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Application of mobile phone-based system for improved crop production recommendation in arusha, Tanzania

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**APPLICATION OF MOBILE PHONE-BASED SYSTEM FOR
IMPROVED CROP PRODUCTION RECOMMENDATION IN
ARUSHA, TANZANIA**

Alpha Edward

**A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree
of Master's in Information and Communication Sciences and Engineering of the
Nelson Mandela African Institution of Science and Technology**

Arusha, Tanzania

January, 2022

ABSTRACT

Agriculture is a dominant activity globally as without which, food would not be produced, consequently depriving human development. Despite the massive role of agriculture in food security, its growth in crop production in Tanzania is being threatened by various challenges including limited access to agricultural information. This study focused on developing a mobile phone-based application for improved crop production recommendations. The study survey involved a total of 156 simple randomly selected respondents in Arusha district to assess whether or not they know how or can use mobile phones to search for internet-based agricultural services as a base for developing a mobile phone-based agricultural information app, and the data collected were analyzed by tableau software. The results show that about three-quarters of respondents possess smartphones and nearly one-third (32.7%) of all respondents use internet-based platforms to search for agriculture information. In terms of the specific need for a well-structured system such as the use of agriculture apps that would quicken access to agriculture information, 75.6% of all respondents said that they would appreciate having it. Also, about 80% of all respondents indicate the readiness for such platforms if availed online for the facilitation of processes in accessing agricultural information. Following these results, a Rapid Application Development (RAD) model was used along with software specific for the development of a mobile app and environments such as Android Studio, PostgreSQL Database and PostGIS to develop an android application. The developed mobile application takes into consideration soil types of different locations found within the Arusha district. Moreover, the app provides the farmer with information concerning soil type found in a specific location. Finally, a testing survey from the farmer's acceptance concluded that this mobile app was accepted to be used by the farmers. Thus, the developed app is recommended for further testing and where possible, improvement on wider coverage and more functions that farmers will need in the future.

DECLARATION

I, Alpha Edward, do hereby declare to the Senate of Nelson Mandela African Institution of Science and Technology that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

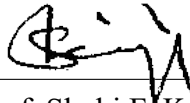


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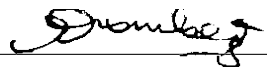
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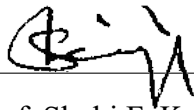
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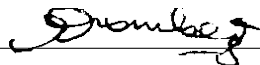
CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the Nelson Mandela African Institution of Science and Technology the dissertation entitled: Application of Mobile Phone-Based System for Improved Crop Production Recommendation in Arusha, Tanzania in fulfilment of the requirements for the degree of Master's in Information and Communication Science and Engineering of the Nelson Mandela African Institution of Science and Technology.



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DEDICATION

I dedicate this work to my family.

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LIST OF ABBREVIATIONS AND SYMBOLS

ACRONYM	DEFINITION
DBMS	Database Management System
DFD	Data Flow Diagrams
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GUI	Graphical User Interface
HTML	Hyper-Text Markup Language
HTTP	Hyper-Text Transfer Protocol
ICT	Information and Communication Technologies
IT	Information Technology
JDK	Java Development Kit
JRE	Java Runtime Environment
JSON	JavaScript Object Notation
NBS	National Bureau of Statistics
NM-AIST	Nelson Mandela Institution of Science and Technology
NGO	Non-Government Organization
ORDBMS	Object-oriented Relational Database Management System
PHP	Hypertext Pre-Processor
RAD	Rapid Application Development
SDLC	Software Development Life Cycle
SMS	Short Message Service
SQL	Structured Query Language
TCP	Transfer Control Protocol
TCRA	Tanzania Communications Regulatory Authority
UAT	User Acceptance Tests
UE	User Experience
UI	User Interface
UML	Unified Modelling Language
WHO	World Health Organization
XML	eXtensible Markup Language

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

Agriculture is a “science or practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food, wool, the raw material for industry, and other products” (Oxford, 2019). Moreover for many years agriculture has been an important part of the development of various societies worldwide (Nirojan, 2017). Agriculture is continuously a basic need for the present and the future society because it contributes significantly to human development and national economies. In Tanzania, it employs over 80% of the total population, It accounts for 56% of the Gross Domestic Product (GDP) and approximately 60% of earnings through exports (Chongela, 2015).

Agriculture information such as soil characteristics, best methods of cultivating crops, weather predictions, best seeds, what to plant, when to plant, where to plant, and where to sell is considered very significant in the development of agriculture (Stefano *et al.*, 2015). These kinds of agriculture information help the farmers on making appropriate decisions and select proper procedures for farming hence contribute to agriculture development (Harris *et al.*, 2016).

One of the main concerns of farmers is the use of soil as a means for crop production. Various crop management choices are aimed at enhancing the soil to boost the production of food. Farmers spot that the soil's physical state will affect crop production and farmers are interested in keeping the productive capacity of the soil (Benjamin *et al.*, 2014). In addition to this researchers Benjamin *et al.* (2014) and Brekke *et al.* (2015) said that soil types play a major role in the growth of crops and soil nutrients are obtainable to plants as soil composition or added to the soil. The nutrients of the soil are an essential soil chemical property and different soil types have different properties.

Although agriculture has a significant contribution to society in terms of food and employment, ways of accessing agriculture information continue to be a challenge to farmers. For instance, in Tanzania, there exist a challenge in getting agricultural information by farmers especially about the time it takes from the source to farmers and correctness in terms of the source's intention (Kimaro, 2018; Siyao, 2019).

Some of the common methods used by farmers to access agricultural information are via radio, television, newspaper, Short Message Service (SMS), extension officers and farmers exchange information to themselves (Prasetya, 2014). These methods are effective but comparatively user-unfriendly as farmers do not own them. Using these methods involves several steps to deliver the information from the source to users (farmers), example there must be time to receive, process, interpret and report the information to the media as a result they are not time-efficient, the period for broadcasting information concerning agriculture may not be appropriate for users who might be going through family problems and not demand-driven (Mtega, 2013). The linkages between farmers, extension officers, and researchers need to be strengthened through the application of information technology to improve the current means of accessing agriculture information (Sanga, 2018).

The mobile revolution has the potential of improving people's livelihood through agriculture. However, there are insufficient mobile applications tailored to improve access to agriculture information (Nirojan, 2017). Currently, there are over 48 million mobile subscribers in Tanzania, of which about 53% of these subscribers have access to the internet (TCRA, 2020). With this massive increasing usage of mobile communication penetration, this research study has the potential of positively impacting the way of accessing agricultural information.

1.2 Statement of the Problem

Despite the massive role of agriculture in food security, its growth in crop production in Tanzania is being threatened by various challenges including limited access to specific agricultural information based on local environment context like soil characteristics, soil types, what crop to plant in a specific soil type, when to plant, and proper methods of cultivating those crops (Mitchell *et al.*, 2018; Nirojan, 2017; Tumbo *et al.*, 2018). In trying to eradicate those challenges through mobile technology this study focuses on developing a mobile phone-based application for improved crop production recommendation based on soil types.

1.3 Rationale of the Study

Agriculture is an important human activity that produces food, wool, the raw material for industry, and other products in the world. However, the use of modern tools and technologies in this sector is very limited compared to different sectors. This is mainly attributed to different factors including the usage of outdated and inefficient practices E.g., Continued reliance on a traditional man-to-man agricultural information sharing system, which in time may not be fast

due to several issues including insufficient Agri-extension-officers, misinterpretation, etc, and technologies for crop production.

On another hand, the advancements of technology have made human beings more dependent on mobile technology. However, there is a significant gap between knowledge experts and farmers. It is widely believed that mobile technology has the potential to bridge this existing gap. Therefore, this study aims to develop a mobile application that will aggregate soil characteristics data and make it easily available to farmers through the use of a mobile application platform which is likely to result in better crop selection and farming practices. The beneficiaries of this study include Smallholder farmers, Agricultural Officers, and Large-scale farmers.

1.4 Objectives

1.4.1 General Objective

The main objective of this study is to develop a mobile phone-based application for improved crop production recommendations based on soil types.

1.4.2 Specific Objectives

This study will be guided by the following specific objectives:

- (i) To identify the proportion of farmers who use mobile phones for accessing internet services.
- (ii) To develop a mobile-based app that will assist farmers to identify different soil types.

1.5 Research Questions

This research study intended to answer the following questions:

- (i) What is the proportion of farmers who use mobile phones for accessing internet services?
- (ii) What are the building blocks for developing a mobile app and data base of soil types for Tanzania?

1.6 Significance of the Study

The outcomes of this research study will demonstrate how mobile phones can be used in accessing soil information specifically soil types and establish a foundation for other researchers working on ways to enhancing agriculture information access in Tanzania.

1.7 Delineation of the Study

Enhancing ways of accessing agriculture information like soil characteristics, what to plant, when to plant, weather condition and methods of cultivation in Tanzania is a wide-ranging field. This research study is not meant to cover the whole area of improving means of accessing agriculture information. Rather, it focuses on developing a mobile application that taking into consideration the soil types. As soil type is a very significant part of the growth of the plants as well as it helps a farmer to decide what type of crop to cultivate.

CHAPTER TWO

LITERATURE REVIEW

2.1 Agriculture Sector Performance Expectations in Tanzania

Tanzania aims to change the economy from an agriculture-dependent economy characterized by low productivity to an expanded and semi-industrial economy characterized by high productivity in the agricultural sector (ASDS II, 2016). Currently, agriculture occupies a high position in the economy. However, its general performance is under expectations in aspects of production level and quality as well as the overall contribution to the national goals (ASDS II, 2016). One of the main cited reasons for low agricultural performance is limited access to quality timely agricultural information services to farmers, small farm size ranging from 1 to 3 hectares, limited access to new production technologies, labour-intensive and low input use (Kimaro, 2014).

Currently, agricultural information reaches farmers mainly through extension services and other sources such as their social networks, cooperative organizations, universities, and others just to mention the main ones. This style of information flow has a weakness since users of such information usually get it just after going through these intermediate agents which usually either delay the information or when conveyed timely, it goes to users while already interpreted by the intermediate agents thus reaching farmers as secondary. In addition, the weakness is worsened by lack of computer and information illiteracy among many agricultural (Sife, 2017).

It was, therefore, important to conduct a study to find out how mobile technology, can be applied to increase access to information by farmers for increased food production. This follows the fact that already the percentage of small-scale farmers with mobile phones in Tanzania is 66% (TCRA, 2019), implying the potentiality of utilizing such resources for agricultural information access to farmers.

2.2 Mobile Technology Penetration in Tanzania

Mobile technology (i.e. technology of making use of a mobile communication system for conveying information from source to the intended destination) has speedily grown to be the most popular means of conveying information, data, voice, and important services in Tanzania (Khak Pour *et al.*, 2021; Schulz *et al.*, 2021). Taking into consideration this transformation, mobile apps (computer software designed to run on mobile devices) for agriculture, in specific, have a major capacity for enhancing agriculture growth. Mobile technology through mobile apps may well offer cheap means for many farmers to access agricultural information like soil characteristics, markets, and finance that formerly were missing to farmers (Qiang *et al.*, 2016). Mobile technology through mobile apps has turned out to be an effective means of communication and social transformation tool because of the wide-ranging coverage and availability (King, 2016).

Moreover, mobile apps have many benefits including ownership, affordability, voice and text communications, immediate and suitable service delivery. Because of this, there has been an increasing number of mobile apps, simplified by the fast growth of mobile information networks and functions also by dropping the costs of mobile phones specifically smartphones (WorldBank, 2012).

The majority of agriculture mobile apps aim at enhancing agriculture by expanding extension services, and smoothing market connections. These mobile apps create an important link between farmers, extension officers (mediators between farmers and research), and agriculture actors. Moreover, the impact of agriculture mobile apps primarily remains in their capability to deliver extension services and access to appropriate agriculture information (Duncombe, 2016). Figure 1 shows the importance of using agriculture mobile applications.

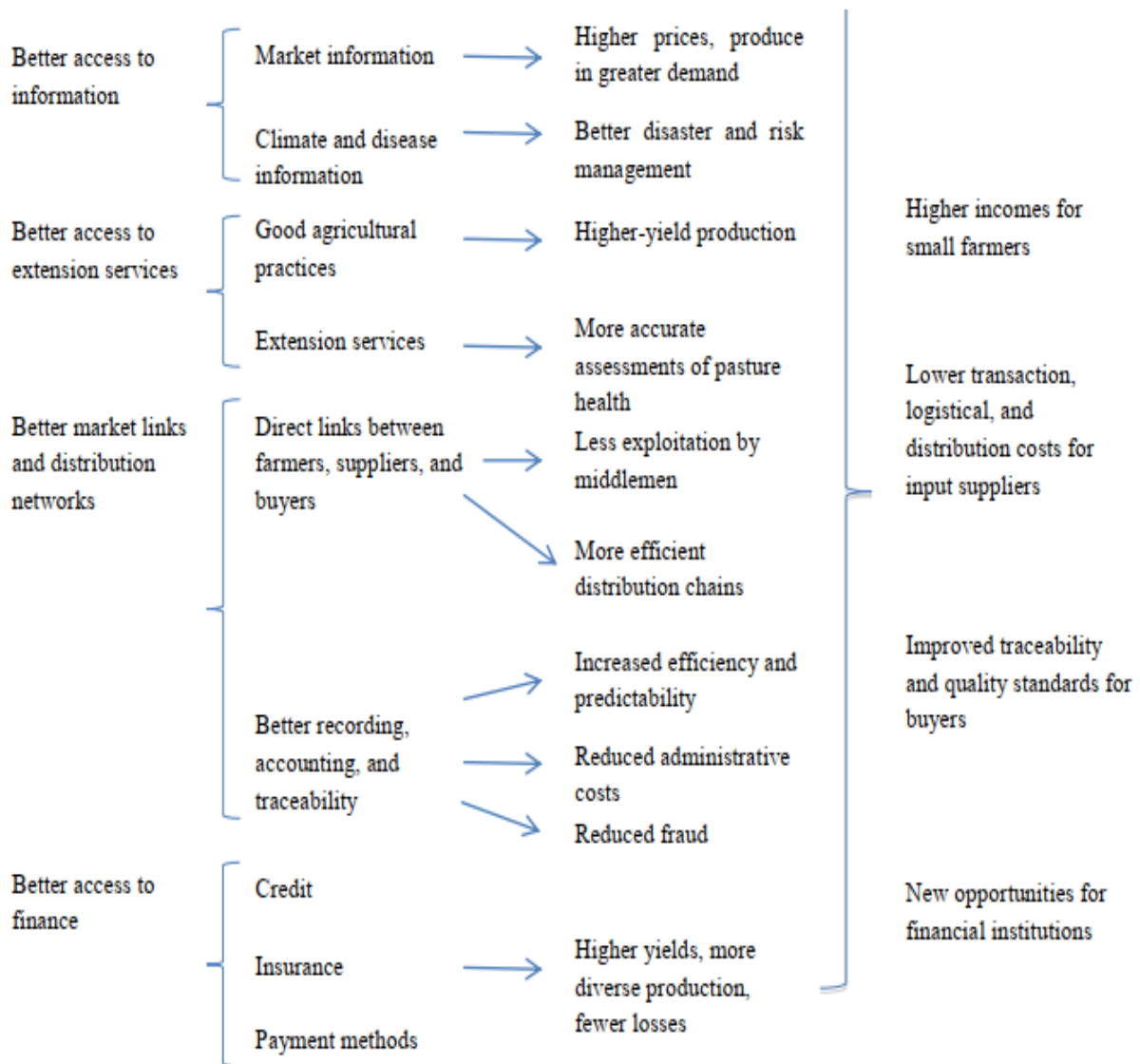


Figure 1: Mobile Apps for Agriculture (Qiang *et al.*, 2016)

Currently, in Tanzania, there is an increasing number of users of smartphones for both the internet and communication. Recently in June 2020 report from Tanzania Communications Regulatory Authority (TCRA) indicated that about 48 million smartphone users (an equivalent to about 86% penetration) were recorded as mobile subscribers and about 48.1 million smartphone users having internet access. Table 1, Fig. 2 and Fig. 3 show the statistical details for the year 2014 to 2020 (TCRA, 2020).

