 2, Asenso-Okyere and Mekonnen[2] reviewed the benefits and importance of weather information systems in Africa, however like many other reviewed literature, they did not deliver a method or an approach that can help deliver the system. Our study in contrast, takes a step forward to deliver a method for developing this system specifically for rural Burkina Faso.

Through this study, we learned that climate change is a huge issue for farmers all around Africa. The issue of weather induced agricultural loss and low agricultural productivity begs the need for a Weather Information system that can help mitigate these losses and improve agricultural knowledge. However we learned that, access to web resources is still a huge issue in Africa because the people lack the skills and resources needed to make use of modern technologies. So even if a full featured system is designed and developed to meet the needs of the people, if the farmers are unable to have access to the system or the information it provides, the system has no value to them. Our study confirmed this using the results from the evaluation that showed that the majority of the farmers could not use the prototype we developed. We therefore learned that there is a need to adjust our method and approach towards developing systems in the context of rural Africa. That when designing and developing any type of system for rural Africa, much focus should be placed on how the system can be implemented using the resources and infrastructure easily available to the people and ensure that they can easily interact with the system. For instance, in rural Mali and rural Burkina Faso, the people dearly lack technological infrastructures and resources therefore, regardless of the type of system, for weather, agriculture, marketing, etc., much emphasis should be placed on how majority of the users can easily access the system.

10.1 Future Work

In terms of future work, we propose that the first step should involve collecting large historical weather data all around rural Burkina Faso and using such data to provide weather predictions at a local level. Data on various weather conditions like rain, temperature, wind, etc. This data once collected over a long period of time can be used in providing more accurate weather prediction. The application of data mining and weather prediction techniques can be used in making this predictions. By providing the system access to this data, it can provide more accurate weather predictions.

In addition, if there was time, we could have done more design cycles and prototype iterations, and properly evaluated them. A future task will be to test the voice interface with more farmers, and test the admin and data-entry user web interface with participants with sufficient knowledge of mobile and web applications. New functionalities from the system designs could be implemented and tested as well.

The last proposed step is an extensive study of the impact of the system on the farmer's productivity. This is because once farmers start to use the system and also implement the knowledge gained from the system, it is important to know if the system actually has a positive impact on the farmers, and if it does, by how much. Indicators for productivity in this study could be amount of crops harvested since the farmers started using the system, the quality of their crops, or the income generated. These values can be compared to old values before the implementation of the system, and if there is or isn't a significant difference. Meaningful conclusions could be drawn from the results.

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Appendix

Cities	Weather Stations
Ouagadougou	TA00160, TA00162
Boromo	TA00161
Dedougou	TA00163
Ouahigouya	TA00164
Dori	TA00167
Po	TA00165
Fada N'gourma	TA00168
Bogande	TA00169
Gaoua	TA00170

Table 1: TAHMO Weather Stations in Burkina Faso

Crop	Weather Condition	Information
Maize	Temp. > 32 °C	Temperature greater than 32°C is detrimental to the crop yield. You are advised not to plant any seeds at this temperature, this will have a bad effect on the yield.
Maize	Temp. < 19 °C	Maize is a warm weather crop and should be grown where the daily temperature is greater than 19 °C. You are advised not to plant maize seeds if the average temperature is less than 19 °C.
Maize	Temp. between 18 to 20 °C	Planted maize will emerge within five to six days at this temperature. This will be a good temperature plant your seeds.
Sorghum	Wind > than 29 km/hr	Strong wind can lead to soil erosion and cause planted seeds to be blown away. Plant your seeds deeper to prevent them from being blown away.
Sorghum	Temp. between 20 to 30 °C	This temperature helps to ensure optimum growth and yield of the crop. It is advisable to plant your crop at this temperature.
Sorghum	Temp. < 21 °C	Temperature below 21 °C can have a dramatic effect on growth and yield of the crop.

