# THE DEVELOPMENT OF CLIMATE AGROMETEOROLOGICAL APPLICATION FOR FARMERS IN NAMIBIA

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*ABSTRACT*

*Climate services involve the timely production, translation, and delivery of useful climate data, information and knowledge for societal decision making. In order to create climate services for farmers that are truly integrated with user-centric design into the development process in an African context, the study has finished an important and crucial step by conducting a literature review and designing a prototype for the application. The goal of this study was to create climate services for farmers in an African context that are genuinely integrated with user-centric design. This led to the co-design and development and integration of a mobile application that provide climate and weather information as well as agricultural information for the main crops such millet, maize and sorghum. The research applied using qualitative research using interview with 3 farmers in the field using random sampling with the approach to inform the study. A survey has been administered to find out how people understand climate services, Agro meteorology and help enhance the mobile application's user experience. A Results shows that farmers are determined and ready to use and excited with the application. These innovations helped farmers to reduce the cost, increase crop capacity and profit. A hypothesis was set that there is a need forintegrating AI into a farmer's application for making farming process more progressive and efficient farming and the integration of Market Place (MP) for farmer's application to market and sell their product the integration of notification system that allows farmers to receive real-time data and IOT for real-time data. The data collected and the survey results demonstrated that the research objectives were being met. The study aims to develop the application that would be scalable, durable and fault tolerant for farmers to use the application successfully.*

*KEYWORDS*

*Climate services for farmers, Co-design, Mobile application, Artificial Intelligence, Internet of Things*

## 1. INTRODUCTION

Agriculture is one of the fastest growth in the economics and it is not an exception for Namibia. Since it contributes to provision of capital, provision of labour, provision of wage goods these all factors increase the growth of agriculture in the economy of a certain country. Agriculture provides the benefit of food security, supply of food as well as fodder, source of raw material. The fact that there's lack of information transfer in between farmers can lead to great impact on farmers in rural areas and commercial. Information on agriculture, markets, and weather is essential for increasing agricultural output, especially to reduce the risk and uncertainty associated with disease and extreme weather events [1].

There implementation of a software tool aid farmers with preparedness of avoiding the risk of crop failure using the agricultural information, to measure the farmers crop temperature, to measure the humidity of the crops of the farmers, to measure the rainfall of the particular area of the farmers. Climate services involve the timely production, translation, delivery of useful climate data, information and knowledge for societal decision making. Those services are depending on several expertise and support by research in climate and related sciences in agriculture, water resources, health, energy and a number of social science fields. In Agriculture, farmers need accessible and usable climate services to manage climate risks in the constantly changing environment. For the benefit of the agricultural sector and farmers, the climate services offer crop tracking, agro-meteorological advisories, weather forecasting, seasonal climate forecasting, climate change projections, statistical assessments of the frequency of extreme weather and climate events in the future, and weather forecasting. Farmers looking for real-time data and strive to ensure enough agricultural inputs to meet the requirements of the crop while taking advantage of the data already present on the farm. Weather data including precipitation, relative humidity, wind speeds, temperatures, and solar radiation will be gathered because these variables have an influence on irrigation. This data can collect from the existing regional Authorities e.g. National Meteorological Authority Centre as well as the weather station neighbouring farms.

The proposed approach used different issues to improve the involvement of users during different technical forums and meeting within a small group and evaluative sessions of the mobile application. The outcome of the research indicated that clients and developers benefited the interaction of the product as it met the clients need. Throughout the development of the application the software had reduced number of errors in the final version of the application. According to [2] stated that, in developing countries the rural areas' farmers face challenge competing in the global marketplace and global forces beyond their control due to lack of access to information and communications to make decisions and reach new markets. Due to low literacy and low access to required information, there is no sharing knowledge and experience end-to-end between producers and consumers. Market information such as coordinating the sale, movement, and distributions of products, is essential for decision making. Lacking irrigation or dependence on unpredictability of changing global weather is resulting many farmers' population migration from rural to urban centers for a more stable livelihood, losing their land and their culture and selling out their farm land to builders.