Table 1: Mobile Penetration from 2014 to 2019 in Tanzania (TCRA, 2020)

Year	2014	2015	2016	2017	2018	2019
Fixed	142 950	142 819	129 597	127 094	124 238	76 288
Mobile	34 108 851	39 665 600	40 044 186	39 953 860	43 497 261	48 056 689
Total	34 251 801	39 808 419	40 173 783	40 080 954	43 621 499	48 132 977
Penetration	71%	79%	80%	78%	81%	86%

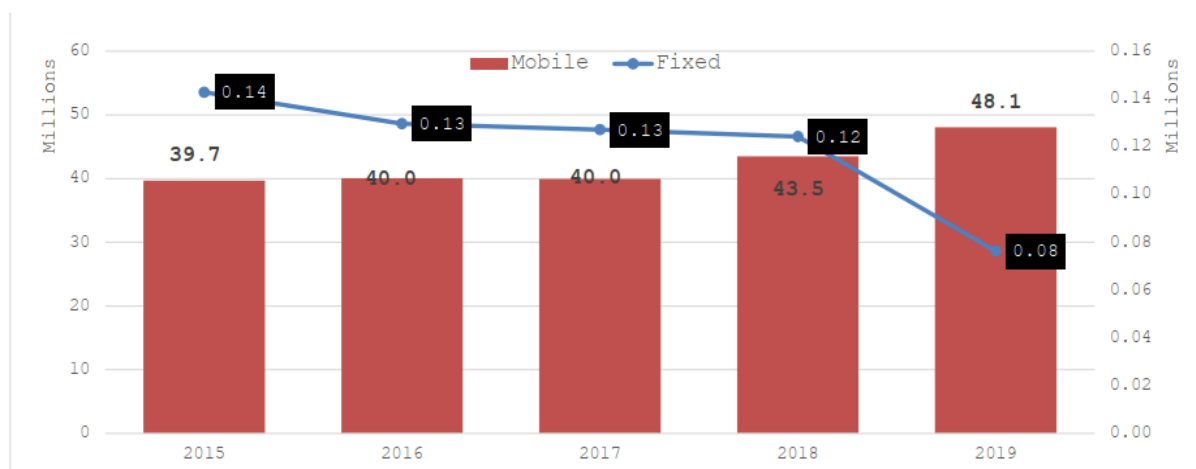


Figure 2: Mobile and Fixed Lines Penetration (TCRA, 2020)

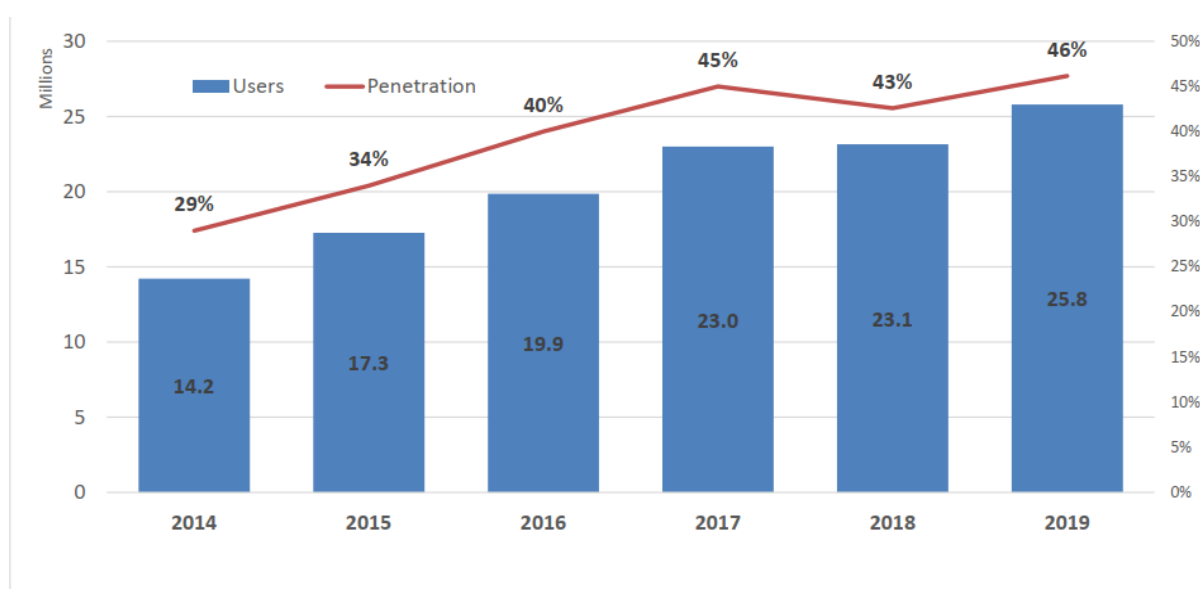


Figure 3: Internet Users in Tanzania (TCRA, 2020)

2.3 Application Status of Mobile Phone-Based Technologies in Agriculture

For many years, the provisions of agricultural advice and information have been accomplished through different methods such as training, extension officer visits, the involvement of stakeholders in participatory approaches, and education centres for farmers. However, these methods are not sufficient. Moreover, the use of most developed agricultural technological innovations is often limited (Tumbo *et al.*, 2018).

The research study done by Jain *et al.* (2015) suggested that it is important for an agricultural information system to be built based on mass-communication technology like mobile systems. Furthermore, localization and the native language of farmers are matters to be linked to these systems. The findings indicated that there is a need for farmers to get appropriate information related to their crops and farming methods. More precisely, agricultural methods require timely, precise, and correct information to be delivered to farmers to facilitate informed decisions on several issues such as the management of farm fields, implementation of improved systems of production, and seizing opportunities that exist in various markets (Mitchell *et al.*, 2018).

Another study by Sharma *et al.* (2015) developed E-Agro that is a mobile application. This application provides expert support to farmers on issues related to the cultivation of crops, diseases, soil (the upper layer of earth that may be dug or plowed and in which plants grow), manures, and pricing, etc. This study primarily focused on bringing modern agricultural practices to farmers located in rural areas.

The study conducted by Kashiwazaki (2019) developed Agri-app as a tool to provide farmers to get on agriculture information from reliable sources, important news concerning agriculture, offering assistance from experts via calls and chat. Moreover, Agri-app consists of many useful videos like mushroom cultivation, watermelon cultivation, sugarcane cultivation, and goat farming.

Furthermore, the research study conducted by Agriculture News Network (ANN) developed the Kisan Yojana app that provides agriculture information concerning the schemes and profit provided by the Indian government to the rural people and farmers (Ravichandran & Koteeshwari, 2016). The main objective of the Kisan Yojana app is to suggest crops, fertilizers to the farmer for his land, and his desired crop (Barh & Balakrishnan, 2018).

Ghanshyam *et al.* (2016) developed an agronomy-a multilingual android mobile application that was offered in English and Indian language to provide information directly to farmers which negates the dependency of farmers on other parties. This application allows farmers to make critical decisions very early. The study argued that this mobile application has the potential of improving the farmer's livelihood.

Another study carried out by English *et al.* (2017) showed how US farmers use the extension as a source of information for precision agriculture. Moreover, younger and well-informed farmers with high incomes were noted to be more receptive to the use of the extension. In addition to that, this study argued that precision agriculture aids the extensional program to be designed better.

The study by Chaudhary and Bhise (2015) stressed the importance of the application of Geographic Information System (GIS) in villages located in India. The study identified the purpose of these systems to be collecting and recording location-based data about farming activities. The study emphasized that the data can potentially be used by other applications and tools in the agricultural sector. The type of data that can be archived by the Geographic Information System includes administrative boundaries, nutrient levels, soil type, and temperature. The study argued that this information can help farmers in deciding the location and types of crops to farm.

A study carried out by Masuki *et al.* (2010) in Uganda investigated the involvement of mobile technology in enhancing communication processes in rural areas which greatly contributed to the agricultural sector. This study emphasized the importance of mobile phones in increasing the efficiency of farmers in rural areas. Furthermore, this study observed that mobile phones were easily available to individuals residing in rural areas with low income. Additionally, farmers in rural areas were observed to be more eager and receptive to using mobile phones for information access regarding agriculture, and the management of natural resources. Due to this, different players along the agricultural value chain were motivated to seek opportunities to make use of mobile apps to promote the development of agriculture.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location of Study

This survey study took place in Arusha at 3.4470°S, 36.6741°E, Tanzania, and was preferred because it's found in the zone counted as one of the best agriculture production zones (Ngirwa & Ally, 2018). The average annual temperature of Arusha is 20°C and rainfall is 837mm or 33inch in a year. Furthermore, Arusha is one of the most developed regions in Information and Communication Technology (ICT) infrastructures and has a vast number of mobile users as well as internet subscribers (TCRA, 2010). Additionally, there are several agriculture institutions such as Tanzania Agricultural Research Institute (TARI), Selian agricultural research institute, and Tengeru agricultural college that provides agriculture advice to the farmers also educates them on different agriculture methods to apply.

3.2 Sampling Technique and Population

This study involved simple random sampling that was applied for both gender males and females, who were respondents to the questionnaire and who were agreed to do so according to their willingness (Micah, 2014). Moreover, the sample size applied was find out by Yamane's formula (as shown below this paragraph) for calculating sample size (Gauhati, 2013). The result was obtained after calculation based on the total population of 49 000 farmers (Chuwa, 2018), a precision level of 0.08, and a 95% confidence level. The sample size was found to be 156 individuals.

Yamane's formula:

$$n = \frac{N}{1 + N(e)^2}$$

Where: n = Sample Size

N = Population Size

e = Precision Level

Therefore;

[Population Size(**N**) = 49 000

Precision Level(**e**) = 0.08

The preferred Confidence level was 95%]

∴ **n** = 156 individuals.

After substituting those values in Yamane's Formula, the result was 156 individuals which represents the sample size to be used. Therefore, the sample size used during the data collection period was 156 farmers.

3.3 Data Collection

3.3.1 Primary Data

In this research study, the preferred method during the process of data collection from farmers and extension officers was questionnaire-based with both close and open-ended questions onto a total of 156 respondents. This method was preferred because it allows farmers to provide their views and experience all these to their language (Blank, 2013). In addition to this, the responses from all individuals who participated were open and anonymous (Cohen *et al.*, 2009).

The data obtained from the respondents of the questionnaire was used to measure the necessity of whether using mobile apps could be a proper way of improving access to agriculture information. The questions used in all sections were independent. Dependent variables were used to evaluate if respondents needed a mobile application platform to access agriculture information (Rubin & Babbie, 2014).

Moreover, to set up both non-functional and functional requirements for the mobile app development process, this study used a mixed approach through the gathering of various important data. The participant (actors of the system or stakeholder) analysis was performed before the requirements gathering.

The analysis was done to collect basic knowledge of the actors to pick up their exact requirements necessity on developing the mobile application for crop recommendation (Monko, 2017). Recognition of the actors of the entire application was significant during the

data collection process for setting up both non-functional and functional requirements for mobile app development.

The key actors of the system were identified and mobile app development requirements were gathered qualitatively via unstructured interviews. Actors of the system were questioned on the details, essential needs, and requisites for the developed mobile application. Through discussion and interview, the essential mobile app requirements were recorded for the specification (Rubin & Babbie, 2014).

3.3.2 Secondary Data

Secondary data was collected from different sources like the Food and Agriculture Organization (FAO) i.e. Agriculture repository databases (FAO, 2019), Agriculture records and statistics from the Tanzania National Bureau of Statistics (NBS, 2019), and Agriculture & Business journals (ICPAC GeoPortal, 2019).

3.4 Data Analysis

3.4.1 Primary and Secondary Data Analysis

Richmond (2016) defines the term data analysis as an interpretation of collected data via logical reasoning and the use of analytics to find out patterns, associations, or courses. Therefore in this research study, the collected data was analyzed by tableau software (Zorrilla, 2018). The secondary data in this study were analyzed through QGIS spatial data analysis. Furthermore, each data was mapped in a specific point in a geographical position on a map. The area covered by water bodies were separated from the main land.

3.5 Material and Tools Used to Develop Database and Mobile-Application

3.5.1 System Development

During the development of a mobile application for crop recommendation, a framework that was adopted was (SDLC) the software development life cycle. It's a structure that defines different duties to be achieved at each stage in the development of the mobile application (Gajalakshmi, 2016). It depicts all the necessary techniques for retaining the value of the application (Kumar, 2013). It comprises a perfect strategy that is suitable for maintaining, developing, application modules (Ragunath *et al.*, 2010). The varieties of mobile application development models are shown in Table 2.

Table 2: Varieties of Mobile Application Development Models (Ismail, 2018)

Model	Attributes			
	Time	Functionality	Cost	Preference
Agile	Short	Dynamic System	Low	High
Rapid Application Development (RAD)	Short	Interactive and Dynamic System	Low	High
Waterfall	Long	Static System	High	Low
Spiral	Long	Dynamic System	High	Low
Incremental	Short	Static System	High	Low

The methodology applied in this research followed the Rapid Application Development (RAD) method, this is because using RAD takes a short time to develop a mobile application for crop recommendation as well as low cost of developing (Naz & Khan, 2015). Furthermore, RAD offers regular interaction between developers and customers throughout the mobile app development stages, for this reason, it keeps the client’s satisfaction (Beynon-Davies *et al.*, 1999). Figure 4 shows the RAD model applied in this study.

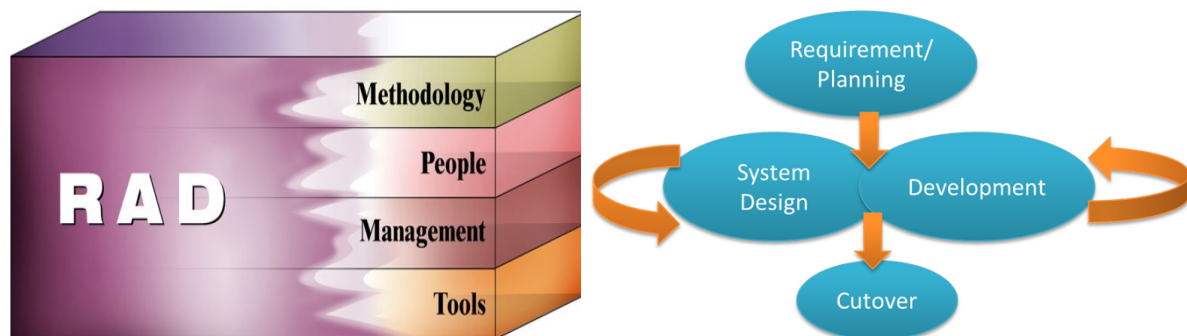


Figure 4: RAD Model (CASEMaker, 2000)

3.5.2 System Modeling

System modelling included different methods of mapping all functional requirements found in this study in a Data Flow Diagram (DFD). The denoted requirements for developing a mobile application for crop recommendations were evaluated by using Unified Modelling Language (UML) artifacts and regulations. Unified Modelling Language is a modelling language used

for visualizing, documenting, stipulating, communicating, and developing various artifacts of mobile apps. It comprises different artifacts including class diagrams, sequence diagrams, use-case diagrams, etc (Habeb, 2018).

In this study, system modelling was prepared by using a visual paradigm for UML software. Visual Paradigm for UML applied for mapping all requirements into use-case diagrams. Having use-case diagrams simplify the process of developing both a conceptual framework and a DFD of the mobile app.

3.5.3 System Implementation

Throughout the implementation phase, several computer software as significant tools for developing mobile apps were used. The software varies according to specific tasks, the software used ranges from database languages, programming languages, to the development environment. The details of mobile app implementation software used in this study are found on the following sections.

3.5.4 Soil Type Database and Mobile-App Design

This section portrays how a mobile-based application was designed and how the soil type database was constructed (Fig. 5).

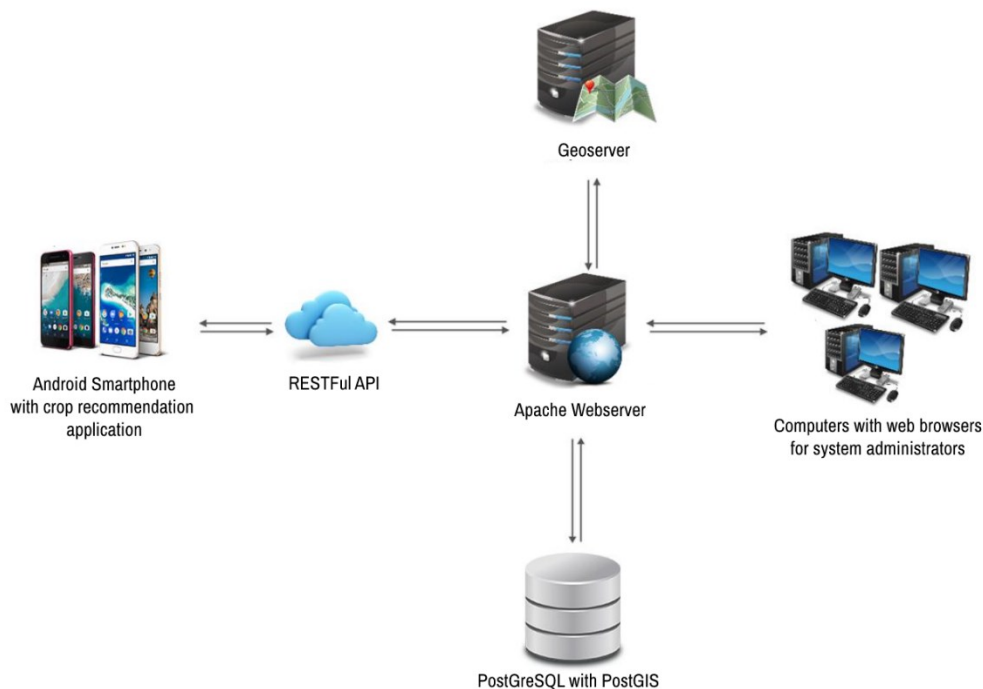


Figure 5: Architecture of the Mobile-Based Crop Recommendation Application

3.5.5 Tools Used to Develop a Soil Type Database

In this study, PostgreSQL and PostGIS tools were used to develop a database for soil type. PostgreSQL is the free open source object-oriented relational database management system (ORDBMS) that was originally developed at the Berkeley, University of California (BOLER, 2020). PostgreSQL is used as the main database to store both geospatial data and non-spatial data used by the mobile application in making proper crop recommendations.

PostgreSQL is an open-source DBMS that supports various SQL standards and features. It supports many complex features including complex queries, updatable views, multi-version concurrency control, foreign keys, transactional integrity, and triggers.

Moreover, it permits developers to insert different preferred features including functions, procedural languages, data-types, and operators (Argyridis, 2015). In this research study, PostgreSQL was used because of its capability to deal with internal security according to the user roles, on top of that it favours external authentication mechanisms including passwords (Helingjie *et al.*, 2017).

In addition to that, PostgreSQL also offers graphical administrative support that helps during the development of different mobile apps hence with the use of pgAdmin, the database development was implemented smoothly. What is 'pgAdmin'? Graphical User Interface (GUI) administrative software that handling PostgreSQL.