Table 2: Sample Crop and Weather Condition Data

n	Sex	Age	English	Phone	Crops	Interests
1	Female	38	Yes	GSM	Beans, Rice, Cassava...	Forecasts on GSM
2	Male	30	No	GSM	Cassava, Guinea Corn, Rice..	Forecasts on GSM
3	Male	35	No	GSM	Maize, Gero(Millet), Cassava...	Forecasts on GSM
4	Male	45	No	GSM	Maize, Rice, Beans, Yam...	Forecasts on GSM
5	Male	65	Yes	GSM	Maize, Yam, Millet...	Forecasts, Crop Advice
6	Male	40	No	GSM	Maize, Beans, Groundnut...	Forecasts on GSM
7	Female	29	Yes	GSM	Maize, Rice, Guinea Corn...	Forecasts on GSM
8	Male	33	Yes	Android	Maize, Pepper, Tomatoes...	Forecasts, Crop Advice
9	Male	24	Yes	Android	Maize, Beans, Yam...	Forecasts, Crop Advice
10	Male	30	Yes	Android	Maize, Yam, Cocoyam...	Forecasts, Crop Advice

Table 3: Summary of Evaluation Results

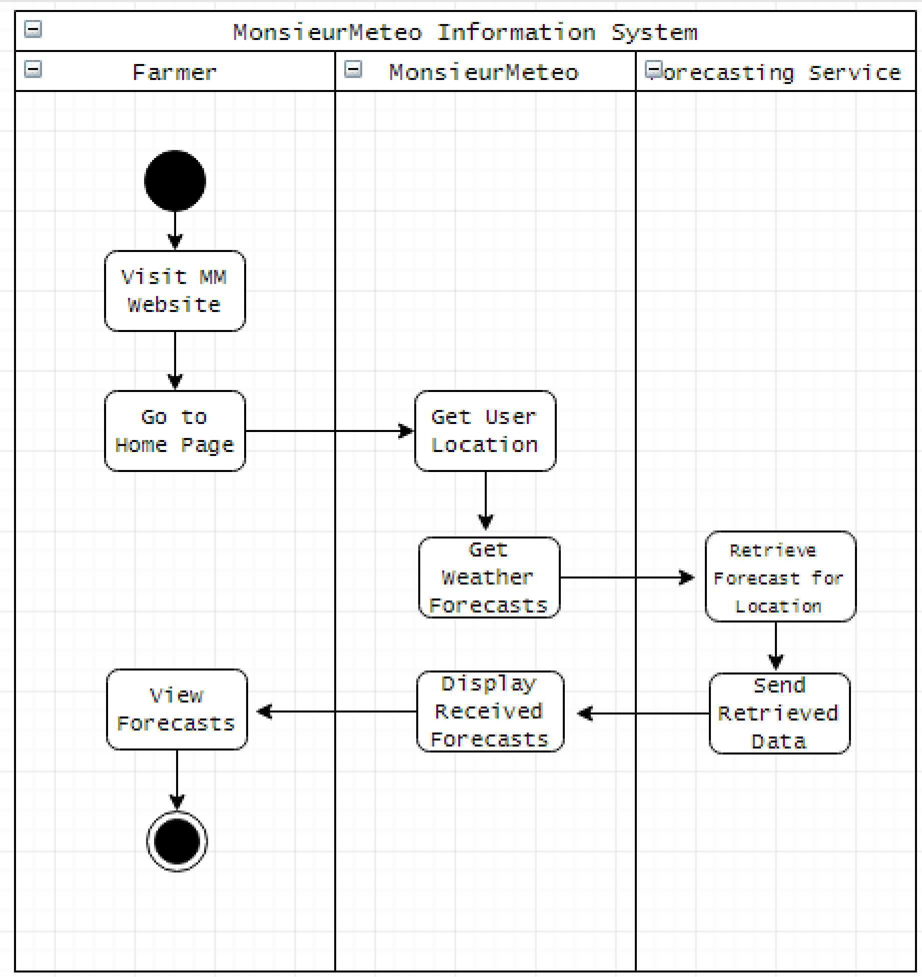


Figure 1: System-User Activity Diagram

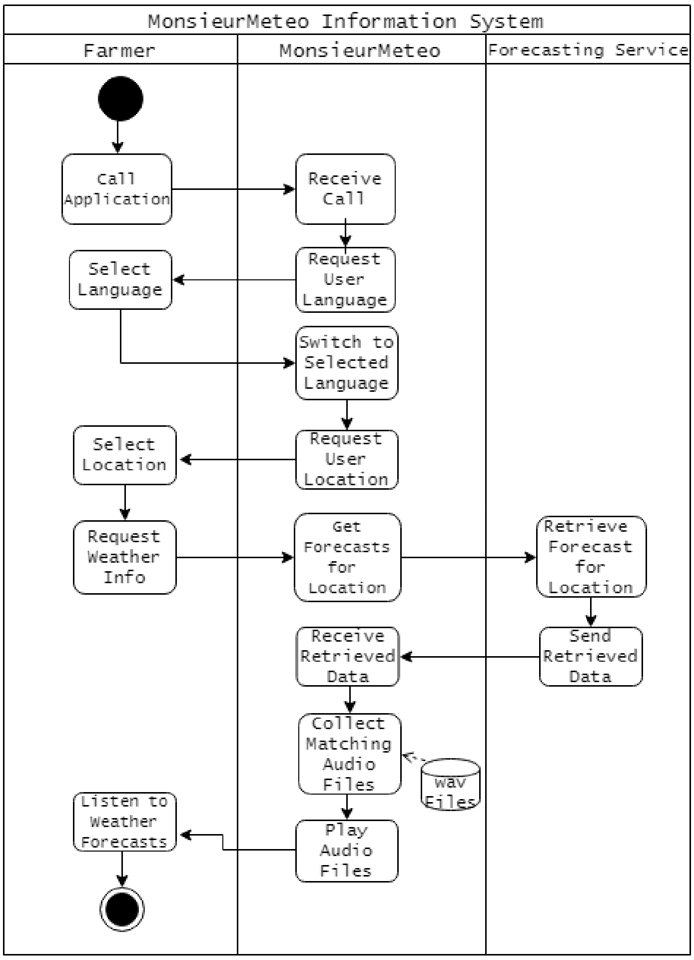


