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Development of horticulture extension support system for the small holder farmers: A case of Tanzania

Maginga, Theofrida Julius

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DEVELOPMENT OF HORTICULTURE EXTENSION SUPPORT SYSTEM FOR THE SMALL HOLDER FARMERS: A CASE OF TANZANIA

Theofrida Julius Maginga

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

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ABSTRACT

Horticulture as part of agricultural sector plays the role for food security, economic growth and nutrition improvement in developing countries. It draws attention for most governments as the main source of employment. Following the governments' recognition of agricultural extension as key facilitator for achieving high crop productivity and an enabler to knowledge resources, number of extension officers have been recruited to help farmers. However, these extension officers cannot reach every farmer due to lack of enough resources and cultural barriers. Consequently, uniform availability of clear information for vegetable cultivations, on crop requirements, climatic information, pests and diseases is a challenge. Meanwhile, there are number of extension support systems that do not meet all the requirements. On this study, a survey that included 145 small holder farmers and 30 agronomists from three regions located in three main horticultural zones in Tanzania was conducted. The data collected through questionnaires and interviews. The findings depicted that a significant number of farmers are not so familiar with ICT enabled horticulture extension support systems. The analysis results also indicated few technological systems that do not yet serve all the farmers. Therefore, in this study an ICT-enabled horticulture extension support system has been developed to help farmers make proper decisions on vegetable cropping systems. The application provides information such as best sowing period of the crop based on weather data in a particular location, crop harvest day, crop requirements, crop pests and disease. Accessibility of this information will help to improve vegetable crop productivity.

DECLARATION

I, Theofrida Julius Maginga do hereby decare to the Senate of The 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.

Theofrida Julius Maginga ____________ 22nd February, 2019

Name and Signature of Candidate Date

The above declaration is confirmed

Dr. Mussa Ally ____________ 22nd February, 2019

Name and Signature of Supervisor1 Date

Dr. Thibault Nordey ____________ 22nd February, 2019

Name and Signature of Supervisor2 Date

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CERTIFICATION

The undersigned certify that they have read and found the dissertation acceptable by the Nelson Mandela African Institution of Science and Technology.

Dr. Mussa Ally ____________________ 22nd February, 2019

Name and Signature of Supervisor1 Date

Dr. Thibault Nordey ____________________ 22nd February, 2019

Name and Signature of Supervisor 2 Date

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DEDICATION

I dedicate this dissertation to my parents Mr and Mrs Julius Maginga, and the whole family. You are my greatest inspiration and the reason why I am working so hard to reach my goals.

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LIST OF ABBREVIATIONS

CPU Central Processing Unit

CSS Cascading Style Sheets

FAO Food and Agriculture Organization

GDP Gross Domestic Product

GFRAS Global Forum for Rural Advisory Services

HTML Hypertext Markup Language

HTTP Hyper Text Transfer Protocol

ICT Information and Communication Technologies

JDK Java Development Kit

JRE Java Runtime Environment

NEA Netherlands Enterprise Agency

PHP Hypertext Preprocessor

SMS Short Message Service

SSL Secure Sockets Layer

TCP/IP Transmission Control Protocol/Internet Protocol

UI User Interface

URL Uniform Resource Locator

WHO World Health Organization

XAMPP Cross-Platform (X), Apache (A), MySQL (M), PHP (P) and Perl (P)

XML Extensible Markup Language

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Horticulture is the branch or part in the agriculture sector dealing with the science or an art of growing plants including fruits, flowers, vegetables and also cultivation of medicinal plants (Limbu, 2000).

According to Central Intelligence Agency (CIA) World Fact-book CIA (2018), agriculture is the predominant sector for wealth creation and poverty reduction in the United Republic of Tanzania, accounting for 23.4 % of national Gross Domestic Product (GDP). Similarly, it is a major source of employment for majority of population, and also provides 95% of food requirement in the country. In addition, the agriculture sector provides more than 50% of the industrial raw materials and 30% of the foreign currency through food production (LIC, 2014).