In addition to that, PostGIS which is a spatial database extender for PostgreSQL was used. This extension adds support for geographic objects allowing location queries to be run in SQL, it was used in linking the location of the user with information that can be used in making recommendations on what crop to cultivate based on the location.

3.5.6 Tools Used to Develop a Mobile App for Crop Recommendation

In this study, various tools were used to develop a mobile-based app such as Android studio, Apache web server, GeoServer, Leaflet, Symfony Framework, XML language, Java, JavaScript Object Notation and WebSocket. Below each tool has been explained accordingly.

3.5.7 Android Studio

According to Aliferi (2016) the term Android Studio is defined as the computer software used in the development of different android applications. Android Studio consists of several libraries that facilitate the development of a mobile application. In this research study, the mobile application was developed according to the android operating system. Android was carefully chosen because the majority of users use the android platform, especially here in Arusha, Tanzania.

Android Studio was used in the development of the mobile application phase of this research study. Because of its numerous functionalities and vast significant libraries including app web view, locations, and maps which are important for the mobile application for crop recommendation.

3.5.8 Apache Webserver

Apache web server is a popular and reliable open-source web server that is suitable for multiple web-based projects of different sizes and nature. The mobile application developed utilizes a RESTful Application Programming Interface (API) to bring various data on crops, weather, and soil profile to the end-user mobile application. This API be built using PHP version 7.4 as the core scripting language and is deployed on the Apache webserver.

Pomaska (2012) define PHP as a server-side or general-purpose scripting language suitable for database linking and operation. It's usually identified for its capability of being compatible and can simultaneously link to several databases and applications, servers without compromising security (Supaartagorn *et al.*, 2010). Also, PHP is open-source software, and it offers the dynamic functionality of a web application (Murach, 2014). In this study, PHP has been used in scripting the linking from the PostgreSQL database via the web application. It offers the channel for database manipulation and connection from the application.

Furthermore, a web-based data management portal is developed to allow system administrators to create, update, or remove data stored in the system to provide relevant and up to date information to mobile application users. This portal is developed using modern web technologies such as HTML5, CSS3, and JavaScript JS, which provide a responsive and fluid user interface that is compatible with devices of various resolutions and screen sizes.

3.5.9 Geoserver

Geoserver is a web server that allows the serving of maps and data from a variety of formats to standard clients such as web browsers and desktop GIS programs. Geoserver is used to serve maps that are shown on the user's mobile application along with crop recommendations.

In addition to that, the maps are rendered on the user's mobile devices using Leaflet which is an open-source Java Script library for mobile-friendly interactive maps. It is designed with simplicity, performance and usability in mind. It works efficiently across all major desktop and mobile platforms.

3.5.10 Symfony Framework

According to Radescu *et al.* (2011) the term Symfony Framework is free of charge PHP web-application structure that consists of PHP modules and various libraries. In this research, it was applied to hasten the completion of a web. Also, it assisted in changing repetitive coding. Furthermore, it offers effective security functions that regardless of having HTTP authentication, X.509 certificate login, and interactive form but also lets the implementation of various authentication features (Porebski, 2012). These features are such as the utilization of double validation by using an in-system validation and by transfer the validation code to the client via email.

3.5.11 eXtensible Mark-up Language (XML)

According to Eltahawi (2016) XML language is a mark-up language intended for storage, display information, transmission via different related hardware, and software independently. By using XML, independently defining data structure and format have been electronically distributed through messaging systems' general syntax for exchanging information between apps. Also, XML as open-source software is very supported and filled with various precise information (Bray *et al.*, 2006).

XML was primarily used in this research study for creating user interfaces in the mobile app. This is because it's inexpensive, simpler in reloading, and off-loading different data in and out of a database at the same time as it keeps the chosen information and user interface presence. Due to the favourite user interface, the user understanding of the mobile app is enhanced.

3.5.12 Java

According to Eck (2010) Java is the object-oriented programming language built for developing and supporting numerous features used in making software. It's usually advantageous for developing applications and computer software because it operates on various operating software (OS) including Windows, LINUX, and UNIX categories. Among many characteristics, Java is fast, portable, provides high performance, security, and stability, especially when running multiple activities simultaneously (Singh, 2017).

Java was used in this study because of having different libraries applied when implementing various functionalities and creating User Interfaces (UI) during the development of mobile applications in the android studio. It shortened the process of creating complex features of the mobile application for crop recommendation.

3.5.13 JSON

JSON is an abbreviation that stands for Java Script Object Notation. ECMA-404 (2014) define it as an open-standard programming language with an independent format style that uses human-readable text to carry data objects holding attribute-value and array data types. It provides the major data types including numbers: floats, integers, and double. Also, include Boolean, string, null, and array.

In this mobile application development, JSON was employed for conveying an array of data from the app via the database. Hence make simpler the link between the mobile application and the database.

3.5.14 WebSocket

The term WebSocket was defined by Skvorc *et al.* (2014) as the computer communication protocol responsible for the full-duplex communication networks across a TCP connection. WebSocket allows real-time contact between a web-server and a web-client, hence it permits real-time data transmission at low overheads. It's possible because WebSocket allows the flows of messages on TCP (Keith, 2013). Currently, WebSocket is supported by various browsers includes Google Chrome, Internet Explorer, Opera, and Mozilla for desktop computers, laptops, and smartphones. WebSocket was used in this research study when developing a real-

time communication module. This allows for real-time communication between extension officers and farmers.

3.6 System Testing and Validation

In ensuring that the developed mobile application meets the requirements of the intended specification, tests were taken out. This was an essential stage to make sure that all bugs have been eliminated hence remained with quality application that satisfies the user's needs. The final mobile application was validated by stakeholders.

3.6.1 System Testing

Mobile app testing was conducted stepwise, firstly unit testing then followed with integration testing. Unit testing according to Olan (2003) is defined as a method of testing the performance of the tiny independent module of the entire system in separation from the next modules. During the implementation of system features, this kind of test was applied. In ensuring that all bugs were eliminated at a maximum level single unit testing was conducted. Each independent module of the mobile app was tested distinctly to discover errors inside its limits during the development of this mobile app.

Integration testing according to Reis *et al.* (2007) is an organized procedure for running tests for discovery errors related to interfacing of one system module to another. This testing was conducted when interfacing and linking the unit-tested modules. Hence preceded the development of a fully functioning application.

Finally, the integrated system was taken for User Acceptance Tests (UAT). This was carried out by users of the mobile app while validating the app compared to the previously specified requirements. To permit UAT, the fully operational mobile application was installed for the users who contributed to the UAT.

3.6.2 System Validation

The validation of this mobile application for crop recommendation developed was done via the user experience (UE) survey. It was conducted by selecting only some members of the identified actors of this system. This was carried out by giving them the system for ordinary practice.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Results

4.1.1 Demographic Attributes of All Participating Individuals

In this research, we find a better way to help farmers to get access to agriculture information like soil characteristics, soil types, best methods of cultivating crops, weather predictions, best seeds, what to plant, when to plant, where to plant, and where to sell. Therefore, this study involves people (Farmers) it's very important to observe the demographic features of the farmers. To ensure this is done, this study considered the following demographic features age, gender, and level of education.

Out of 156 of all respondents who participated, males were a little bit higher (50.6%) than females (49.4%) respondents. The majority of participants were found between the age group of 30 to 39 years this was approximately 28.9% of all respondents. Table 3 illustrates the demographic properties of all respondents who participated in this research study.

Table 3: Demographic Properties of all Respondents

Requirement	Types of Replies	Respondents (n)	Percentage (%)
Gender	Male	79	50.6
	Female	77	49.4
		Total = 156	100%
Age (in Years)	Below 20	3	1.9
	20 - 29	40	25.6
	30 - 39	45	28.9
	40 - 49	43	27.6
	50 - 59	23	14.7
	60 and above	2	1.3
		Total = 156	100%
Education	Non-formal education	5	3.2
	Primary education	29	18.6
	Secondary education	64	41
	Tertiary education	58	37.2
		Total = 156	100%

4.1.2 Mobile Possession Distribution

More than three-quarters (77.6%) of all respondents own smart-phone, while only 5.1% of respondents did not possess a mobile phone. Figure 6 portrayed the distribution of mobile ownership.

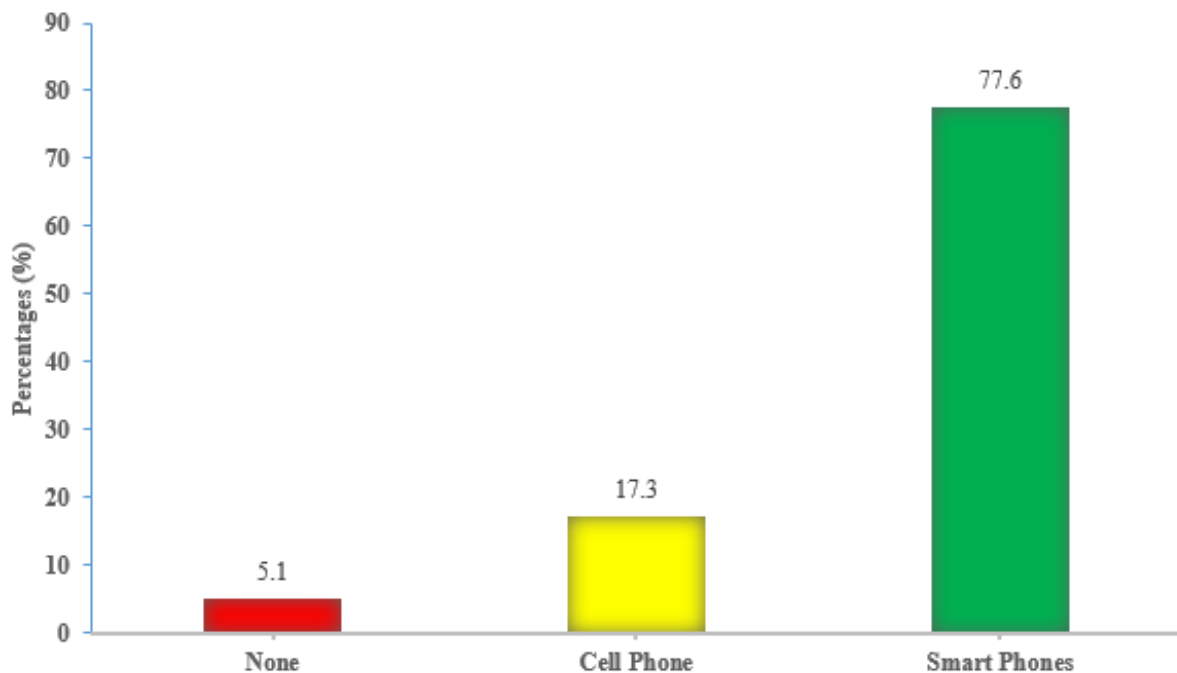


Figure 6: Mobile Possession Distribution

4.1.3 Sources of Agriculture Information

In this part, the farmers were acceptable to select several sources of agriculture information they always use to seek for agriculture information. Nearly one-third (32.7%) of all respondents opt to search for agriculture information from the internet. Other respondents preferred to exchange agriculture information within themselves while very few (3.2%) of them rely on social media as a source of agriculture information. Figure 7 portrayed the Sources of Agriculture Information.

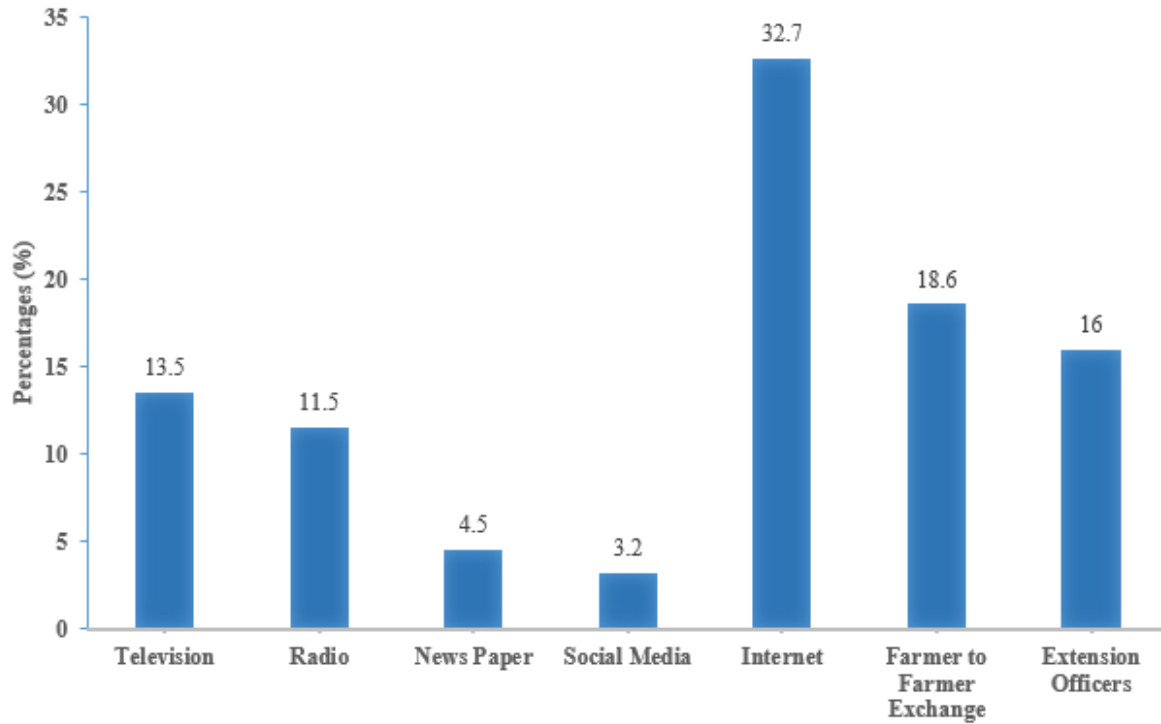


Figure 7: Sources of Agriculture Information

4.1.4 Views on Accessing Agriculture Information Online

In this section, all respondents were welcome to give their views on what they think about accessing agriculture information through an online platform. All respondents were allowed to answer more than one question in this section. About 80% of the respondents claim that they think they can retrieve agriculture information via an online platform. Table 4 shows different views on accessing agriculture information online.

Table 4: Views on Accessing Agriculture Information Online

Requirement	Types of Replies	Respondents (n)	Percentage (%)
I search for various agriculture information via online sources	Yes	83	53.2
	No	73	46.8
	Total = 156		100%
I think I can retrieve agriculture information via an online platform	Yes	125	80.1
	No	31	19.9
	Total = 156		100%
I would appreciate having agriculture mobile apps for accessing agriculture information	Yes	118	75.6
	No	38	24.4
	Total = 156		100%

4.1.5 Views on Mobile Application as a Solution

This study aims to enrich access to agriculture information through the mobile application platform. Respondents were allowed to provide their opinion on this matter. The majority of the respondents, i.e., more than 80% agree that the mobile application platform would be a solution to the present problem. Figure 8 portrayed views on the online platform as a solution.

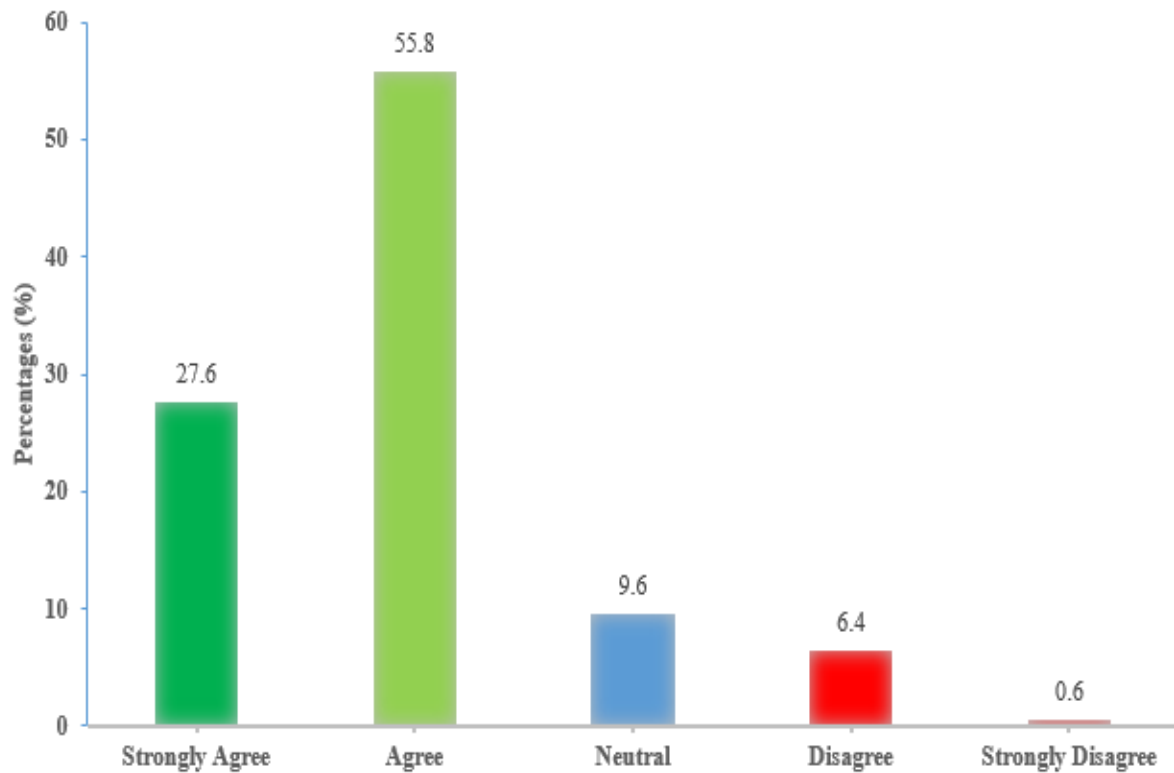


Figure 8: Views on the Mobile Application Platform as a Solution

4.2 A Database of Soil Type for Tanzania

Using both PostgreSQL and PostGIS a database for soil map in Tanzania was constructed. PostgreSQL database supports this developed mobile application for crop recommendation. Some PHP and JSON scripts were used in linking the database and users of this mobile app to permit easy and constant data manipulation such as data retrieval, data updating, insertion of data, and data deletion process. Figure 9 shows the database schema.