Figure 2: System-User Activity Diagram - Voice

Day	average humidi	total rainfall (mr	average temper	min temperature	max temperatur	average windsp
2018-02-21	41.38	0	31.89	28.28	38	2.03
2018-02-22	38.63	0	32.52	25.6	39.01	1.59
2018-02-23	32.63	0	33.16	27.2	39.6	0
2018-02-24	72.45	0.42	24.83	22.96	26.73	2.31
2018-02-25	53.5	0	28.99	22.97	34.48	0
2018-02-26	33.08	0	31.91	25.97	37.65	0
2018-02-27	35.33	0	32.73	26.1	38.71	0
2018-02-28	33.92	0	33.03	27.07	38.52	0
2018-03-01	27.63	0	33.7	26.48	40.2	0
2018-03-02	20.5	0	33.69	26.07	40.35	0
2018-03-03	22	0	33.3	24.8	40.06	0
2018-03-04	19.38	0	34.06	25.94	40.45	0
2018-03-05	18.08	0	34.1	27.12	40.05	0
2018-03-06	18.25	0	33.48	26.93	39.47	0
2018-03-07	16.21	0	33.4	27.1	39.73	0
2018-03-08	30.71	0	33.36	27.75	39.13	0
2018-03-09	17.29	0	33.84	26.3	40.54	0
2018-03-10	15.54	0	33.64	26.85	40.74	0
2018-03-11	21.54	0	33.73	25.38	40.45	0