For the last decade, horticulture sub-sector of agriculture has excessively grown at an annual rate of 6 - 10 % supported by local and foreign investors. This makes it a significant part to food security, economic growth and nutrition improvement among many small holder farmers (Kinuthia *et al*., 2017). To serve the fast-growing demand and market opportunities available in the national, regional and international markets, the Horticultural Development Council of Tanzania (HODECT) and the resolutions of the National Horticulture Stakeholders Workshops of 2005, 2008 and 2010 demanded the need for the formulation of the National Horticultural Development Strategy 2012 - 2021 to demand-driven edge of the horticulture stakeholders (Council, 2012).

The available national strategy foresees facilitation of the development of horticultural industry so as to improve nutritional status, increase incomes, and reduce poverty while increasing productivity and quality of the products. The recent potential growth in horticulture exports has indicated the vast potential development in the Tanzania agricultural sector. Several notable strengths include well suitable soils, diverse climatic condition which is suitable for cultivation of a large range of horticultural crops, and great commitment from the government to support agricultural activities. There are also vast opportunities for major potential development of the industry together with increasing investment flows into agricultural activities. In East Africa, there is a rapid growth for export markets and increasing awareness of health and nutritional benefits of horticultural products (Council, 2012).

Meanwhile around the globe, in 2013 fruit production has been estimated to about 676.9 million tonnes increased as compared to 2012 were it was around 656.9 million tonnes. In other developed countries such as United States, Finland and China to mention a few also have a mechanism to help farmers for managing their crops through computer aided extension systems to maximize their output (Yan-E, 2011). According Food and Agriculture Organization (FAO) reports, weak extension support systems explained is the main reason for under productivity of cropping systems in developing countries (Qamar, 2005). In common given range, the production yield of vegetable crops like tomatoes can range between 40 - 100 t/ha depending on agro-ecological conditions and practices, but average tomato yields in sub Saharan countries (including Tanzania) are under 19.4 t/ha less than minimum production standard except for South Africa. In this given context there is a need for the country like Tanzania to adopt the use of ICT enabled extension system of which it will help farmers to enter into the foreign or international markets.

Moreover, technology advancement has played a vital role in the development of agricultural industry. Nowadays, it is even possible to cultivate crops using agricultural biotechnology in desert areas as with the technology plants are able to survive in a drought condition. Crops have been made able to resist droughts and pests from the genetic engineering concepts of technology. Despite the slow adaption to technology, farmers have been able to use modern machines, acquire modern transportation, cooling facilities for delivering crops such as tomatoes, and improved irrigation systems (Ramey, 2012). Due to this rapid agricultural growth, technological changes and needs are inevitable in agriculture. Modern science and technology deployment help small holder farmers to broadly participate in the whole farming process and activities, thereby strengthening decision making and opening opportunities for exploitation (Kader, 2013).

1.2 Problem Statement and Justification of the study

The horticultural sub-sector of agriculture has transpired in the production, harvesting, and postharvest handling practices over the last several decades (Mushobozi, 2010).

The lack of proper flow of information from the agronomists to the small holder farmers on when to start cultivating based on weather condition in their particular location is one of the challenges (Piperno *et al.*, 2000), including awareness on what fertilizers to use, best farming practices, accurate data on possible pests and disease for particular species they want to cultivate are the major problems to small holder farmers (Swinnen *et al.*, 2013).

However, production and cultivation information need to be easily accessed and shared so as to improve the horticulture activities (GFRAS, 2017).

Nevertheless, availability of agricultural information will result to high quality products, expand market and from adoption of improved technology. The industry will be able to acquire improved nutrients (fertilizer), pest management and recognition of market requirements (Focken *et al*., 2004). The use of technology will also provide great assistance on the flow of information from the agronomists to the small holder farmers through extension officers (Council, 2012). Therefore, this research has focused on developing an ICT- enabled extension support system to help small holder farmers acquire accurate information.

1.3 Research Objectives

1.3.1 General Objective

The main objective of the research was to develop a horticulture extension support system for small holder farmers in Tanzania, that is going to help extension officers easily disseminate clear and timely information to the farmers for cultivation of vegetable crops.

1.3.2 Specific objectives

(i) To analyze the strengths and weaknesses of existing extension support tools used by small holder farmers in Tanzania.