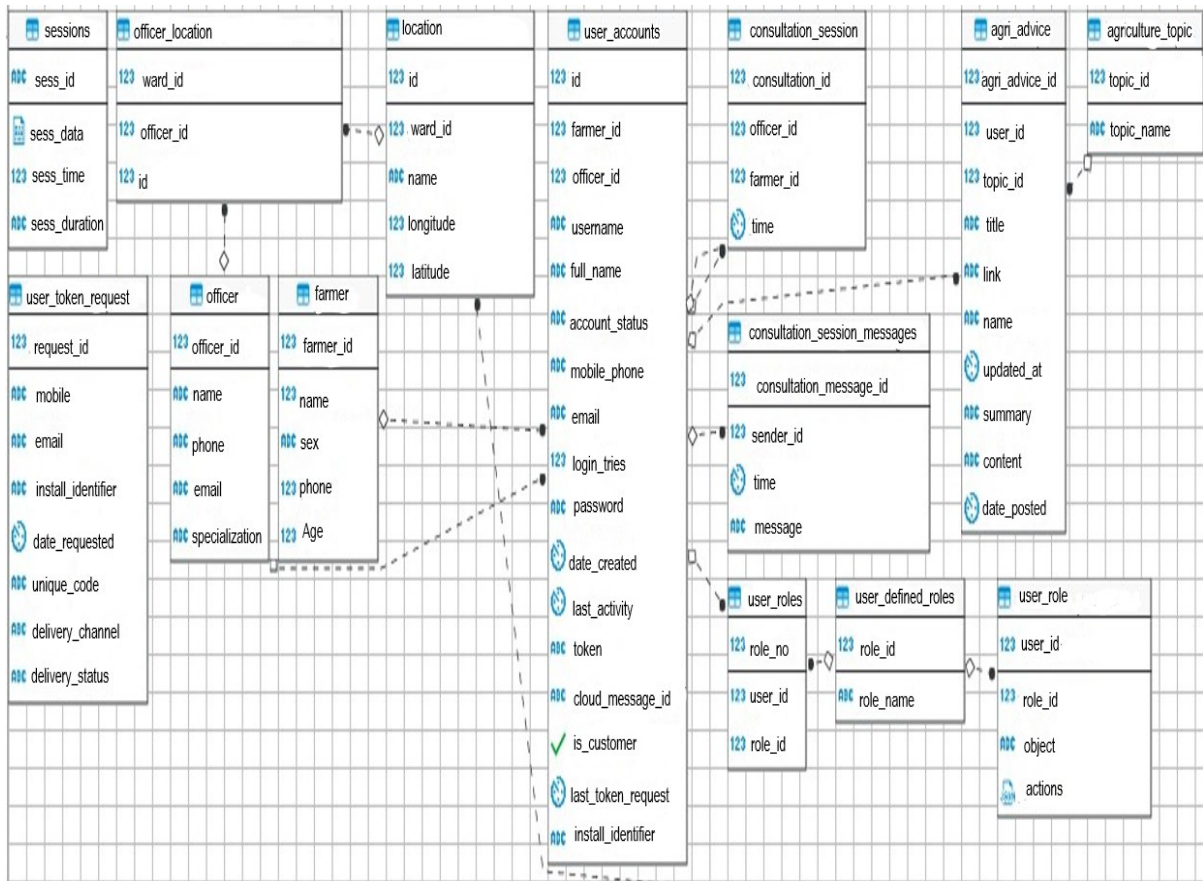


Figure 9: Database Schema

4.2.1 Agriculture Information to be Stored in the Database

There are several kinds of information concerning agriculture such as soil types, soil characteristics, what to plant, when to plant, where to plant, market, etc. All these are considered very meaningful in the development of agriculture (Stefano *et al.*, 2015). Therefore, this research study took the essential types of agriculture information that are highly preferred by farmers. Table 5 shows different kinds of Agriculture information farmers needs.

Table 5: Different Kinds of Agriculture Information Farmers Needs

Agriculture Information	Very Often	Often	Occasion	Rarely	Never	Total
Soil	31	89	27	6	3	156
Fertilizer	13	31	75	35	2	156
Seeds	11	75	33	28	9	156
Weather	5	8	61	57	25	156
Irrigation	20	27	55	49	5	156
Market	24	36	49	30	17	156
Diseases	33	67	34	21	1	156
Planting Material	19	16	81	24	16	156
What to plant	42	73	21	15	5	156
When to plant	35	81	20	18	2	156
Where to plant	20	32	69	14	21	156
Water Conservation	19	43	37	42	15	156
Harvesting Methods	7	13	32	45	59	156
Cultivation Techniques	40	53	37	16	10	156
Pest Management	38	61	46	8	3	156
Government Schemes	3	7	21	37	88	156

4.3 System Design and Modelling

4.3.1 Functional and Non-functional Requirements

System requirements in this research were in two categories namely non-functional requirements and functional requirements. Both non-functional and functional are providing a guiding principle for implementing the mobile application (Dabbagh *et al.*, 2016). Table 6 and Table 7 indicate non-functional and functional requirements.

Table 6: Non-Functional Requirement

Requirement	Description
Scalability	This agriculture mobile application ought to be scalable, i.e. its ability to survive and operate fine even when increases the amount of work or scope.
Security	This developed mobile app should ensure authentication to all clients before letting the user interact with the app functionalities. By maintaining passwords like maximum password age and minimum age, password history, and encryption for storage of passwords.
Responsiveness	A quick reply is needed by this app.
Maintainability	The app must be frequently maintained like be able to support or add new features, functionalities without altering the complete system.
Operating System	The app is based on the Android platform.
Robustness	The app should be able to continue to operate precisely if something incorrect occurs.
Language	The mobile application should consider using Swahili and English.

Table 7: Functional Requirement

Requirements	Explanation	Actors
User Registration	All users of the system must register to the system through a username and password	Farmers and Extension Officers
Managing User Account	All users accounts are managed by System Administrator	System Administrator
Online Agriculture Information	The system should let farmers get access to agricultural information	Farmers
Recommendation	Extension Officers should provide agriculture advice to the farmers	Extension Officer
Agriculture Advice	Extension officers should provide agriculture advice to farmers	Extension Officer
User and Technical Support	The system administrator should ensure that the system provides services for every user of the system	All users and System Administrator

4.3.2 The Use-Case

The interaction among actors of the system is analyzed by using UML such as a use-case diagram. This labels the expected system functionality from the interactions among external actors and a system (Molina *et al.*, 2000). Table 6 and Table 7 shows the important functionality of the entire application for crop recommendation. Therefore, to analyze those interactions by using UML then Fig. 10 and Fig. 11 show the use case diagram for the entire system.

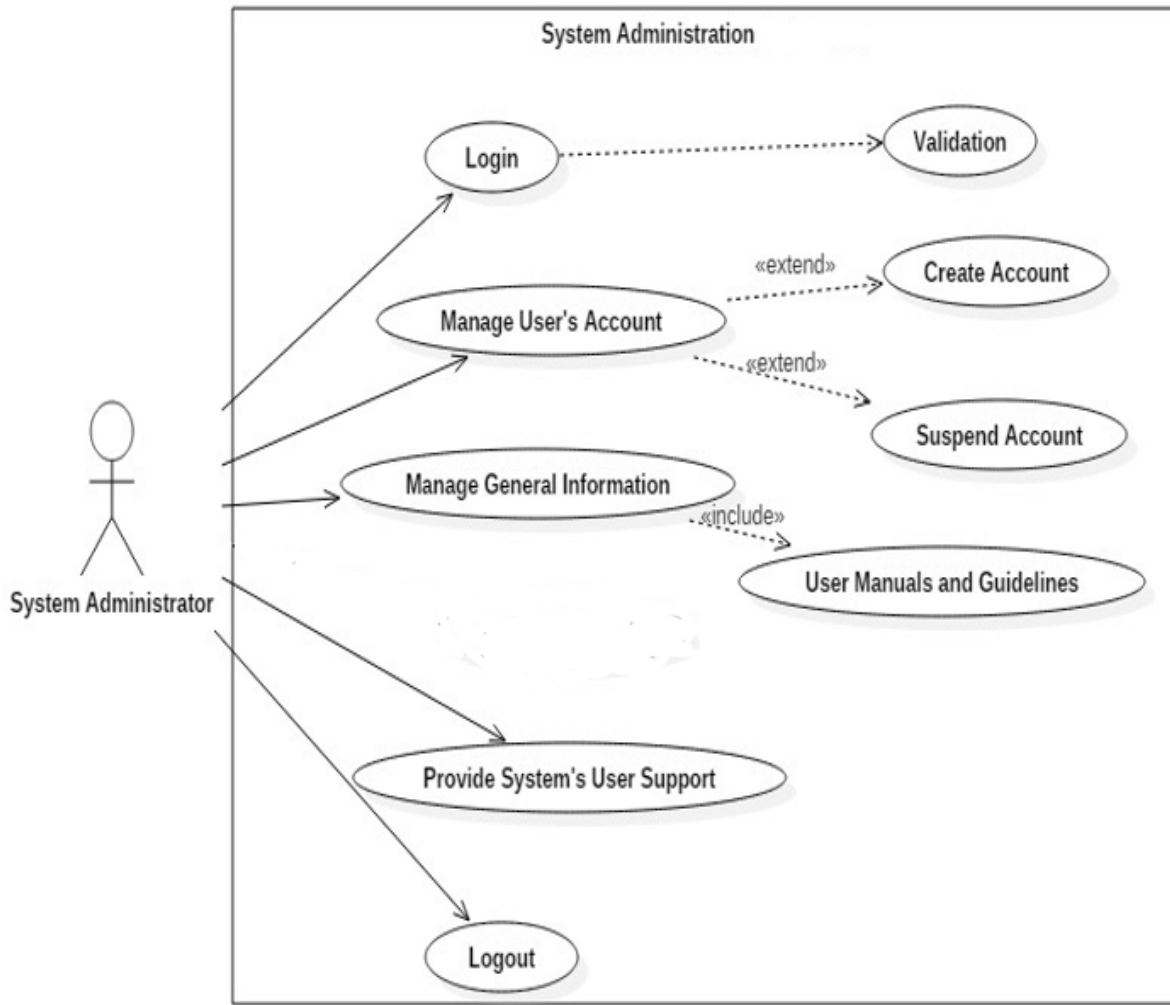


Figure 10: Use-Case Diagram for Administration of the system

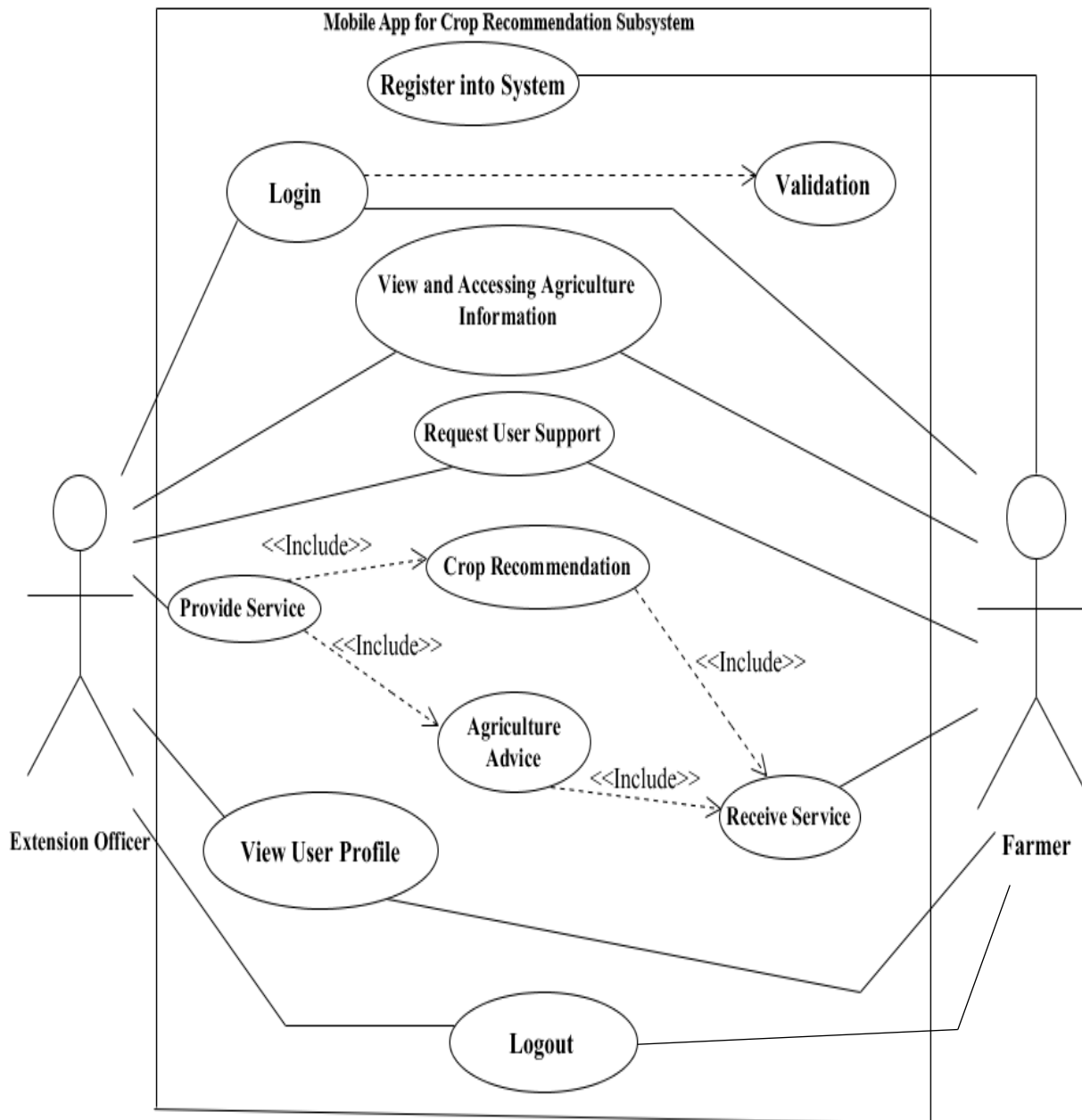


Figure 11: Use-Case Diagram for Crop Recommendation Subsystem

Therefore, the above use-case diagrams show the simplest way concerning how clients interact with the developed mobile application for crop recommendation. The next phase will include both the interaction of users of this app and the movement of information from one point to another.

4.3.3 Data Flow Diagram (DFD)

The DFD shows the flow of data in this system and Fig. 12 illustrate in what way the information will be pass-through from one point to another.

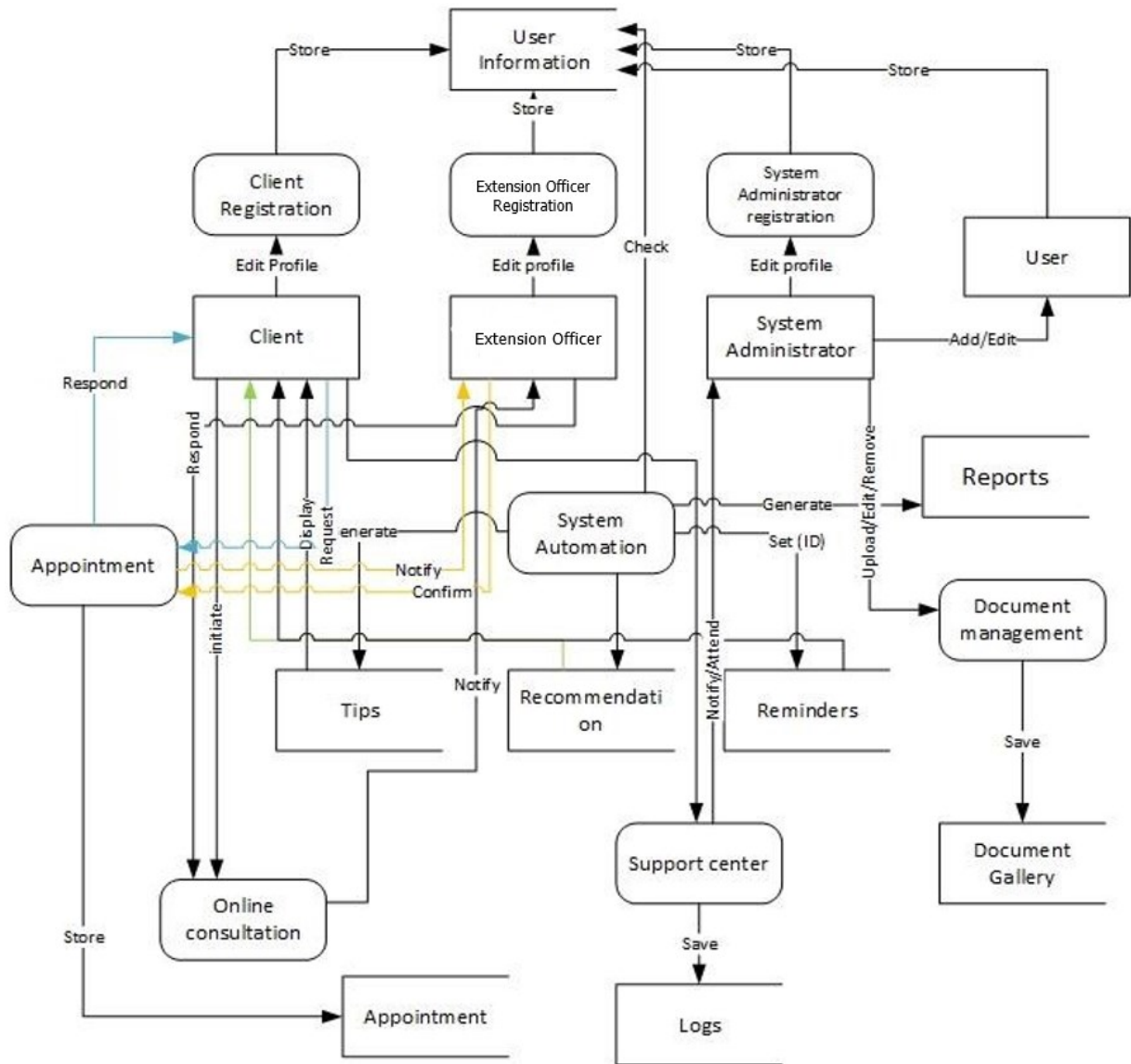


Figure 12: Data Flow Diagram for a Mobile Application for Crop Recommendation

4.3.4 System Framework

The conceptual framework demonstrates the way concepts of this study are systematized to reach a research target. The analyzed requirements were used to formulate the conceptual framework of this system as shown in Fig 13.