## 2. OBJECTIVES

To develop an Agro-meteorological application that will combine real-time weather information according to the profiles of small-scale farmers in Namibia and integrating a Mobile Application to send notification to the Farmers.

## 3. RELATED WORK

According to [3] Weather and climate play an important role in agricultural production. It has a profound influence on crop growth, development and yields; on the incidence of pests and diseases; on water needs; and on fertilizer requirements. Accurate understanding of extreme meteorological parameters is crucial for farmers to generate more. This information is also useful for modifying the crop environment, taking precautions against frost and powerful winds, and planning irrigation, all of which help to effectively control water usage and prepare for droughts. In addition, droughts and floods are two examples of extreme weather that can ruin crops and lower output. The emphasis on introducing a digital system is on the proper well documented feasibility study and the quality and integrity of data and involvement of stakeholders which are farmers, that allows the software to meet its needs [3].

According to the author [4], A means of getting new technologies, better farming methods, and better management knowledge to farmers is through agricultural extension. There aren't enough extension agents, and there isn't enough time, especially in emergencies like weather- or pest-related ones. As a consequence, radio has gained recognition as a very efficient technology for distributing knowledge, instruction, and technology in rural areas. The poorer segments of the population can now afford low-cost transistor radios that run on batteries, while other communication tools like television stay in the hands of a small minority. Furthermore, there is no literacy requirement for using radio as a contact medium. Additionally, barriers are being removed by the growing shift to local radio program creation and broadcasting. Language and dialect boundaries are also disappearing as local radio programming becomes more prevalent. Due to the local population's typically high vulnerability, there are negative effects on food and water security when drought directly affects agriculture and water resources over such large spatial and temporal scales [4].

As aforementioned, Downy Mildew (Plasmopara Viticola), which can develop and spreadrapidly and result in significant crop losses in some years depending on the weather, is one ofthe most significant vineyard diseases in the Western Cape. In an effort to define the weather circumstances favoring the disease outbreak, researchers from the Agricultural Research Council (ARC) collaborated with growers. Over a number of years, they kept an eye on the weather on the fields as well as any downy mildew outbreaks in the vineyards. The producers must choose which agrochemicals to use, how often to apply them, and whether or not to spray. They need to avoid crop failure due to infection while balancing the number of applications in accordance with economics, minimizing the impacts of pollution. Donsige Skimmel Vroeg- Waarskuwingsmodel (DSVW), which stands for "Downy Mildew Early Warning Model" in Afrikaans, was developed as a result [5]. It offers a user-friendly graphical output of past weather variables (up to three weeks), as well as a three-color indication of a high, medium, and low chance of potential favorable periods for the occurrence of both primary and secondary infections. The model must be run with the daily hourly weather data that is downloaded via telephone modem from the automatic weather stations as input. The model's result is then sentto the growers via email or fax. [5].

According to [6], Although there are many advantages to using satellite remote sensing to supplement low density in situ observations, there are a number of issues that must be resolved before they can fully contribute to drought tracking. These typically include changes to satellite sensors that can cause temporal inhomogeneities, the relatively brief record lengths of satellite products, and the indirect nature of the retrievals of physical variables. They should be used with care, in particular, due to errors in individual products, inconsistencies between products, and nonclosure of the water budget. Droughts cause less than 20% of all natural disasters in Sub-Saharan Africa (SSA), but they affect more than 80% of the region's people (UN/ISDR 2009). Because a large portion of the region relies on rain-fed agriculture, it is especially vulnerable to climate change. On average, agriculture accounts for 25% of the continent's gross domestic product (GDP) and employs close to 70% of the labor population [6].