(ii) To develop the horticulture extension support system (web and mobile application) for smallholder farmers.

(iii) To validate the developed horticulture extension support system.

1.4 Research Questions

(i) What are the strengths and weakenesses of the existing extension support tools for small holder farmers in Tanzania?

(ii) What are the development requirements for smallholder farmers' web and mobile horticulture extension support systems?

(iii) What are the validating processes for the developed horticulture extension support system?

1.5 Significance of the study

(i) The significance of this study is to help small holder farmers manage properly their vegetable cropping systems.

(ii) This study is going to provide a solution to small holder farmers for growth and expansion in cultivating vegetable crops together with adapting the cultivation of highly nutritious crops through the usage of an extension support tool.

(iii) The developed horticulture extension support system is going to help agricultural stakeholders to identify most favorable climatic periods, suitable crop rotations, crop associations, and acquire information on suitable cultural practices based on organic fertilization, irrigation, and also pests and diseases.

(iv) The study will help farmers for vegetable crops to make clear decision about when is the best period for cultivating vegetable crops based on particular locations' weather data.

(v) The study is going to assist extension officers on providing education to the small holder farmers through the use of technology.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

On this chapter we review major parts of the study including the practice of horticulture activities in developing countries, extension support systems and other related research works.

2.2 Horticulture in Developing Countries

Horticulture is a potential sector in the agricultural field. Despite the fact that agriculture crops supply varieties of human major requirements such as protein and carbohydrate, with no horticultural crops many of the dish cuisines would not be sufficient in regards to vitamins and mineral provided by fruits and vegetables. Horticultural crop products are the great sources for the vitamins and minerals in human bodies. Some of the vegetables like green leafy vegetables, yellow-fleshed fruit like mangoes and pumpkins are vital foods to be recommended for Vitamin A deficiency, which is a critical cause for blindness. International organizations Food and Agriculture Organization (FAO) and (WHO) World Health Organization, have reported that eating fresh fruits and vegetables on a daily basis will help to fight against the micronutrient deficiencies problems, and also it helps on the prevention of chronic diseases associated with unhealthy diet lifestyles (Swilling *et al.*, 2011).

In many developing countries, the whole field of agriculture is given attention in many of the schools but leaves behind the major part of horticulture or with only few picked crops for attention. In countries like Kenya, horticulture has grown efficiently and resulted into food crops exports and opportunities for employment. The development has expanded to various educational institutions, and has led to the establishment of the horticulture departments in universities (Kairuki, 2015).

In Africa where population is growing too fast than any other continent in the world, by the year of 2030 the number may reach up to 986 million, where citizens of the continent will require about 74 million jobs to be created. Horticulture subsector itself generates employment as the key factor to reduce poverty in developing countries and also creates urban green belts and recycle urban waste to productive resource (Swilling *et al.*, 2011).

Meanwhile, in the whole of Africa where agriculture is practiced in traditional ways by most of the small holder's farmers, this agricultural type is comprised with many challenges such as low yielding production, it is rain fed and lacks access to timely and critical information for market facilitation (Jones *et al*., 2011). On such challenges if ICT gets to be embedded in, stakeholder systems may help to bring growth and economic development and also bridge the knowledge gaps for better agricultural practices. Currently there is massive ownership of personal ICT devices such as mobile phones and Tablets among different individual of which it has brought an advantage to the application developers and meanwhile mobile technology is highly adopted as the number one choice of technology for delivering ICT solutions (WorldBank, 2012).

2.3 Extension Support Systems

The extension support system concept talks of scientific techniques that include new knowledge practices for education provision to farmers. In agriculture perspective, it encompasses communication and training activities organized for people in the rural areas from different disciplines of agriculture so as to facilitate interaction and foster collaborations within information system, which includes agricultural research, agricultural education and information provision (Swinnen *et al*., 2013).

Globally, extension support system is a recognized factor for enhancing agriculture sector. Developing countries, donors such as World Bank and other foundations like Bill and Melinda Gates Foundation have been giving priority on the support for improving agriculture, extension support systems and agricultural innovation systems (Moore, 2017).