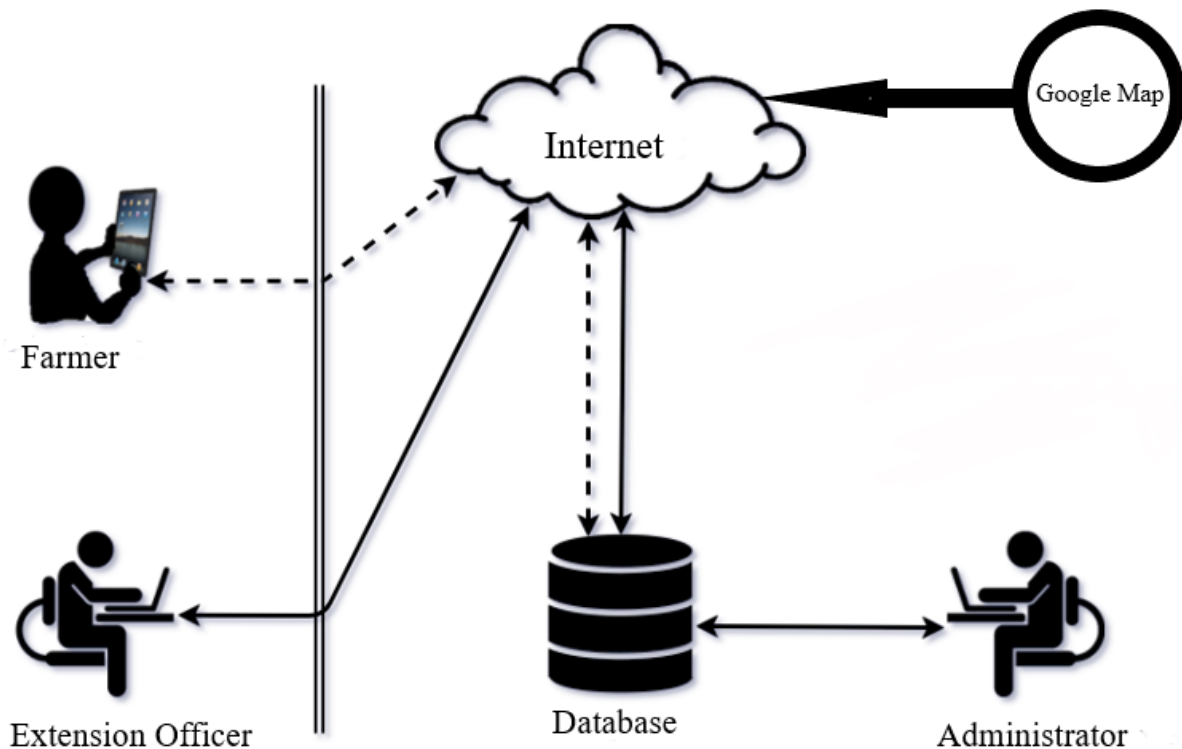


Figure 13: Conceptual Framework for a System

A farmer can trace the location by using phone GPS, they can retrieve agriculture information from the database, climate condition, also they can receive the recommendation from the extension officer.

Extension officers can provide information relative to a specific type of crop, pass information or innovation from the research institute to the farmers, also demonstrate how to use this information. Extension officers can assess and assist farmers in their efforts to produce agricultural products in best practice. can store important agricultural information into the database.

The administrator ensures the system work as planned, maintains the system and its components. He is responsible for the storage of information in the database.

4.4 System Implementation

4.4.1 Mobile Application Implementation

This mobile app for crop recommendation was developed by using the android platform. It has simple user interfaces and it's easy to use. Figure 14 show the user interface.

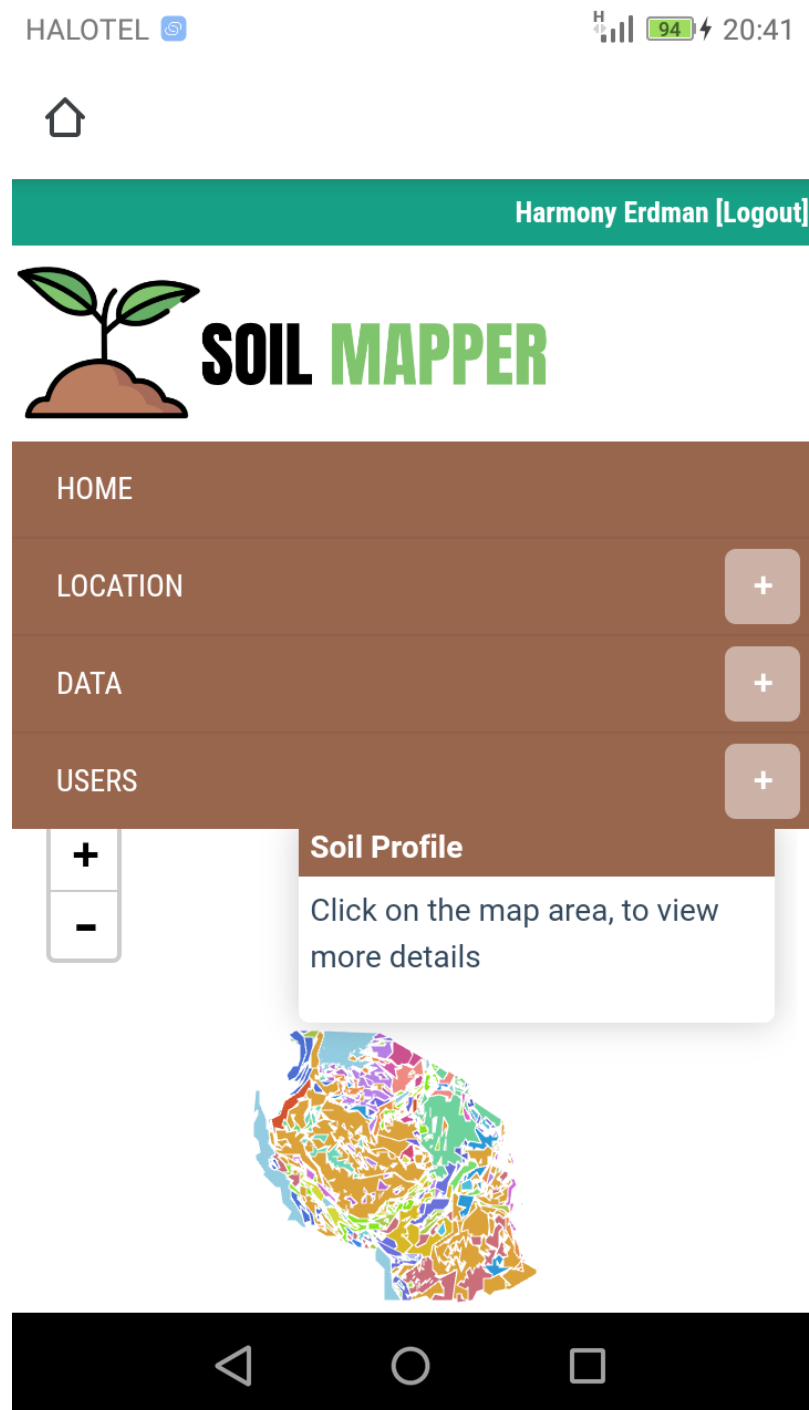


Figure 14: User Interface UI

All users of this mobile app must have a registered and activated account before they log-in to the system. In the registration panel, users must submit personal details asked by the system useful for both security and extension officers. This has been shown in Fig. 15

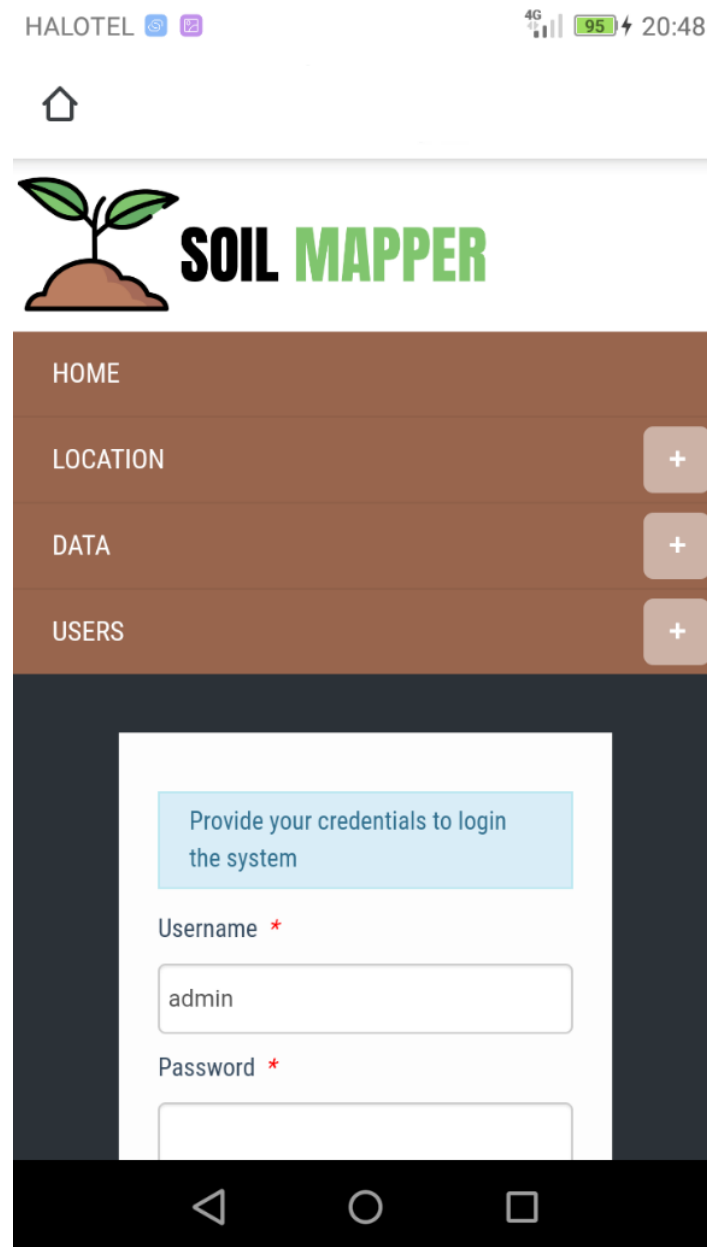


Figure 15: User Required to Enter Username and Password to Login to the System

If users are successfully registered into the system, then they will be able to continue by log-in into the system by using the registered username and password. After log-in into the system, they will first be introduced to the main menu having all categories of services listed and which are delivered by this mobile app. Figure 16 shows the menu UI.

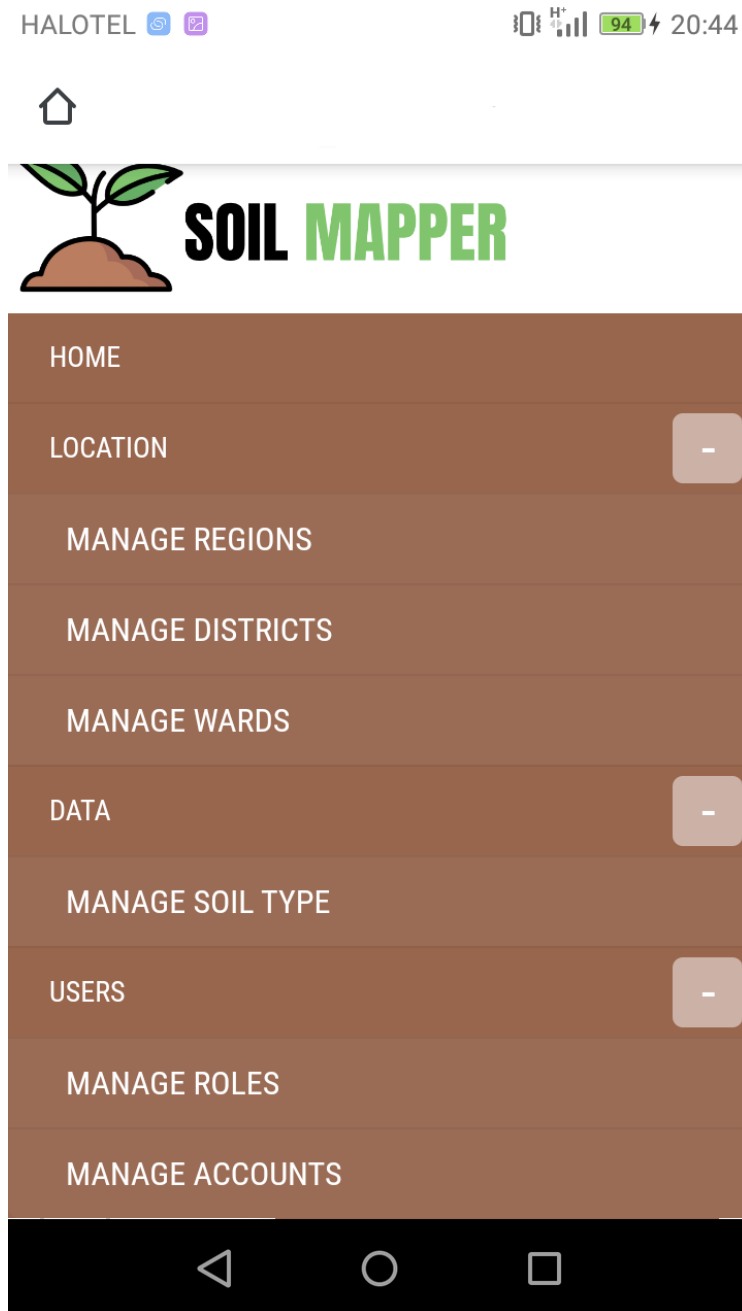


Figure 16: Menu UI

- (i) **Agriculture Information and Tips:** The farmer can be able to view various agricultural information and tips that have been posted by extension officers from time to time. All information and tips are organized in ascending order according to the time and day they were posted. Also, a farmer may wish to search for other location information concerning soil and will be available as shown in Fig. 17(a) and Fig. 17(b) where a farmer searches the soil type of Olasiti.

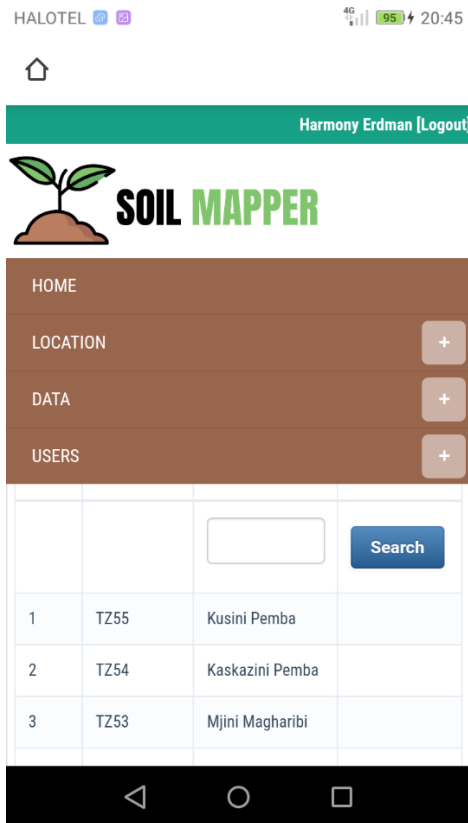


Figure 17(a): Search UI

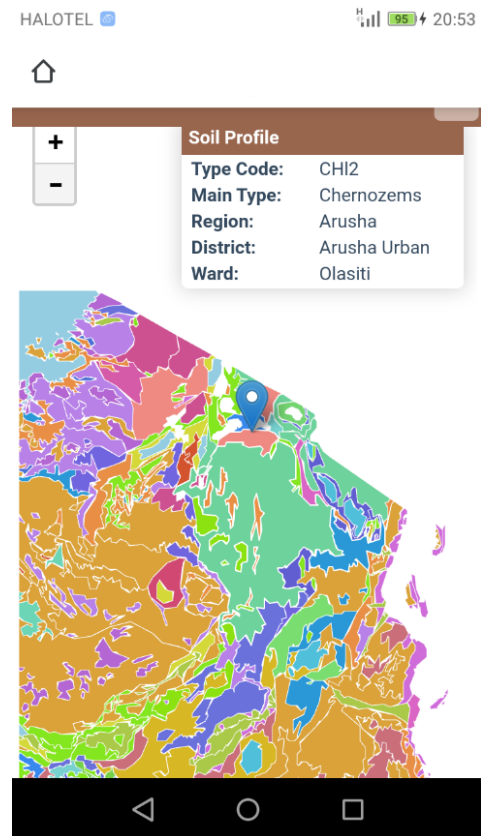


Figure 17(b): Olasiti Soil Information

- (ii) **Farmer's Location:** Farmers may be able to trace their location and identify the specific soil type found in that area. Also, may be able to view what kind of crops are supported by that particular soil type. Figure 18 shows how farmers can trace their location and identify soil type.