There is no proof that historical climatic data given through any agricultural project for meteorological purposes is integrated into the agricultural sector in Sub-Saharan African countries. It demonstrates that many MNOs that run agro-meteorological services are unimpressed with the various services provided to farmers and the insufficient weather services given to farmers. Instead, India has created a sophisticated system for sending farmers agro meteorological warnings, some of which are done so via mobile devices. RegionalMeteorological Centers transmit weather information to 130 AMFUs which are located in each of the Agro-climatic zones. They then create Agro-advisory information in collaboration with agricultural specialists, which incorporates weather data with crop and soil recommendations and offers recommendations for reducing losses and maximizing inputs [7].

Summer cyclones frequently have a windy component. Rainwater splashing causes infections and worsens disease when wolfberry stems are in motion and scratch fruits and other plant parts. In a year with a high incidence of disease, the proportion of diseased fruits results in a 50% loss in output, with a sharp decline in market price because of the poorer fruit quality. Meteorological conditions play a key role in the occurrence and development of this fungus disease. The fungus disease of the wolfberry will spread rapidly if the rainfall is around 40 mm for that same time criterion. 50 to 80 percent of crops will now be impacted or turn black.

Comprehensive preventative and control methods were discovered, and forecasting and alert models were developed. To determine the signs of the fungus disease in its early stages, the severity of the epidemic disease is divided into five categories based on the field epidemic state. [8].

This agricultural method improves water infiltration while lowering soil moisture evaporation and water runoff in these (semi-)arid regions, which receive the majority of their rain in the late summer and fall. Using the information in [9] [10], we have briefly described and discussed the example of watermelons grown in a better microclimate made by covering sandy soil with eight to ten cm of pebbles dug up from river beds, explaining the wind erosion protection, the soil surface evaporation prevention, and the warming of the seed bed so created. It has been observed that, especially at night, the soil surface temperatures at the bottom of such covered cavities can be up to five degrees warmer than those at the pebble surface. Due to the length of the growing season and the significance of early sowing, this can be a crucial frost protection problem for the method. In the early stages, plastic can help shield seeds and seedlings from frost, but not all farmers use it because of location issues. Further details are also in [11]. With the approval of the China Meteorological Administration, Beijing, a Provincial Government Meteorological Service provided the policy support for this capacity development in microclimate improvement. [12].

Compax has years of experience applying integrated Control and SCADA/DCS systems, and it provides a mature range of products and services. With projects in Israel, South America, Europe, and the Caspian area, it specializes in Water and Waste Water, Oil and Gas, and Process applications. Their expertise lies in integrating cutting-edge software tools, data acquisition, process management, and advanced communications (data voice and video over wireless cellular satellite fiber, etc.) into a synchronized operation that maximizes productivity and profit for their clients. The range of capabilities includes everything from providing full turn-key systems to providing expert guidance on integrating complicated industrial computerized systems. Here are some examples of some of its completed projects: SCADA technology for monitoring and controlling Bogota's urban water distribution, sewage collection, and wastewater treatment is provided by the EAAB Bogota Municipality. The water department of the city of TEL AVIV uses the SUPERVISOR CONTROL PACKAGE (SCP) to command and control the city's water supply. Monitoring system for the Kishon River maintained by the Kishon River Authority. The Barcelona Flood Water Management System is mainly impacted by rain in Spain. Technology includes: Customer-developed designs and construction of municipal command and control centers; feasibility studies and system analyses. Management of Risk and Water Safety Implementation for Wastewater Treatment Plant Management and Potable Water Plant Management vast city complexes Create and design networks Cost- and energy-saving measures Contemporary Technology (Industrial equip IT Communication) intelligent use of water resources [13].

According to [14], when utilizing info on the local climate There are two options available to agrometeorologists when presenting historical observational data: they can either show the derivatives or by-products of these historical data. They leave it up to farmers to evaluate and interpret the data if they opt to only show the raw data. Sadly, the majority of smallholder farmers lack the skills and equipment required to evaluate raw data. Therefore, this choice is not significantly different from blocking access to agro-meteorological information. If the agrometeorologists choose the latter option, they will need to stress the inherent uncertainty in statistical derivatives of historical data in order to retain their credibility. Seasonal outlook prediction literature provides some insight into this problem.