In Tanzania, agricultural extension services fall under the responsibility of the government, specifically under the Ministry of Agriculture. The services are geographically dispersed provided by the Village Extension Workers. The system is typical conducted in a bureaucratic manner within the Ministry of Agriculture. Services of agricultural extension are administered by the Assistant Commissioner for Extension Services (ACES), who works with a team of Subject Matter Specialists (SMSs) in various disciplines including irrigation, land use planning, plant protection, Agro-mechanization, agronomy, horticulture pasture improvement, veterinary services and marketing.

The whole structure and the team is not adequate enough to reach every farmer on time and thus result to overwhelming division of works among extension officers. Every extension officer is required to have direct contact and being responsible with an average of about 2 villages of 1000 farm families, which means an extension officer cannot work as perfect as they are supposed to with every farmer. The problem is also amplified by other barriers such as transport and other limitations related to cultural point of view where women are denied accessibility to fully extension services. From that fact, the focus tend to deviate from all farmers to male farmers (Kairuki, 2015).

With regards to the access of information, expansion of networks, and use of low-cost ICTs to improve timely access to precise and reliable information, Information and communication technologies (e-mail, internet, phone, radio, TV, print) are still underutilized in the implementations of extension strategies. In Tanzania, level of ICT utilization is low comparing to the country's potential resources. Many agricultural extension experts have realized that an information technology revolution is unfolding, with remarkable and largely unrealized potential for rural development. Many of the ICT tools that are commonly used in other countries around the world are now found in Tanzania. The use of technology could play a key role in extension services provisions and information delivery. Although ICTs may counterpart other extension and the available knowledge services, there is a potential need to know how farmers currently gain access to the required information. The government of Tanzania may need to find the necessity of designing and support the policy environment with an integration of programs that make use of the right contents of technological tools available for agricultural extension service delivery (GFRAS, 2017).

2.4 Other Related Works

The study conducted by Ngowi (2015) had the objective to deliver a working prototype that will support agricultural stakeholder to have better flow of information. This was based on the fact that information and communication technologies adaptation have the major potential output to help on empowering rural society for better sustainable agricultural practices. The study came up with an integrated web-based system to help small holder farmers getting information on the market channels for crops. It allows farmers to upload the pictures for their crops to easily market their crop products and to bridge the gap between farmers and vendor.

According to Sanga (2018) the solution that has been implemented by other researchers for the agricultural practices in Tanzania is the Agro-Advisory platform widely known as UshauriKilimo. The platform is an integrated system that has web based advisory information system. It gives farmers access to advices in different agriculture issues like agronomic practices, livestock husbandry, and other agricultural related information related to marketing information by sending any question through an SMS and get a response from an agricultural expert.

Tigo Tanzania has also introduced a solution for small holder farmers, which is called mobile Tanzania farming app. The greatest aim of this application is to help farmers get up to date market information on how a farmer can get connected to the crop buyers which in turn helps farmers to make better marketing decisions (TanzaniaInvest, 2014).

Other existing information systems for helping small holder farmers are farmer connect and Kilimo Salama. On the farmer connect application, agencies help farmers to tackle various challenges that are faced in their day to day agricultural practices, and also give farmers weather forecast information. The platform is integrated with other portals to get accurate information on the policies for agricultural practices (FarmerConnect, 2012). While not diverging much from the farmer connect platform's concept, Kilimo Salama platform enables small holder farmers dealing with maize and wheat cultivation to receive insurance for their farm against drought and too much rain. With information integrated from the weather stations, the information acquired helps to calculate rainfall formula and in the end the payout to farmers is obtained. The platform enables farmers to get knowledge on the best period based on weather condition to cultivate their products and thus results to sufficient growth of crops (KilimoSalama, 2015).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

This chapter provides explanations on the materials and methods used for conducting this research. The research study area, methods used for data collection, architectural designs, the functional and non-functional requirements together with the technology that has been used to implement the developed horticulture extension support system. Moreover, the chapter explains on the development of the mobile and web-based applications for the horticulture extension support system to small holder farmers.