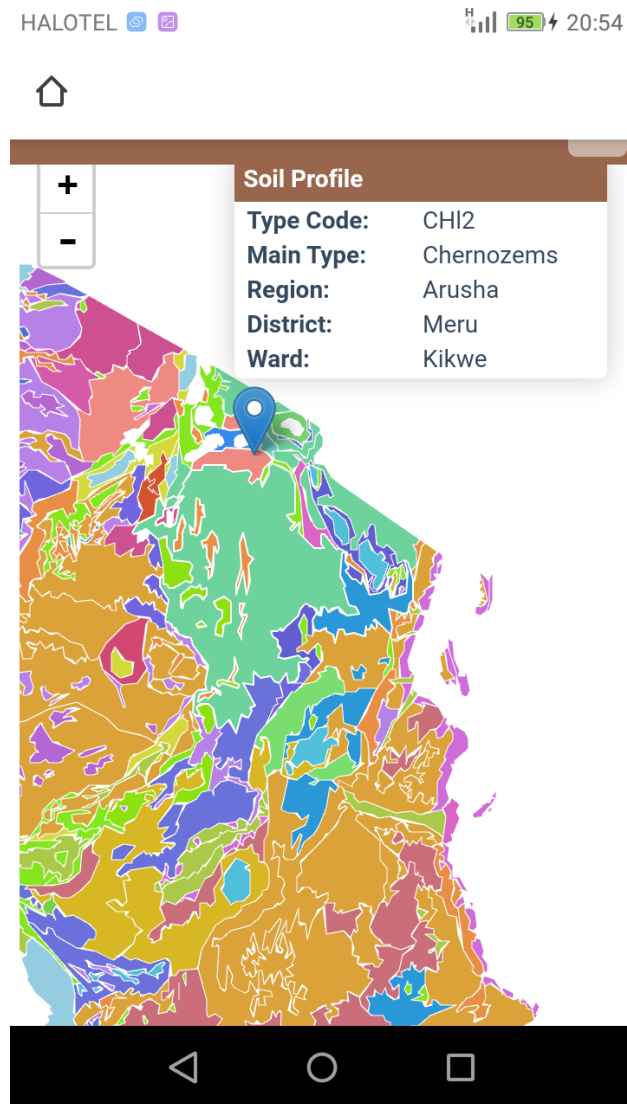


Figure 18: Farmers Can Trace Their Location and Identify Soil Type

- (iii) **User's Profile:** In this panel, the user may be able to edit their details, they can change passwords whereby for them to change the password they must enter the current one then they must enter a new password that will be linking to their email address.
- (iv) **Logout:** After finishing using the application the farmer will be able to sign out this will ensure their confidentiality. Also, after logout users can be out of the system and no one would be able to sign in by using their names. To access agriculture information users will require to log in again by using their registered username and password.

4.5 System Validation

4.5.1 System Testing

In this section, the developed system was tested so that we can assure it meet the specified system's requirements. Therefore, after testing each module of the system the results are shown below in Table 8.

Table 8: System Testing Outcomes

The requirement of the developed system	Test Outcome
The developed mobile app should support the android operating system (OS).	PASS
The developed mobile app should support the English language.	PASS
The login feature and logout must work to permit the user to sign in when need to do so and sign out after using the system.	PASS
The register or sign-up function must work to let an unregistered user be able to register to the system.	PASS
The system admin must be able to modify the client account when there is a need of doing so. The system must support that functionality too.	PASS
Both the system admin and extension officer must be able to upload content like different agriculture information to the system and to remove it when it's outdated.	PASS
The user of the system must be able to view the published contents so that they can retrieve important information.	PASS
The user may be able to change the password and when they forget the password, they may be able to restore it through email linked to the system.	PASS

4.5.2 Users' Acceptance Validation

The developed mobile application for crop recommendation then the system was sent to the user to use for a while and return their acceptance validation. Therefore, participants in this process were as follows: 24 participants contributed to the validation survey, 20 participants installed this mobile app for crop recommendation in their smartphones, 2 extension officers, and 2 the administrators of the system.

A total of 5 days were given to all participants of this conducted validation survey for them to use this developed mobile app and then, required to fill in the validation survey questionnaires. The results of this validation survey were handled based on a mean score corresponding to this scale below:

- Strongly Agree = 5 score,
- Agree = 4 score,
- Neutral = 3 score,
- Disagree = 2 score, and
- Strongly Disagree = 1 score.

In this research study, the acquired mean score was greater than 3.5 score for every acceptance validated attribute. Hence, this indicating that this developed mobile application for crop recommendation was strongly accepted by many of the respondents. Also, it shows that the respondents were satisfied with both the ability and quality of this mobile application. Table 9 shows the acceptance validation from the users.

Table 9: Acceptance Validation from the Users

Validation Attribute	Views from the Users					Mean Score
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
The mobile app user's interfaces are lovely and easy to interact with it	14	4	2	0	0	4.6
The mobile app is user friendly i.e easy to understand	13	5	1	1	0	4.5
There are no compatibility issues that arose between the app and your smartphone	17	3	0	0	0	4.85
There is a need for technical assistance to completely exploit this application	0	1	1	6	11	1.5
This mobile app is valuable and supportive in accessing agricultural information	7	9	4	0	0	4.15
The interaction between extension officers and farmers is completely nice and interesting	11	6	3	0	0	4.4
I will use this mobile app to access agricultural information	15	5	0	0	0	4.75
I am mostly satisfied and convinced to use this app	10	9	1	0	0	4.45
I will advise other farmers to use the mobile application for crop recommendation	12	8	0	0	0	4.6

4.6 Discussion

This study found out more than three-quarters (77.6%) of all respondents own smartphones and use them for accessing internet services. Such a finding implies that farmers possess the necessary mobile infrastructure needed for the internet-based information delivery process. In other countries where such a higher proportion of smartphone users exist, experts have designed mobile-based online platforms for solving agriculturally based problems. For instance, Criyagen developed Agri-app as a tool to provide farmers to get agricultural information from reliable sources, important news concerning agriculture, offering assistance from the experts via calls and chat. Additionally, Agri-app consists of many useful videos like mushroom cultivation, watermelon cultivation, sugarcane cultivation, and goat farming (Barh & Balakrishnan, 2018; Kashiwazaki, 2019). In Canada, experts developed a mobile-based platform that collects information of several crops and shares that information with farmers in a very short time hence increase crop production (Khak Pour *et al.*, 2021).

Another mobile-based online platform is an E-Agro mobile app that provides expert support to farmers on issues related to the cultivation of crops, diseases, manures, and pricing, etc. (Sharma *et al.*, 2015). Primarily E-agro app focused on bringing modern agricultural practices to farmers located in rural areas. Furthermore, in India, the Agriculture News Network (ANN) developed the Kisan Yojana app that provides agriculture information concerning the schemes and profit provided by the Indian government to the rural people and farmers (Barh & Balakrishnan, 2018; Ravichandran & Koteeshwari, 2016). The main objective of the Kisan Yojana app is to suggest crops, fertilizers to the farmer for his land, and his desired crop (Barh & Balakrishnan, 2018).

This study finds out nearly one-third (32.7%) of the respondents opt to search for agriculture information from the internet. These results indicate that despite the existence of other sources of agriculture information still, some of the farmers opt to search for agriculture information from the internet and this implies that if experts develop an organized online platform through agriculture apps, then the majority of farmers will be able to utilize the platform for accessing agriculture information. In other countries where farmers show the massive uses of the internet and the need of having online platforms researchers and experts join their effort to find a solution. For instance, a world bank report (Qiang *et al.*, 2016) indicates that it is important for farmers to have agricultural mobile apps that can facilitate the process of accessing agriculture information through reliable online sources. In addition

to this, other studies conducted in 2014 and 2020 revealed that farmers seek agriculture information via the internet hence they need the right tool i.e., mobile-based apps to ease the process of accessing agriculture information (Schulz *et al.*, 2021; Stenberg, 2014).

Also, Fig.7 indicates that other respondents preferred to exchange agriculture information within themselves and also via direct contact with extension officers. Such finding implies that still, the methods used by some of the farmers are ineffective because it takes time for agriculture information to spread from farmer to farmer, and also original information can be altered during the process of passing it from the first person to the last one, hence that agriculture information can reach to users as secondary or passive and that can affect the quality of the intended message by the developer. This finding is related to the 2017 FAO report which revealed that farmers get information through extension officers and farmer to farmer exchange (FAO, 2017).

Moreover, Fig.7 shows that 3.2% of farmers rely on social media for agricultural news. Also, during a focus group discussion those who use social media said that not only do they seek agriculture information on social media but also, they use it as an online market for their agricultural products. This finding indicates that although a small number of the farmers use social media as one of the online platforms still there is a need for a tool like a reliable online platform that can provide agriculture information to the majority of the farmers. The presence of a reliable online source through agriculture apps can help the majority of farmers to get agriculture information easily and hence farmers can fully utilize social media for accessing agriculture information. For instance, the study conducted in Kenya assesses the impact of social media on farmers and they recommend that agriculture information centres like agriculture online platforms need to be created so that farmers can fully utilize social media for accessing agriculture information (Kipkurgat *et al.*, 2016). In addition to this, the research study conducted in 2015 suggested that it is important for an information system for agriculture to be built based on mass media like the internet and mobile apps (Jain *et al.*, 2015). Furthermore, localization and the indigenous language of agriculturalists are matters to be linked to these systems. The findings indicated that there is a need for farmers to get appropriate information related to their crops and farming methods. More precisely, agricultural methods require timely, precise, and correct information to be delivered to farmers to facilitate informed decisions on several issues such as the management of farm

fields, implementation of improved systems of production, and seizing opportunities that exist in various markets (Chhachhar *et al.*, 2016; Mitchell *et al.*, 2018; Schulz *et al.*, 2021).

This study finds out about 80% of the respondents claim that they will prefer to retrieve agriculture information via an online platform while 75.6% respond that they will appreciate it if experts will develop agriculture mobile apps to help them accessing agriculture information. Such finding indicates that online platforms through agricultural mobile apps can be a strong tool for farmers to get access to agriculture information especially if such agricultural mobile apps are availed online through an organized platform, farmers would use them frequently to ease the process of accessing agriculture information. For instance, a study conducted in Kenya reveals that the majority of farmers seek agriculture information through different online sources and therefore farmers need a tool that will help them to obtain agriculture information from online sources easily (Kipkurgat *et al.*, 2016). This finding holds a different view from the one in another study that shows that farmers were not bothered to use online sources to search for agriculture information they need. Instead, they were concerned about the price of fertilizers, insecticides, seeds, and transportation. Also, the study claim that farmers need accessibility and fair cost of fertilizers, seeds as well as irrigation (Vassalos & Lim, 2016).

Furthermore, this study finds-out more than 80% of the respondents agree that the mobile application platform would be a solution to the present problem. This finding implies that the majority of farmers have a positive attitude towards this approach of using the online platform through agriculture mobile apps as a way forward towards enriching access to agriculture information. Recently a study conducted early last year indicated that the majority of farmers need a mobile application platform to access different agriculture information (Emeana *et al.*, 2020). Also, a study conducted in Australia shows that farmers are eager to have an online platform that can ease access to agriculture information. In addition, the study indicates that Australian farmers have a positive attitude towards using agricultural apps (Schulz *et al.*, 2021). Furthermore, a study conducted in Indonesia about the use of an online platform through a mobile-based android app to motivate farmers to share agriculture information online during the covid 19 pandemic, indicates that farmers are keen to have an online platform for them to share agriculture information (Rosita & Suryaman, 2021).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study concludes that the development of mobile-based apps will be a strong tool that will provide a high possibility to improve the current agriculture information sharing process. Also, agriculture apps have full potential to enriching access to agriculture information, this is because the majority of farmers 77.6% have smartphones and already 32.7% are currently using internet-based platforms to search for agriculture information.

Furthermore, it has been found that most farmers 80% have a positive attitude towards the approach of using the online platform through agriculture mobile apps as a way forward towards enriching access to agriculture information. This is because farmers need agriculture information and some of them go further and seek such information through online sources like the internet, and social media so that they can fulfil their needs. Hence this study realizes that if experts develop a reliable online platform through agriculture apps, then the majority of the farmers will fully utilize such platforms for accessing agriculture information.

Therefore, due to the advancement of technology, this study realizes that it is essential for farmers to have agriculture apps as a major tool to facilitate the process of retrieving agriculture information. The online platform through mobile-based apps will be a tool of high benefit as a reliable source of agriculture information which is also cheap and convenient for the users of such platform.

Moreover, this research survey study assessed the farmers on the current situation for them to access agriculture information and common means of accessing agriculture information; also, if there is a necessity for having a mobile application. Moreover, this study developed a mobile application after taking into consideration both the non-functional requirement and functional requirements from the users of this mobile app.

In addition, the majority of farmers said that they would appreciate having agriculture mobile apps for accessing agriculture information on the online platform. This platform ought to be reliable, simple, and using a native language like Swahili. This mobile application platform will save the time of searching for agriculture information as well as will increase crop

production. The production will increase because farmers will get appropriate information and advice from agriculture experts on time.

The public should be aware of the existence of that mobile application platform so that they can make use of resources effectively. Moreover, the platform will simplify the work of extension officers to reach their farmers. Agriculture information in every aspect of agriculture will be available to uplift small scale farmers. Agriculture information such as best seeds, best methods to apply, market, weather information, soil information, what to plant, when to plant, where to plant, and where to sell all this information will be of benefit to the farmers.

5.2 Recommendations

This study recommends forthcoming research studies to emphasize evaluation of the achievement of the mobile application for crop recommendation in try to ensuring access to agriculture information, increase crop production, and Agriculture development in general. Also, future research should take into account other Agriculture information which will be needed by farmers since this mobile app doesn't cover all agriculture information because this field of agriculture information is very huge and change based on time and environment.

Mobile Service providers like Vodacom, Tigo, Halotel, Airtel, etc should be considered to expand internet connectivity, telecommunications facilities to rural regions (GSMA, 2018). The required services to most villages in rural areas are such as Internet services, mobile communication services, Television broadcasts, and other ICT infrastructures. Initiatives like the creation of telecommunication centres in those areas, extending different information and communication technology services like the Internet, mobile phone, radio broadcasting, and computer are applicable and appropriate.

Moreover, the government via a particular sector should accelerate participatory people's education programs for raising people's awareness of make use of agriculture mobile applications and other ICTs sources of agriculture information. Also, the government must find a better way of reducing the cost of communication and internet services so that it can be affordable costs to people, this will make it easier for farmers to use the developed mobile application since it uses internet services most of the time.

Therefore, to make sure that crop production and agriculture, in general, grow to the expected amount the use of information technology, mobile technology is a way forward to make this

dream come true for the present society and the future in Tanzania. A lot of effort must be applied to ensure that information technology knowledge is provided in rural areas where most of the farmers are located to allow an easy understanding of how to use mobile technology to improve crop production and how mobile applications can facilitate the way of accessing agriculture information.