## 4. METHODOLOGY

A researcher can easily implement the best design for the research because the study used a quantitative research design. The aim is to collect, analyze, find pattern and averages, make prediction, and test the relationship on how it can be successful to implement the Agrometeorological application for farmers in Namibia.

### 4.1. Research Design

The study employed a quantitative methodology, and a review of prior research materials, journal articles, conference papers, articles, blogs, books, webpages, and academic tools was conducted. Research was done regarding on which particular software package that will be suitable for Agro meteorological application building to meet the requirement of researchproject objectives. The study is further divided into stages that were followed to complete the project. Here are the stages that were followed.

### 4.2. Data Analysis

The study focused on two types of data analysis which are predictive analysis and descriptive analysis. The study analyzed the data by predicting the weather forecasting in 3 days, the study made a prediction of informing the farmers the right time to sow, harvest, planting by predicting the particular weather. In addition, the study developed a system that send this information to the farmers through their mobile devices. Further, the study used qualitative data analysis by developing the system by coding using the Microsoft Visual Studio C# with the use of descriptive data analysis by collecting huge amount of data that need to be summarized and interpreted. The questionnaire used random stratified sampling, a population of 8 participant's part taken 4 students from University of Namibia (UNAM) and 4 farmers from Naumbabale Village in Ohangwena region, further the survey question can be found on the appendix, the survey provided the following results. The result made the study to be researched on, 87.50% understand the terminology of the term Agro-meteorology, where 12.50% participants do not understand the terminology. 87.50% participants concluded that they have not used the application in their farm before and 12.50% concluded that they have used the application before in their farm. 87.50% participants concluded using an Agro-meteorological application may require training and 12.50% stated is less accessible in their environment. All participants agreed on this question shows 100% people agreed there's a need to develop an Agrometeorological application for farmers. Participants on this question 50% of them stated meteorology to farmers is significant for real-time and forecast weather information, and 25% ofeach agreed on the other two answers. All participants answer this question by stating their own views on how they see the effectiveness and the need to develop an application for farmers.

## 4.3. Software Developmental Methodology

The study focused on deciding which development life cycle is suitable to implement the Agrometeorological application with mobile notification system integrated in the software since the nature of the study used different data collection methods to complete the development of the software as in Figure 1. Using incremental prototyping in a managed project setting, the Dynamic System Development Method (DSDM) is an agile software development method that offers a framework for creating and maintaining systems that adhere to strict time constraints. [15]. He further stated that the modified Pareto principle served as the inspiration for the DSDM ideology. Only enough work is needed for each increment to enable to the next increment environment, so an application can be delivered in 80% of the time it would take to deliver the full 100% application. The main practices in DSDM involve feasibility study, requirement gathering, planning, designing, and testing. In addition, it allows for improvement of the prototype each time it goes through iteration.

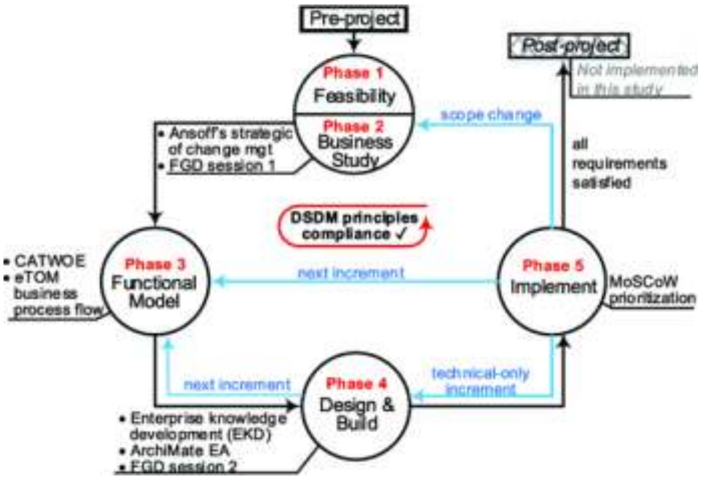


Figure 1. Dynamic System Development Method (DSDM)