Figure 3: Sample Weather Data from Weather Station in Ouagadougou

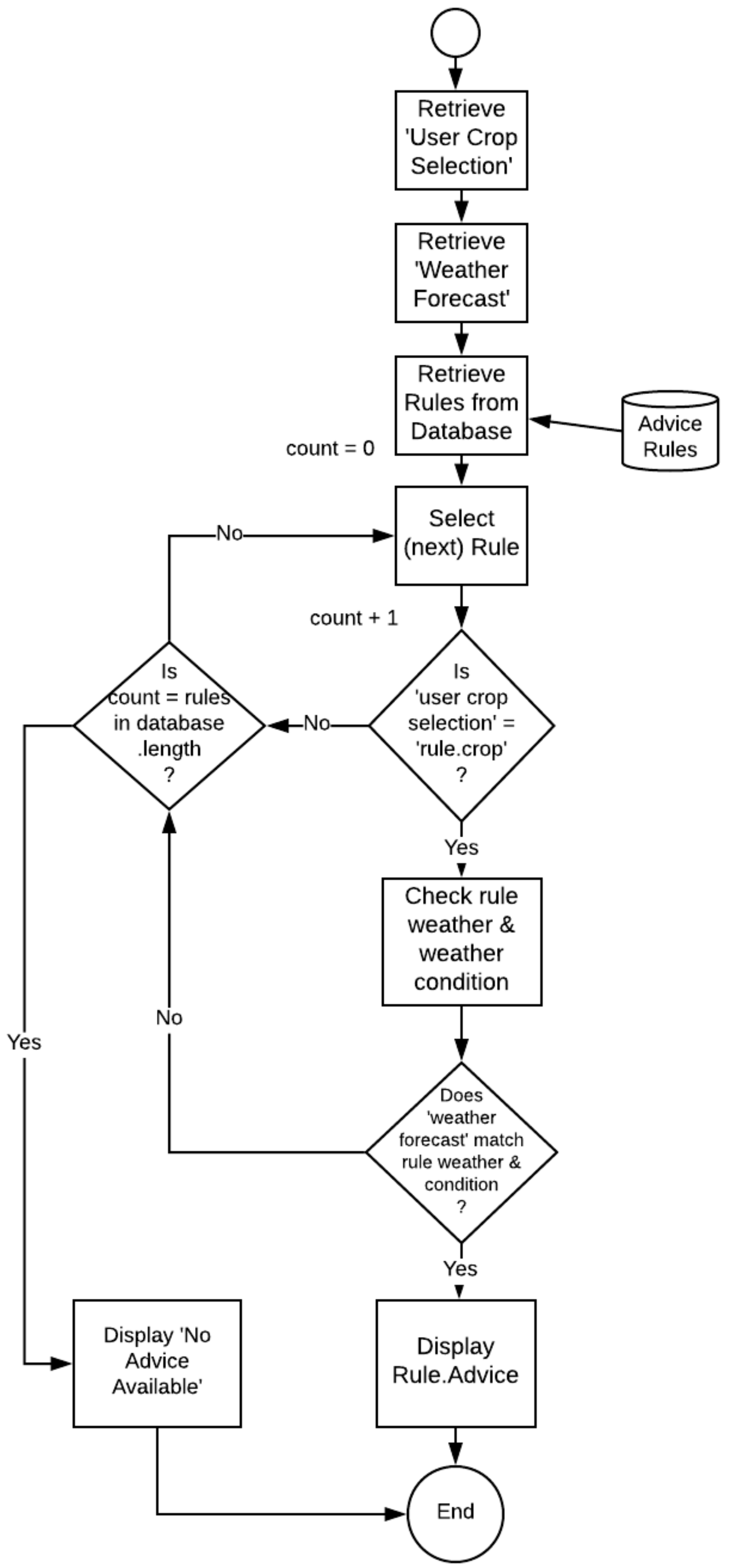


Figure 4: Sample Weather Data from Weather Station in Ouagadougou

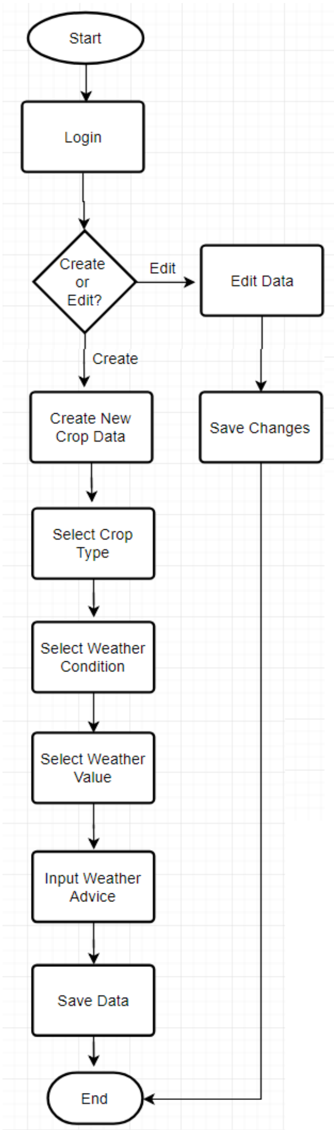