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APPENDICES

Appendix 1: Soil Types, Use and Management (Mlingano Agricultural Research Institute, 2006)

SN	Soil Types	Potential Use and Management	Limitations
1.	Albi Gleyic Arenosols	Arable cropping with soil water conservation practices, tree crops, extensive grazing	Low available water capacity, very low natural fertility, susceptible to erosion
2.	Calci-Gleyic Solonetz	Extensive grazing, Soda mining	Strong sodicity and wetness
3.	Calci-Hyposodic Planosols	Suitable for extensive grazing and in some place's wetland rice	Strong sodicity and salinity, very low fertility
4.	Calcic Solonetz	Extensive grazing, Soda mining	Strong sodicity
5.	Cambic Arenosols	Arable cropping with soil water conservation practices, tree crops, extensive grazing	Low available water capacity, very low natural fertility, susceptible to erosion
6.	Carbonati-Sodic Solonchaks	Suitable for extensive grazing, arable cropping requires reclamation	Strong salinity and sodicity
7.	Chernozems	High natural fertility and their favourable topography permit a wide range of agricultural uses	Susceptible to drought condition
8.	Chromic-Arenic Lixisols	Suitable for perennial crops or forestry, arable farming requires fertilizers and/or liming	Low natural fertility, Slaking/crusting, Compaction and erosion on sloping land
9.	Chromic-Ferralic Cambisols	A wide variety of agricultural uses with the maintenance of soil organic matter and nutrient levels	Low natural fertility
10.	Chromic-Ferric Acrisols	Adapted cropping systems with complete fertilization and preservation of the surface soil	Low natural fertility, Aluminium toxicity, strong phosphate fixation, slaking/crusting
11.	Chromic-Luvic Phaeozems	High potential for agriculture, Improved pastures and forestry	Periodic drought, wind and water erosion
12.	Chromic-Natric Vertisols	High natural fertility suitable for a wide range of crops, Small-scale and Large-scale irrigated crops	Difficulty work ability, Difficulty water management
13.	Chromic Cambisol	A wide variety of agricultural uses with the maintenance of soil organic matter and nutrient levels	Low natural fertility
14.	Chromic Lixisols	Suitable for perennial crops or forestry, Arable farming requires fertilizers and/or liming	Low natural fertility, Slaking/crusting, Compaction and erosion in sloping land
15.	Chromic Luvisols	Potentially suitable for a wide range of agricultural use	Vary with climate, topography, depth or stoniness
16.	Cutani-Chromic Luvisols	Potentially suitable for a wide range of agricultural use	Vary with climate, topography, depth or stoniness
17.	Dystric Calcisol	Adequate drainage and periodical liming required for arable cropping, horticulture and dairy farming	Vary with climate, topography, Wetness
18.	Epi-Dystric Gleyic	Adequate drainage and periodical liming required for arable cropping, horticulture and dairy farming	Wetness

SN	Soil Types	Potential Use and Management	Limitations
19.	Epi-Dystric Gleysols	Adequate drainage and periodical liming required for arable cropping, horticulture and dairy farming	Wetness
20.	Eutric-Gleyic Fluvisols	High natural fertility suitable for rainfed and irrigated agriculture with adequate drainage	Susceptible to seasonal flooding, high groundwater levels and salinity
21.	Eutri-Humic Regosols	Vary widely but can support capital-intensive irrigation, low volume grazing and forestry	Susceptibility to erosion, drought, shallowness
22.	Eutri-Pelic Vertisols	High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated crops	Difficult work ability, difficult water management
23.	Eutri-Rhodic Cambisols	A wide variety of agricultural uses with the maintenance of soil organic matter and nutrient levels	Vary with climate, topography, depth or stoniness
24.	Eutric Cambisols	A wide variety of agricultural uses with the maintenance of soil organic matter and nutrient levels	Vary with climate, topography, depth or stoniness
25.	Eutric Fluvisols	High natural fertility suitable for rainfed and irrigated agriculture with adequate drainage	Susceptible to seasonal flooding, high ground water levels and salinity
26.	Eutric Leptosols	Low volume grazing, forestry	Shallowness, stoniness, rockiness
27.	Eutric Nitisols	Very productive but require the application of P-fertilizer as slow-release, low-grade rock phosphate	Low base status and low available phosphorus
28.	Eutric Planosols	Suitable for extensive grazing and in some place's wetland rice	Strong sodicity and salinity, very low fertility
29.	Eutric Vertisols	High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated crops	Difficult work ability, difficult water management
30.	Ferralic Arenosols	Arable cropping with soil water conservation practices, tree crops, extensive grazing	Low available water capacity, very low natural fertility, susceptible to erosion
31.	Ferralic Cambisols	A wide variety of agricultural uses with the maintenance of soil organic matter and nutrient levels	Low natural fertility
32.	Ferric Lixisols	Suitable for perennial crops or forestry, arable farming requires fertilizers and/or liming	Low natural fertility, slaking/crusting, compaction and erosion on sloping land
33.	Fibric Histosols	Extensive grazing or forestry, capital intensive arable cropping or horticulture with reclamation	Wetness, low soil fertility, rapid mineralization losses, loss of volume (shrinkage) and collapse
34.	Fluvic Histosols	Extensive grazing or forestry, capital intensive arable cropping or horticulture with reclamation	Wetness, low soil fertility
35.	Gleyic Solonchex	Extensive grazing, Soda mining	Strong sodicity and wetness
36.	Grumi-Pellic Vertisols	High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated crops	Difficulty work ability, difficulty water management
37.	Haplic Acrisols	Adapted cropping systems with complete fertilization and preservation of the surface soil	Low natural fertility, compaction and erosion on sloping land
38.	Haplic Ferralsols	Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming	Low natural fertility and tendency to fix phosphates
39.	Haplic Lixisols	Suitable for perennial crops or forestry, arable farming requires fertilizers and/or liming	Low natural fertility, slaking/crusting, compaction and erosion on sloping land

SN	Soil Types	Potential Use and Management	Limitations
40.	Haplic Luvisols	Potentially suitable for a wide range of agricultural use	Vary with climate, topography, depth or stoniness
41.	Haplic Nitisols	Very productive but require the application of P-fertilizer as slow-release, low-grade rock phosphate	Low base status and low available phosphorus
42.	Haplic Phaeozems	High potential for agriculture, improved pastures and forestry	Periodic drought, wind and water erosion
43.	Haplic Solonchaks	Suitable for extensive grazing, arable cropping requires reclamation	Strong salinity
44.	Haplic Solonetz	Suitable for extensive grazing, arable cropping requires reclamation	Strong salinity, Periodic drought, wind and water erosion
45.	Humi-Gleyic Fluvisols	High natural fertility suitable for rainfed and irrigated agriculture with adequate drainage	Susceptible to seasonal flooding, high ground water levels and salinity
46.	Humi-Rhodic Luvisols	Potentially suitable for a wide range of agricultural use	Vary with climate, topography, depth or stoniness
47.	Humi-Umbric Acrisols	Adapted cropping systems with complete fertilization and preservation of the surface soil	Low natural fertility, aluminium toxicity, strong phosphate fixation
48.	Humi-Umbric Leptosols	Low volume grazing, forestry	Shallowness, stoniness, rockiness
49.	Humi-Umbric Nitisols	Very productive but require the application of P-fertilizer as slow-release, low-grade rock phosphate	Low base status and low available phosphorus
50.	Hypoluric Arenosols	Arable cropping with irrigation or soil water conservation practices, tree crops, extensive grazing	Low available water capacity, very low natural fertility, susceptible to erosion
51.	Lithic Leptosols	Low volume grazing, forestry	Shallowness, stoniness, rockiness
52.	Luvic Phaeozems	High potential for agriculture, improved pastures and forestry	Periodic drought, wind and water erosion
53.	Molli-Endogleyic Fluvisols	High natural fertility suitable for rainfed and irrigated agriculture with adequate drainage	Susceptible to seasonal flooding, high ground water levels and salinity
54.	Mollic Andosols	High natural fertility but require the application of lime, organic matter and phosphate fertilizers	Strong fixation of phosphorus, susceptible to erosion on sloping land
55.	Mollic Fluvisols	High natural fertility suitable for rainfed and irrigated agriculture with adequate drainage	Susceptible to seasonal flooding, high ground water levels and salinity
56.	Mollic Solonetz	Extensive grazing, soda mining	Strong sodicity
57.	Pellic Vertisols	High natural fertility suitable for a wide range of crops, small-scale and large-scale irrigated crops	Difficulty work ability, difficulty water management
58.	Profondic Luvisols	Potentially suitable for a wide range of agriculture use	Vary with climate, topography, depth or stoniness
59.	Rhodi-Acric Ferralsols	Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming, appropriate	Low natural fertility and tendency to fix phosphates
60.	Rhodi-Profondic Lixisols	Suitable for perennial crops or forestry, arable farming requires fertilizers and/or liming	Low natural fertility, slaking/crusting, compaction and erosion in sloping land

SN	Soil Types	Potential Use and Management	Limitations
61.	Rhodic Acrisols	Adapted cropping systems with complete fertilization and preservation of the surface soil	Low natural fertility, aluminium toxicity, strong phosphate fixation, slaking/crusting
62.	Rhodic Cambisols	A wide variety of agricultural uses with the maintenance of soil organic matter and nutrient levels	Low natural fertility
63.	Rhodic Ferralsols	Suitable for a wide range of crops, maintenance of soil organic matter, periodic liming, appropriate	Low natural fertility and tendency to fix phosphates
64.	Rhodic Lixisols	Suitable for perennial crops or forestry, arable farming requires fertilizers and/or liming	Low natural fertility, slaking/crusting, compaction and erosion on sloping land
65.	Sodic-Luvic Chernozems	High natural fertility and their favourable topography permit a wide range of agricultural uses	Susceptible to drought condition
66.	Sodi-Mollic Cambisols	A wide variety of agricultural uses with the maintenance of soil organic matter and nutrient levels	Strong sodicity
67.	Stragnic Solonetz	Extensive grazing, soda mining	Strong sodicity
68.	Sodic Solonchak	High natural fertility and their favourable topography permit a wide range of agricultural uses	Strong sodicity,
69.	Umbric Acrisols	Adapted cropping systems with complete fertilization and preservation of the surface soil	Low natural fertility, aluminium toxicity, strong phosphate fixation, slaking/crusting
70.	Umbric Andosols	High natural fertility but require the application of time, organic matter and phosphate fertilizers	Strong fixation of phosphorus, susceptible to erosion on sloping land
71.	Umbric Nitisols	Very productive but require the application of P-fertilizer as slow-release, low-grade rock phosphate	Low base status and low available phosphorus
72.	Vitric Andosols	High natural fertility but require the application of time, organic matter and phosphate fertilizers	Strong fixation of phosphorus, susceptible to erosion on sloping land

Appendix 2: Yamane's Formular

$$n = \frac{N}{1 + N(e)^2}$$

Where: n = Sample Size
 N = Population Size
 e = Precision Level

Appendix 3: Questionnaire for Farmers

Introduction

This questionnaire aims to assess whether an online platform through agriculture apps could be a proper way to enrich access to agriculture information in Arusha, Tanzania. Thanks for your time to be part of this research.

Instruction: Fill in the blank spaces by writing the correct answer/word about the statement OR by placing a tick (✓) in the Square Brackets ([]) with the answer/word that best fits the statement/question (*based on your experience*).

1. Personal Information:

First Name: Surname: (*Optional*)
Gender: Male [] Female []
Age: (*Years*)
Residence: Village: Ward: District:
Contacts: Mobile Phone no: Email: (*Optional*)

2. Education Level:

Non-formal Education [] Primary Education [] Secondary Education []
Tertiary Education []

3. Which source(s) do you use to get and/or provide agriculture information?

Radio [] social media [] Television [] Newspaper [] Internet [] Extension
Officers [] Farmer to Farmer Exchange []
Others (mention):

4. Which of the following limit you from accessing agriculture information by using the source(s) in (3.) above?

Lack of electricity [] Timing of broadcasting [] Poor roads []
Costs (too expensive) [] Services not available [] Others (Mention):
.....

5. What kind of Agriculture information do you prefer to find and access?

Transport costs [] Buyer and Traders [] Soil [] Price [] Fertilizer [] Demand
of produce [] Other (Mention):

6. What agricultural information would you prefer to be available to your community?

Climate information [] Soil information [] Agricultural policy [] Price information
[] Seeds and Fertilizer [] Markets [] Other (Mention):

7. Are you aware of the use of the Internet?
 Yes No
 If *yes*, how/where do you access the Internet?
 Using my mobile phone My computer Internet cafe
 Where else?
8. Do you possess a mobile phone?
 Yes No
 If *yes*, what type of mobile phone do you possess?
 Cellphone (Featured) Smartphone
9. Do you use a mobile phone to acquire agriculture information and/or farming services?
 Yes No
 If *yes*, how do you use mobile phone to acquire agriculture information?
 Browsing agricultural forums social media Government portal SMS
 Others (Mention):
10. Have you ever used any mobile apps to find and access agriculture information?
 Yes No
 If *yes*, mention the app(s):
11. An online platform through agriculture application (mobile app) to be used as a solution to access agriculture information, what is your opinion?
 Strongly Agree Agree Neutral Disagree Strongly Disagree
12. Do you think there are losses for farmers to use an online platform through agriculture apps to access agriculture information?
 Strongly Agree Agree Neutral Disagree Strongly Disagree
13. Do you think there are benefits for farmers to use an online platform through agriculture apps to access agriculture information?
 Strongly Agree Agree Neutral Disagree Strongly Disagree
14. Do you think there is a need for developing an online platform through agriculture apps for improving the way of accessing agriculture information?
 Strongly Agree Agree Neutral Disagree Strongly Disagree
15. Please rate your knowledge on Internet use.
 Best Better Good Average Poor Don't Know
16. I search for various agriculture information via online sources.
 Yes No

17. I think I will be able to search for various agriculture information through online platforms.
Yes [] No []
18. I think I can retrieve agriculture information via an online platform
Yes [] No []
19. I think I can analyze and interpret the agricultural information I get from online sources
Yes [] No []
20. How do you rate your method of obtaining agriculture information?
Very Effective [] Capable and Effective [] Needs Improvement []
Unsatisfactory []
21. I would appreciate having agriculture mobile apps for accessing agriculture information
Yes [] No []

RESEARCH OUTPUTS

(i) OUTPUT 1: Research Article

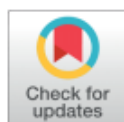
Edward, A., Mbega, E. R., Kaijage, S. F. (2021). Potential of Mobile-Based Apps Online Platforms in Fast-Tracking Access of Agriculture Information. *Indian Journal of Science and Technology*, 14(39), 2953-2960. <https://doi.org/10.17485/IJST/v14i39.729>

(ii) OUTPUT 2: Poster Presentation

Edward, A., Mbega, E. R., Kaijage, S. F. Application of Mobile Phone-Based System for Improved Crop Production Recommendation in Arusha, Tanzania



RESEARCH ARTICLE



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Potential of Mobile-Based Apps Online Platforms in Fast-Tracking Access of Agriculture Information

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Abstract

Objectives: This paper report the potential of online mobile phone-based platforms in fast-tracking access of agricultural information to farmers, with a case study of Arusha, Tanzania. **Method:** We used the questionnaire-based and focus group discussion methods and a total of 156 respondents were randomly selected for data collection. **Findings:** The results showed that 77.6% of respondents possess smartphones and 32.7% of them use internet-based platforms to search for agriculture information which usually is not applicable or specific in their local Arusha context. Such finding raised a need for developing internet-based platform for accessing agricultural information by farmers for use in their local context. Thus, the same respondents were assessed for their readiness to use a mobile-based agricultural app if developed. The results indicated that 80% of the respondents were willing and would use the app. **Novelty:** The paper demonstrated how mobile phone-based apps can be used to quicken accessibility of agricultural information in a local-based, context-specific location.

Keywords: Mobile Apps; Agriculture Information; Online Platform; Smartphones; Information Access

1 Introduction

Agriculture is a dominant activity globally as without which, food would not be produced, consequently depriving human development⁽¹⁾. It is a major source of income and industrial raw materials in many countries worldwide⁽²⁾. In Tanzania, agriculture employs over 80% of the total population and accounts for 56% of the Gross Domestic Product (GDP) and approximately 60% of earnings through exports⁽³⁾. Due to its role in food and incomes, need for correct information such as the best methods of cultivating crops, ways of keeping livestock, weather predictions, soil characteristics, high-quality seeds, what to cultivate, when to cultivate, where to cultivate, and the best markets for selling agricultural products is very significant in the development of agriculture^(4,5). Such kind of agricultural information helps the farmers on making appropriate decisions and select proper procedures for farming hence contributing

to agriculture development⁽⁶⁾.

Agricultural information in developing countries is commonly shared with farmers through extension services, local social networks, and cooperative organizations^(7,8). However, there exists a significant gap as when such information goes through those agents, it reaches users as secondary or passive and that can affect the quality of the intended message by the developer. For instance, in Tanzania, there exist a challenge in getting specific agricultural information by farmers especially about the time it takes from the source to farmers and correctness in terms of the source's intention. Some of the common methods used by agriculturalists to access agriculture information include radio, television, newspaper, extension officers and farmers exchange information to themselves^(8,9). These methods are effective but comparatively user-unfriendly as farmers do not own them. Using these methods involves several steps to deliver the information from the source to users, example there must be time to receive, process, interpret and report the information to the media as a result they are not time-efficient, the period for broadcasting information concerning agriculture may not be appropriate for users who might be going through family problems and not demand-driven⁽¹⁰⁾. The linkages between farmers, extension officers, and researchers need to be strengthened through the application of mobile-based apps to improve the current means of accessing agriculture information⁽¹¹⁾.

The mobile revolution has the potential of improving people's livelihood through agriculture^(5,12). However, there are insufficient mobile applications tailored to improve access to agriculture information^(13,14). Currently, there are over 43 million mobile subscribers in Tanzania⁽¹⁵⁾, in which about 53% of these subscribers have access to the internet⁽¹⁶⁾. With this massive usage of mobile communication and internet penetration, this study has the potential of positively impacting the way of accessing agricultural information.

This study depicts the assessment of whether using an online platform through agriculture apps could be a proper way of improving access to agriculture information. Furthermore, this paper emphasized the importance of mobile-based apps in increasing the efficiency of farmers because mobile phones are easily accessible to individuals residing in rural areas, especially farmers with low incomes. It has become obvious that farmers are eager and receptive to use mobile application platforms for information access regarding agriculture^(13,17). Nationwide, according to the Tanzania Communications Regulatory Authority (TCRA) annual report, the percentage of small-scale farmers with mobile phones in Tanzania is 66%⁽¹⁶⁾. Thus, this work was conducted to identify the proportion of the study population with mobile phones which are specifically smartphones, and also assess willingness whether or not a development of a mobile-based online platform will be a strong tool they can use for accessing agricultural information.