### 4.3.1. Hardware and Software requirements

The overall conceptual System Architecture is shown in Figure 2. The software tools needed to build a desktop application integrated with mobile application are listed below. Firstly, one needs to install Microsoft Visual Studio and SQL Server 2014 Management Studio. In this case, the developers used Microsoft Visual Studio 2015 C#, the developer used Twilio Network Service Provider for farmers to receive notification from the system. Additionally, all of the accounts that were registered during the application's signup period were stored in the SQL database, which served as the main backend database. Figma, UXpin, WireframePro, Canva used for graphical user interface design. To create a desktop application and a mobile application, the following hardware was set up: a laptop with standard configurations and 4 mobile IOS and Android smartphones, one of which was used to evaluate the application and the other to serve as a target user device.

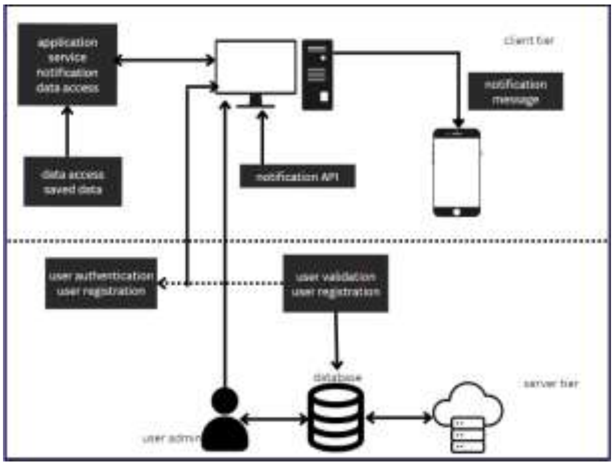


Figure 2. Conceptual System Architecture

### 4.3.2. Testing and Evaluation

The program underwent testing to see if user needs are satisfied and if it performs as intended. To make sure the program operates flawlessly as elicited from the requirement specification gathered from the small-scale farmers, four different types of testing were finished. Unit testing, combined testing, system testing, and acceptance testing are the four testing phases. Figure 3 -9 shows the screenshots for the running system.

The sign-up screen in Figure 3 is the first point of interaction between the system and the user and the log in screen. In order to access the home page or the dashboard, you must check in with your user login and sign-up credentials, such as your username and password. A user can navigate the system by selecting the elements in Figure 4 that are depicted in the form. The user selects part of the system to enter the system has four features which are Weather Center for providing real time data, Information Center for providing user agricultural information, Notification Center to allow the user to receive their notification through their mobile phones. Figure 5 allows the user to enter their village/town to receive their weather information and forecast weather information in real time. Figure 6 allows the user to receive their information regarding the guideline on how to farm their crops and read information online about agricultural worldwide standard for trading services. Figure 7 allows the administrator to send notification to the farmer through their mobile devices about real time data of weather and agriculture. Figure 8 tells the user that they received their notification through their mobile devices. Figure 9 allows the user to query their information regarding about Agro-meteorology and receive their answer at the same time.