3.2 Research Study Area

This study has been conducted in the United Republic of Tanzania. While the country endows almost 44 million hectares suitable for agriculture, only 14 million is cultivated, according to Agricultural Sector Development Strategy. This is due to the fact that some of the areas have low soil fertility, land degradation, and drought. Until recently, agriculture in Tanzania has been based more on land expansion for cultivation rather than focusing on high productivity.

The study area was selected based on the horticultural productivity on the areas to help on answering the research question, '*What are the strengths and weakenesses of the existing extension support tools for small holder farmers in Tanzania?'* that was based on the first objective of the study. The study focused on different areas, which include Mwanza, Morogoro and Arusha regions in Tanzania. These regions are located in the zones considered as the most horticultural production areas. The zones include Northern Zone (Kilimanjaro, Tanga, Manyara and Arusha), Coastal Zone (Dar es salaam, Coast and Morogoro) and Lake zone (Mwanza); other zones include central zone, Zanzibar, and southern highlands as shown on Fig. 1. The selected areas as the case study contributed on acquiring the needs and requirements for developing horticulture extension support system.

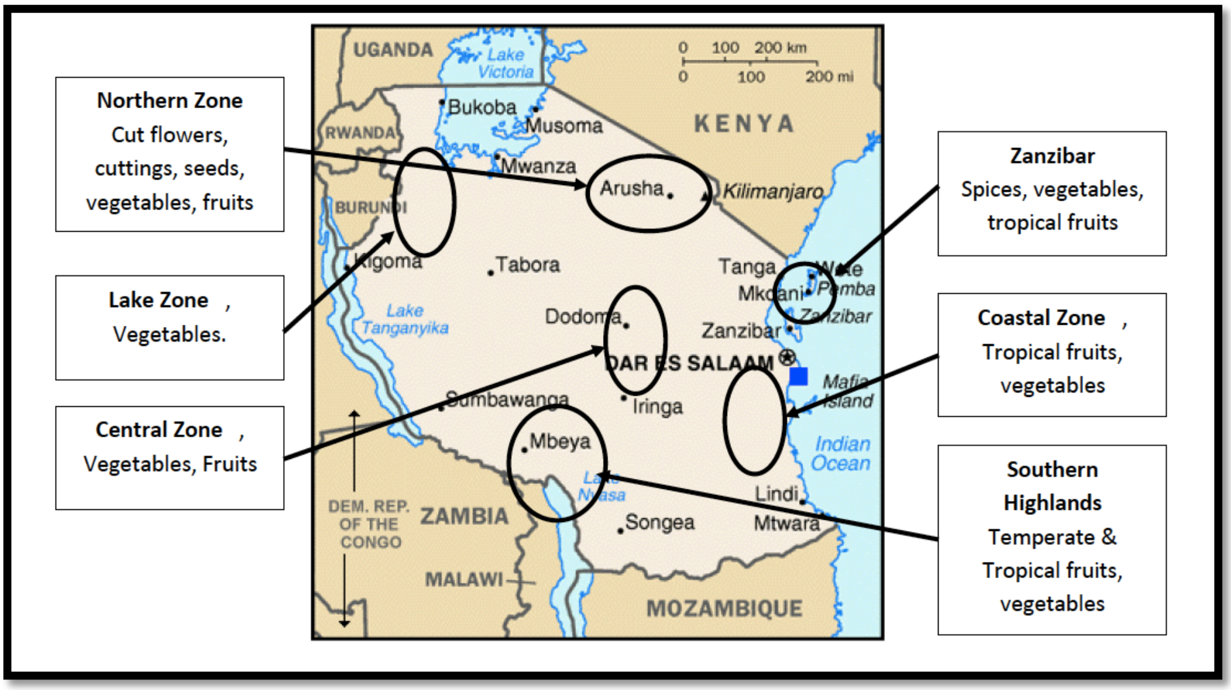

Figure 1: Tanzania map indicating main horticultural zone areas (NEA, 2015)

3.2.1 Sample size and sampling technique

The sample size for the study included extension officers, farmers and agronomists/agricultural experts. Farmers growing vegetable crops and extension officers were 145 people in total responding to the same kind of questions, and agronomists/agricultural experts were 30 in number responding to a different set of questions. Simple random sampling technique was used to select respondents so as to give equal chance to participate in the study and respond on inquiries on the needs for the developing a horticulture extension support system.