Figure 5: Manage Advice

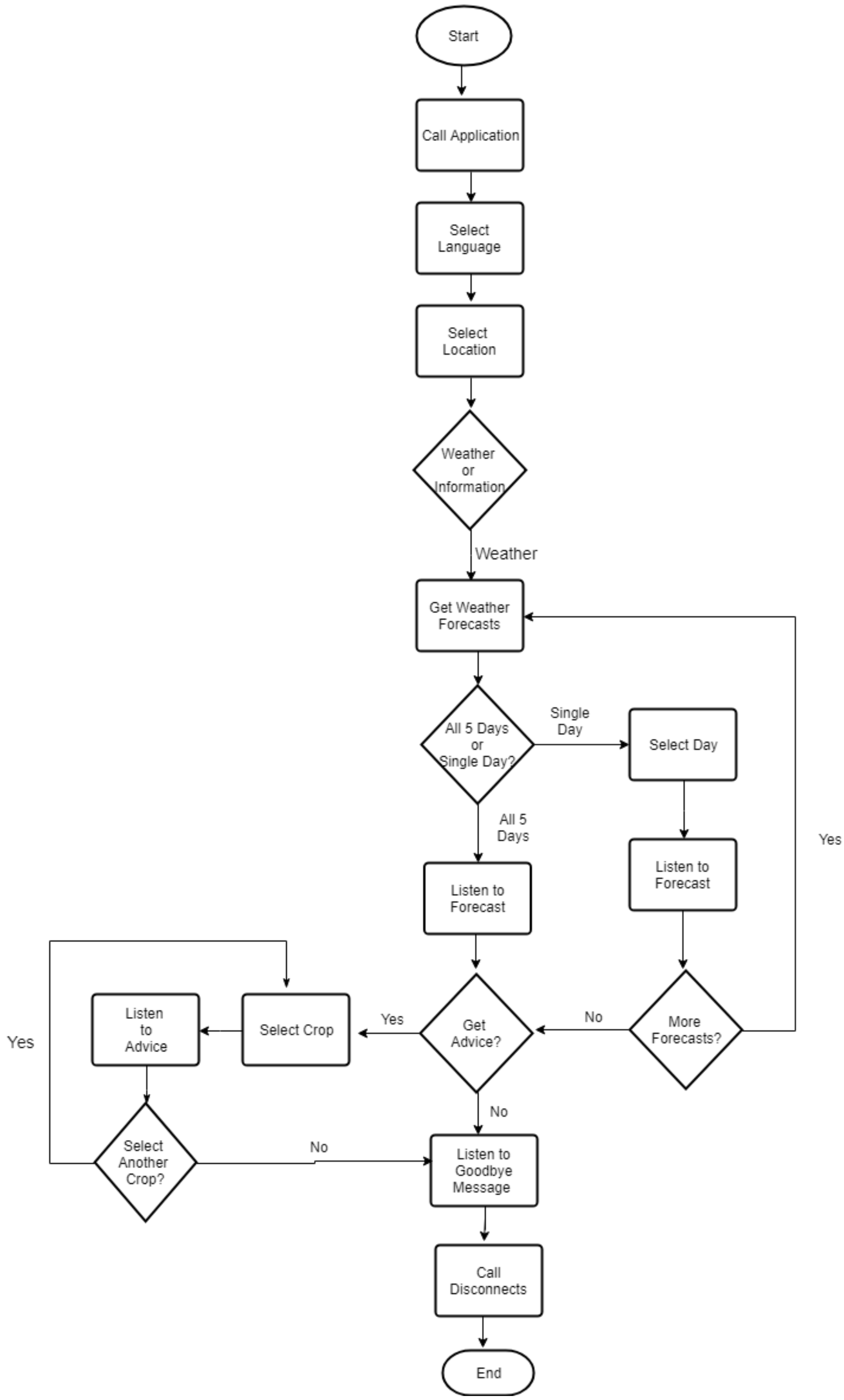


Figure 6: System-User Activity Diagram - Voice

Evaluation Questionnaire for Monsieur Meteo

Gender:

Male ☐ Female ☐

Age:

Do you own a smartphone (Android or IOS)?