2 Methodology

The questionnaire-based and focus group discussion methods were used for this research survey. These approaches were used because it allows farmers to provide their views and experience all these to their language⁽¹⁸⁾. Also, it offers the opportunity to study participants involved in interaction that is focused on understandings and attitudes. Both techniques were conducted among different groups of farmers and agriculture experts, involving extension officers, and farmers working in the fields. The responses from all individuals who participated were open and anonymous⁽¹⁹⁾. The data obtained from the respondents of the questionnaire were used to measure the necessity of whether using an online platform through agriculture apps could be a proper way of improving access to agricultural information. The questions used in all sections were independent. Dependent variables were used to evaluate if respondents needed a mobile application platform to access agricultural information. A total of 16 focus groups was created each consisting at most 10 participants. Each group took an average of 37 minutes session for discussion of the topics.

In this survey study, the sample size applied was found out by Yaman's formula⁽²⁰⁾ as shown below. The result was obtained after calculation based on a total population of 49,000 farmers, a precision level of 0.08, and a 95% confidence level. The sample size was found to be 156 individuals. Random sampling was applied for both gender males and females, who were respondents to the questionnaire⁽²¹⁾. Finally, the data collected from respondents were analyzed by tableau software⁽²²⁾.

Yaman's Formula:

$$n = \frac{N}{1 + N(e)^2}$$

Where: n = The sample size

N = The population size

e = Level of precision

This survey study took place in Arusha, Tanzania, and was preferred because it's found in the zone counted as one of the best agriculture production zones⁽²³⁾. Furthermore, Arusha is one of the most developed regions in Information and

Communication Technology (ICT) infrastructures and has a vast number of mobile users as well as internet subscribers⁽²⁴⁾. In addition, there are several agriculture institutions such as Tanzania Agricultural Research Institute (TARI), Selian agricultural research institute, and Tengeru agricultural college that provide advice on agricultural activities to the farmers, education on different agriculture methods to apply.

3 Results and Discussion

3.1 Demographic Attributes of All Participating Individuals

Out of 156 of all respondents who participated, 50.6% were males and 49.4% were females. The majority of participants were between the age group of 30 to 39 years this was approximately 28.9% of all respondents. Table 1. Illustrates the demographic properties of all respondents who participated in this research study.

Table 1. Demographic Properties of All Respondents

Requirement	Types of Replies	Respondents (n)	Percentage (%)
Gender	Male	79	50.6
	Female	77	49.4
	Total = 156		100%
Age (in Years)	Below 20	3	1.9
	20 - 29	40	25.6
	30 - 39	45	28.9
	40 - 49	43	27.6
	50 - 59	23	14.7
	60 and above	2	1.3
	Total = 156		100%
Education	Non-formal education	5	3.2
	Primary education	29	18.6
	Secondary education	64	41
	Tertiary education	58	37.2
	Total = 156		100%

3.2 Mobile Possession Distribution

More than three-quarters (77.6%) of all respondents own smart-phone as can be seen in Figure 1. Such a finding implies that farmers possess the necessary mobile infrastructure needed for the internet-based information delivery process. In other countries where such a higher proportion of smartphone users exist, experts have designed mobile-based online platforms for solving agriculturally based problems. For instance, the Criyagen company in Bengaluru developed Agri-app as a tool to provide information on crop production and protection, also, offering assistance from the experts via calls and chat. Furthermore, The app allows farmers to access information related to agriculture from sowing to harvesting^(25,26). Therefore, empowering users to attain high-efficiency technology-enabled crop production and marketing of the agriculture produce. In Canada, experts developed a mobile-based platform that collects information of crops and monitoring crops specifically wheat, peas and canola⁽²⁷⁾. The developed platform can measure the temperature of the crops, height and can collect images of the crops for investigation.

In India, experts developed an E-Agro mobile app that provides expert support to farmers on issues related to the cultivation of crops, diseases, manures, crop recommendations based on soil type and weather⁽²⁸⁾. The app focuses on bringing modern agricultural practices to farmers located in rural areas. Furthermore, the Agriculture News Network (ANN) developed the Kisan Yojana app that suggests crops, fertilizers and provides agriculture information concerning the schemes and profit provided by the Indian government to the farmers^(26,29). Figure 1 below portrayed the distribution of mobile ownership.

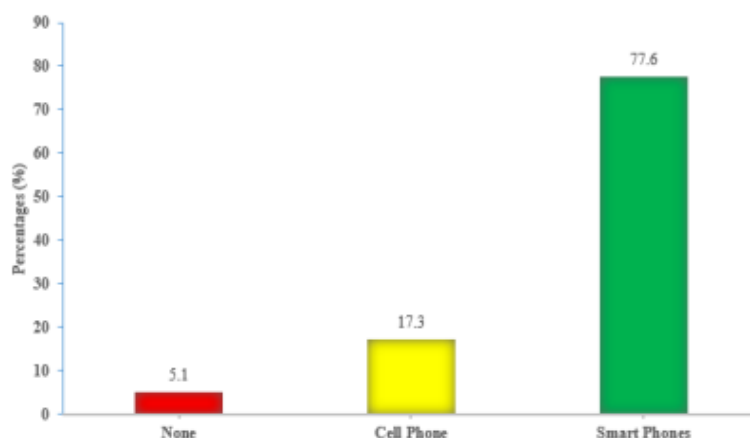


Fig 1. Mobile Possession Distribution

3.3 Sources of Agricultural Information

In this part, the farmers were accepted to select several sources of agriculture information they always use to seek agricultural information. Nearly one-third (32.7%) of the respondents opt to search for agriculture information from the internet. These results indicate that despite the existence of other sources of agriculture information still, some of the farmers opt to search for agriculture information from the internet. Also, during group discussion, the participants said that they use the internet for searching agriculture information but most of the time they get information that usually is not applicable or specific in their local Arusha context. This implies that if experts develop an organized online platform through agriculture apps, then the majority of farmers will be able to utilize the platform for accessing specific agriculture information which will be applicable in their environment. For example, more than 53% of the Indians retrieved the internet from their mobile phones, this encourages experts to develop mobile-based platforms for solving agriculturally based problems^(26,28,29). Also, a world bank report⁽³⁰⁾ suggests that it is important for farmers to have agricultural mobile apps that can facilitate the process of accessing agriculture information through reliable online sources. In addition to this, studies conducted in 2014 and 2020 revealed that farmers seek agriculture information via the internet hence they need the right tool i.e., mobile-based apps to ease the process of accessing agriculture information^(13,31).

Also, Figure 2 indicates that other respondents preferred to exchange agriculture information within themselves and also via direct contact with extension officers. Such finding implies that still, the methods used by some of the farmers are ineffective because it takes time for agriculture information to spread from farmer to farmer, and also original information can be altered during the process of passing it from the first person to the last one, also, agriculture information can reach to users as secondary or passive and that can affect the quality of the intended message from the source. This finding is related to the 2017 FAO report which revealed that farmers get information through extension officers and farmer to farmer exchange⁽³²⁾.

Moreover, Figure 2 shows that 3.2% of farmers rely on social media for agricultural news. Also, during a focus group discussion those who use social media said that not only do they seek agriculture information on social media but also, they use it as an online market for their agricultural products. This finding indicates that although a small number of the farmers use social media as one of the online platforms still there is a need for a tool like a reliable online platform that can provide agriculture information to the majority of the farmers. The presence of a reliable online source through agriculture apps can help the majority of farmers to get agriculture information easily and hence farmers can fully utilize social media for accessing agriculture information. For instance, the study conducted in Kenya assesses the impact of social media on farmers and they recommend that agriculture information centres like agriculture online platforms need to be created so that farmers can fully utilize social media for accessing agriculture information⁽³³⁾. In addition to this, the research study conducted in 2015 suggested that it is important for an information system for agriculture to be built based on mass media like the internet and mobile apps⁽³⁴⁾. Furthermore, localization and the indigenous language of agriculturalists are matters to be linked to these systems. The findings indicated that there is a need for farmers to get appropriate information related to their crops and farming methods. More precisely, agricultural methods require timely, precise, and correct information to be delivered to farmers to facilitate

informed decisions on several issues such as the management of farm fields, implementation of improved systems of production, and seizing opportunities that exist in various markets^(5,13,35). Figure 2 portrays the Sources of Agriculture Information.

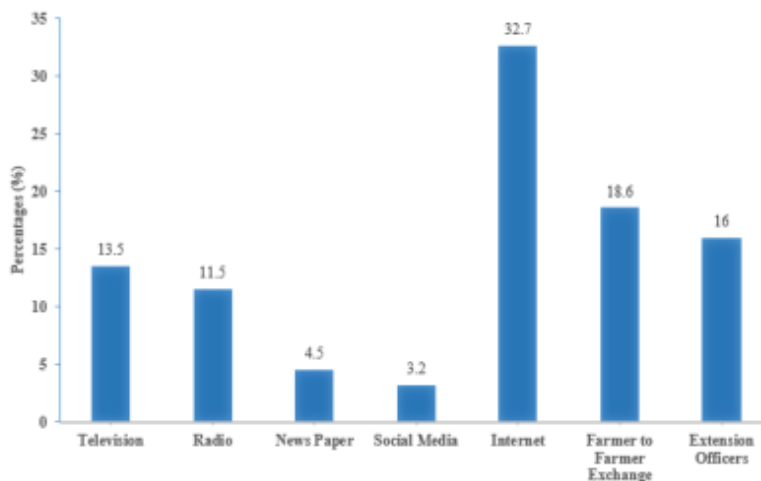


Fig 2. Sources of Agriculture Information

3.4 Views on Accessing Agricultural Information Online

In this section, all respondents were welcome to give their views on what they think about accessing agriculture information through an online platform. All respondents were allowed to answer more than one question in this section. About 80% of the respondents claim that they will prefer to retrieve agriculture information via an online platform while 75.6% responded that they will appreciate it if experts will develop agriculture mobile apps to help them access agriculture information. Such finding indicates that online platforms through agricultural mobile apps can be a strong tool for farmers to get access to agriculture information especially if such agriculture apps are availed online through an organized platform, farmers would use them frequently to ease the process of accessing agriculture information. For instance, a study conducted in Kenya reveals that the majority of farmers seek agriculture information through different online sources and therefore farmers need a tool that will help them to obtain agriculture information from online sources easily⁽³³⁾. This finding holds a different view from the study that shows that farmers were not bothered to use online sources to search for agriculture information they need. Instead, they were concerned about the price of fertilizers, insecticides, seeds, and transportation. Also, the study claim that farmers need accessibility and fair cost of fertilizers, seeds as well as irrigation⁽³⁶⁾. Table 2 shows different views on accessing agriculture information online.

Table 2. Views on Accessing Agriculture Information Online

Requirement	Types of replies	Respondents (n)	Percentage (%)
I search for various agriculture information via online sources	Yes	83	53.2
	No	73	46.8
	Total = 156		100%
I think I can retrieve agriculture information via an online platform	Yes	125	80.1
	No	31	19.9
	Total = 156		100%
I would appreciate having agriculture mobile apps for accessing agriculture information	Yes	118	75.6
	No	38	24.4
	Total = 156		100%

3.5 Views on Mobile Application Platform as a Solution

This study aims to enrich access to agriculture information through the mobile application platform. Respondents (farmers) were allowed to provide their opinion on this matter whereby more than 80% of the respondents agree that the mobile application platform would be a solution. This finding implies that farmers have a positive attitude towards this approach of using agriculture mobile apps. This is because the farmers need a tool that will facilitate access to agriculture information as well as provide information which is applicable or specific in their local environment context⁽³⁷⁾. For instance, a study conducted in Australia shows that farmers are eager to have an online platform that can ease access to agriculture information. In addition, the study indicates that Australian farmers have a positive attitude towards using agricultural apps because, they believe the platform will increase efficiency and help them make more informed decisions⁽¹³⁾. Furthermore, a study conducted in Indonesia about the use of the online platform through the mobile-based app to motivate farmers to share agriculture information online during the covid 19 pandemic, indicates that farmers are keen to have an online platform for them to share agriculture information especially during the lockdown as well as the marketing of agricultural products⁽³⁸⁾. Figure 3 below depicts the views on the online platform as a solution.

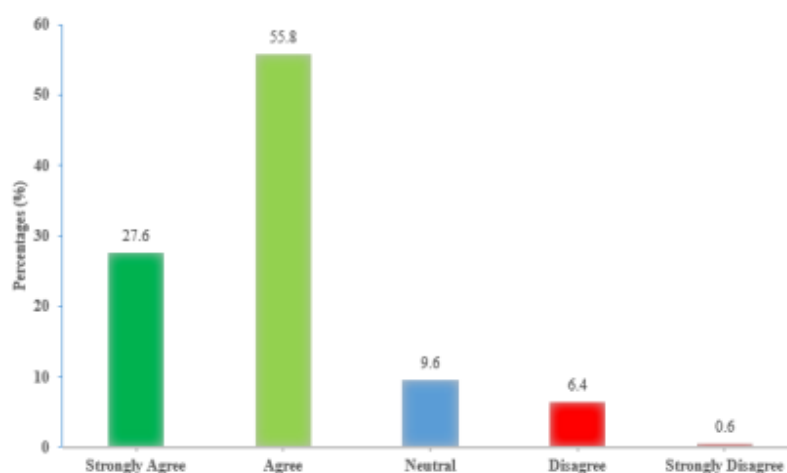


Fig 3. Views on the Online Platform as a Solution

4 Conclusion and Recommendation

This study concludes that the development of online platforms through mobile-based apps will be a strong tool that will provide a high possibility to improve the current agriculture information sharing process. Also, agricultural mobile-based apps have full potential to enrich access to agriculture information, this is because the majority of farmers 77.6% have smartphones and already 32.7% are currently using internet-based platforms to search for agricultural-based information.

Furthermore, it has been found that most farmers about 80% have a positive attitude towards the approach of using the online platform through agriculture mobile apps as a way forward towards enriching access to agriculture information. This is because farmers need agriculture information and some of them go further and seek such information through online sources like the internet, and social media so that they can fulfil their needs. Hence this study realizes that if experts develop a reliable online platform through agriculture apps, then the majority of the farmers will fully utilize such platforms for accessing agriculture information.

Therefore, due to the advancement of technology, this study realizes that it is essential for farmers to have agriculture apps as a major tool to facilitate the process of retrieving agriculture information. The online platform through mobile-based apps will be a tool of high benefit as a reliable source of agriculture information which is also cheap and convenient for the users of such platform.

Forthcoming research studies should concentrate on developing an online platform through agriculture apps so that farmers can use it to get immediate feedback from the information sources such as universities, research institutes, and extension officers hence enriching access to agriculture information.

Study Limitation

This study takes into consideration only individuals who were mentally fit and willing to share their views and opinion in this study. Moreover, the information has been collected within the Arusha region only which is located in northern Tanzania.

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OUTPUT 2: Poster Presentation



Application of Mobile Phone-Based System for Improved Crop Production Recommendation in Arusha, Tanzania

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Introduction

- The world population is projected to reach 9 billion by 2050, while sub-Saharan Africa will have 2 billion people by the same year.
- Currently, 80% of Tanzanians depend on agriculture for their livelihood. The current population growth must be accompanied by higher growth rates in food production and accessibility.
- Agriculture information such as soil type, soil characteristics, best methods of cultivating crops, weather predictions, best seeds, what to plant, when to plant, where to plant, and where to sell is considered very significant in the development of agriculture.
- Although agriculture has a significant contribution to society in terms of food and employment, ways of accessing agriculture information like soil characteristics continue to be a challenge to farmers.
- Some of the common methods used by farmers to access agricultural information are via radio, television, newspaper, extension officers and farmers exchange information to themselves.
- These methods are effective but comparatively user-unfriendly as farmers do not own them.
- The linkages between farmers, extension officers, and researchers need to be strengthened through the application of information technology to improve the current means of accessing agriculture information.

Problem Statement

- Despite the massive role of agriculture in food security, its growth in crop production in Tanzania is being threatened by various challenges including limited access to agricultural information like soil types, soil characteristics, what crop to plant in a specific soil type, when to plant and proper methods of cultivating those crops.
- In trying to eradicate those challenges through mobile technology this study focuses on developing a mobile phone-based application for improved crop production recommendation based on soil types.

Objectives

- To develop a mobile phone-based application for improved crop production recommendations based on soil types.
- To identify the proportion of farmers who use mobile phones for accessing internet services.

Proposed Solution

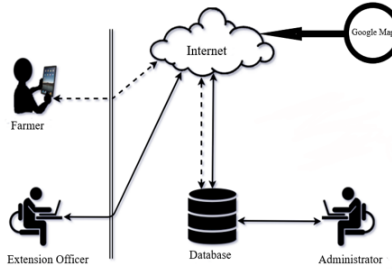


Figure 1. Proposed Solution

Research Findings

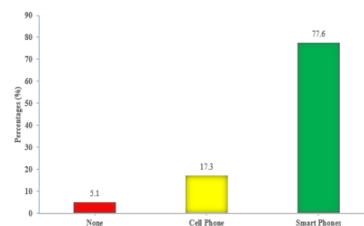


Figure 2. Mobile Possession Distribution

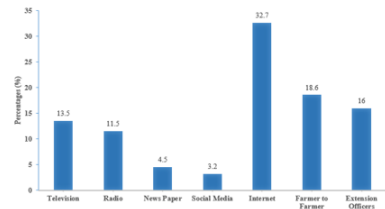


Figure 3. Sources of Agriculture Information

Developed System



Figure 4. The mobile app for crop recommendation

Conclusion

- This study concludes that agriculture apps have full potential to enriching access to agriculture information, this is because the majority of farmers 77.6% have smartphones and already 32.7% are currently using internet-based platforms to search for agriculture information.