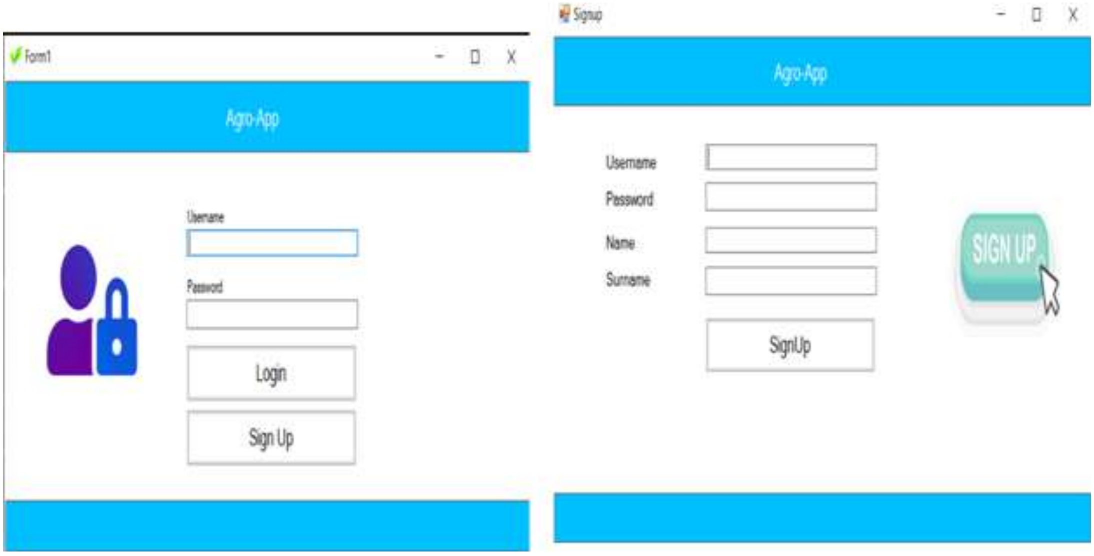


Figure 3. Sign-up Page

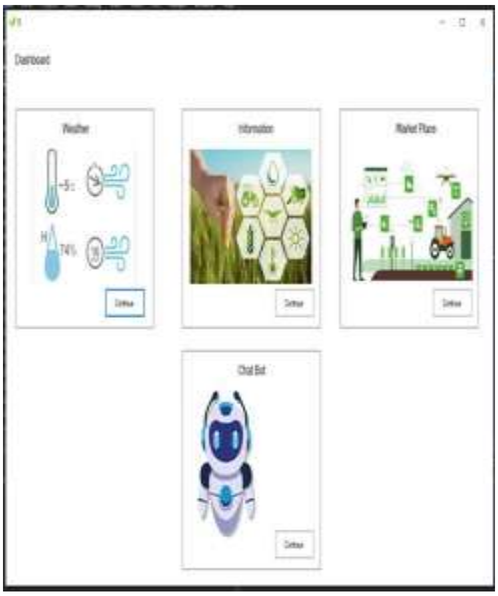

Figure 4. Dashboard

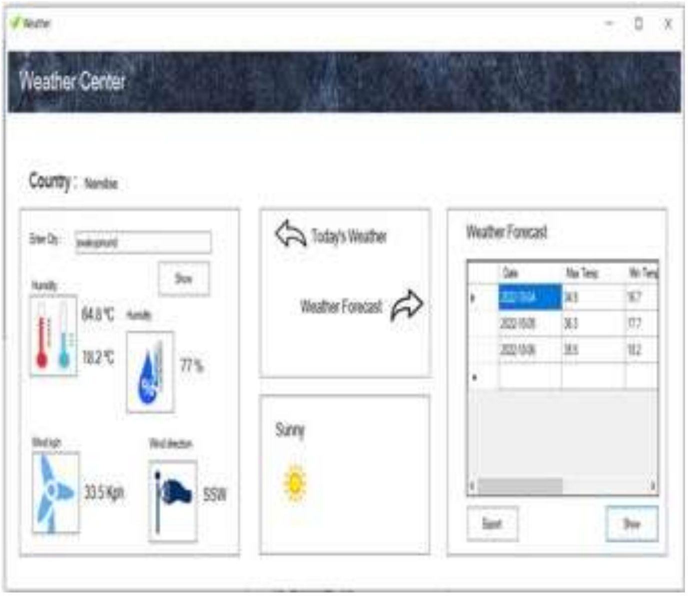


Figure 5. Weather Center


Figure 6. Information Center

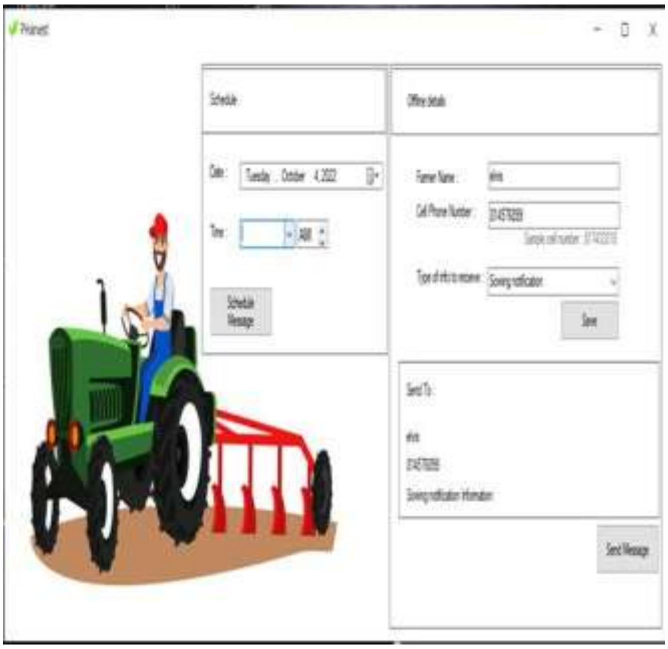

Figure 7. Notification System

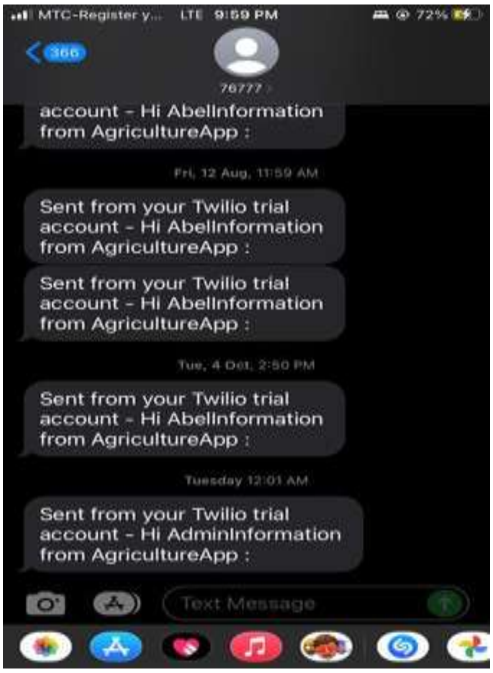


Figure 8. Mobile Phone Receiving Notification

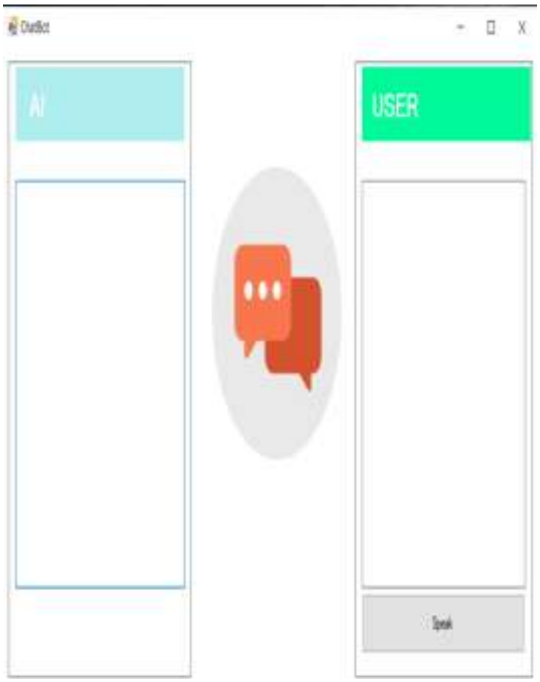


Figure 9. ChatBot

### 4.3.3. Survey Result

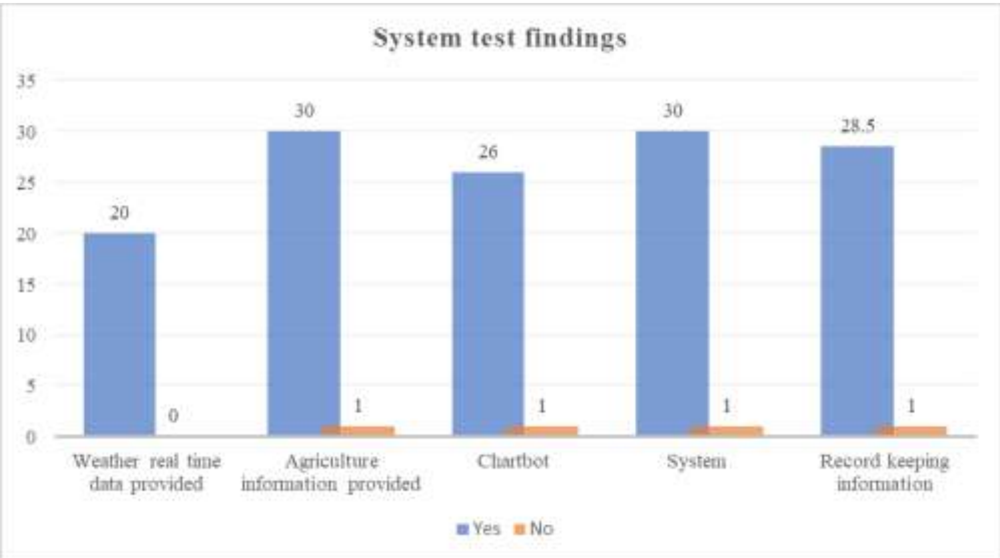


Figure 10. Farmers Participating with the Developed Application

In Figure 10, shows that Farmers real time data provided is accurate and 100% of the participant are happy with provision of real time data, 97% of the participant indicated that their agricultural information were provided, 96% indicated that there were able to query information from the system furthermore 97% indicated that that data are saved in the database their able to log in into the system.