What crops do you plant?

System Usability Scale

Instructions: From the following statements, mark one box that best describes your reaction to the application.

		Strongly Disagree				Strongly Agree
1.	I think that I would like to use this website frequently.	☐	☐	☐	☐	☐
2.	I found this website unnecessarily complex.	☐	☐	☐	☐	☐
3.	I thought this website was easy to use.	☐	☐	☐	☐	☐
4.	I think that I would need assistance to be able to use this website.	☐	☐	☐	☐	☐
5.	I found the various functions in this website were well integrated.	☐	☐	☐	☐	☐
6.	I thought there was too much inconsistency in this website.	☐	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this website very quickly.	☐	☐	☐	☐	☐
8.	I found this website very cumbersome/awkward to use.	☐	☐	☐	☐	☐
9.	I felt very confident using this website.	☐	☐	☐	☐	☐
10.	I needed to learn a lot of things before I could get going with this website.	☐	☐	☐	☐	☐

Additional Questions

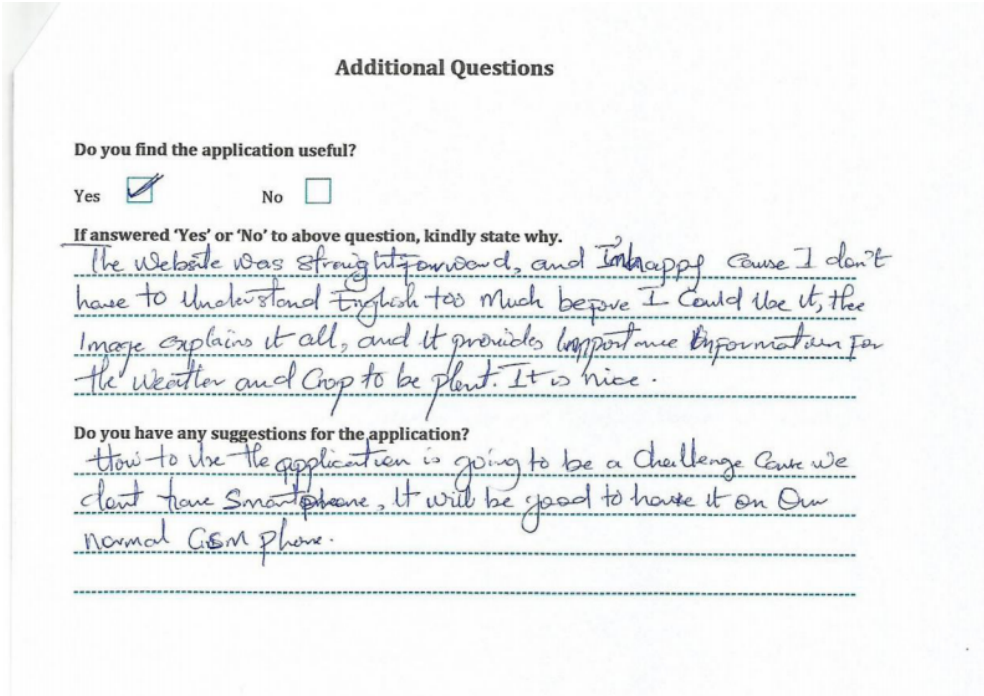
Do you find the application useful?

Yes ☐ No ☐

If answered 'Yes' or 'No' to above question, kindly state why.

Do you have any suggestions for the application?

Figure 7: Evaluation Questionnaire



Additional Questions

Do you find the application useful?

Yes ☑ **No** ☐

If answered 'Yes' or 'No' to above question, kindly state why.

The Website was straightforward, and I'm happy Cause I don't have to Understand English too much before I Could Use it, the Image explains it all, and it provides Importance Information for the Weather and Crop to be plant. It is nice.

Do you have any suggestions for the application?

How to Use the application is going to be a Challenge Cause we dont have Smartphone, It will be good to have it on Our normal GSM phone.

Figure 8: Sample Farmer Response