## 5. CONCLUSION

In conclusion, more of Agro-meteorology application need to be implemented in Namibia that describe different topics in Agro-meteorology. Different farming system needs to be improved to achieve a quality crop growth any wrong doing during sowing, planting and harvesting will leads to crop failure, poisoned crops attacked from fungal disease and pest, wrong cropping pattern, which leads to high cost of living and deteriorate the livelihoods of the farmers. Using API (Application Programming Interface), AI, Twilio integration in the application made it easier for farmers to receive, communicate and sell their product which helps to enhance the livelihood of the farmers and upgraded their farming techniques. Integration of Twilio system in the application helps the bulk system notification in the future. There were no enough fund to implement the weather station design which made the project to scale down and no enough funds to implement the bulk notification to enable all farmers to receive notification messages which made only 10 user to be registered to receive notification message. The lack of IOT devices to integrate them in the system to detect weather and climate which made the project to scale down due to lack of funds.

## 6. RECOMMENDATION

Agrometeorology is broad topic with a growing interest in research fields, because it has variety of fields such as. Hydrology, soil, pest outbreak planning, drought management, crop growth simulation modelling. This project mainly focused on creating an Agro-meteorology application for farmers in Namibia integrated with mobile notification system where user can receive their real time data of weather and climatic information and sell their product on the system. The project can further extend on features such as the detection of fungal disease on particular plants and present their fungicides, implementation of a weather station for an Agro-meteorology application, integration of IOT physical devices into the application, implementation of crop zonation and crop planning. Different software modules currently being build that will shape the success extending of features to the project in future are GRASS(Geographic Analysis Supporting System), OSSIM(Open Source Software Image Map), Map Server. This module will help developers to create application by using the recommendation stated above or may lead to new interesting discoveries.

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