3.2.2 Data collection methods

Data collection on this study was conducted from the end of December, year 2017 up to mid-march, year 2018. For the specified period of time, the study employed interview, questionnaire, and observation as the techniques for data collection.

(i) Interview: Structured interviews with interview guide questions involved few extension officers/agricultural experts. The main focus of this method was to understand various ways that are used for horticulture extension support systems in the identified areas, their respective weaknesses, and to understand various ways that are used to provide the right information to farmers.

(ii) Questionnaires: This method gave opportunity for farmers to provide feedback on their experience for horticulture extension support systems anonymously as recommended by (Cohen *et al*., 2014). Self-administered questionnaires were provided to the farmers and to some of the extension officers to obtain their responses on various matters such as the use of technological devices to access information, types of vegetable crops that farmers are engaged with, and whether they think there are benefits associated with the use of technology for horticulture extension support systems.

(iii) Observations: This method was applied throughout the field works in the farms. The aim was to learn the applicability of the horticulture extension support systems and the requirements for cultivating various vegetable crops.

3.2.3 Data analysis methods

Both qualitative and quantitative data were obtained during the study through the interview, questionnaires, and observations conducted. Data were analyzed using Tableau tool.

3.3 Architectural Design

On the previous section of this chapter, the discussed parts were research study area, sample size and data collection techniques. On this section the study represents the requirements that were outlined for the development of horticulture extension support systems for the small holder farmers.

3.4 Requirement Analysis

The requirement specifications for the software development involved functional and non-functional requirements. The collected data from the above-mentioned methodologies, were stipulated to obtain functional and non-functional requirements. Functional requirements captured the intended behavior of the system to perform the following functions which depends on the user's level and permission package,

3.4.1 Functional requirements

(i) Sign Up

This function allow user such as an agronomist to register their details in the web/mobile application so that they can gain an authorized access to the system, the information provided by the user in the sign-up form is stored in the users table within the database.

(ii) Login

This feature of the system allows a user to gain access to the application by providing their credentials, which are username and password. After authentication, the user gets access to main menu. Menu functions are varied depending on user's level and permission package.

(iii) View/Delete/Edit (Agronomist User)

This feature of the system allows the agronomist user to add information in the system such as weather data, crops, crops requirements, pests, and diseases. The interface gives user the appropriate links for uploading data to the database named crop_tool. After uploading the data user gets access to query the uploaded information and view them in table forms or graphical format. User also gets access to delete unrequired data from the database.

(iv) View (Normal User)

Normal user can be an extension officer who gains access to data that have been stored in the database by the agronomist. The data includes weather data, types of crops and their requirements, and also list of pests and diseases. User can also request dynamic data from the database.

(v) Search

This function allows users to perform search on weather data stations and on the forum page. User types the name of the location in the textbox to get easy access on the weather information in a particular location or can input data on the forum to get easy access of information on the forum. In both cases, the entry is searched as a case insensitive substring.

3.4.2 Non-Functional requirements

(i) Reliability Requirements

The system developed operates under reliable environment, with automatic backup and recovery features. Back up on the database information is frequently being performed.

(ii) Availability Requirements

The system developed is available, hosted to be accessed all over the internet under a given URL throughout the year, except for the maintenance period. In case of maintenance, users will be notified on the unavailability in advance.

(iii) Security Requirements

The system developed is accessible at each level only to the specified and authenticated users. System includes the sessions to ensure security on the users with high privilege. The system ends an open session automatically when it is not used for a specific period of time. Network communications uses SSL cryptographic protocols.

3.5 Architectural System Design

The proposed design of the horticulture extension support system has been divided into three major sub- systems: server application, client application and the database.

The server application's major design considerations included easy crop requirements data retrieval, easy database updates, multiple clients support, and a minimal set of administrative features. The server application has been designed to be as flexible as possible. Given the project's constraints of human resources, software resources, and time, the server is not completely "data independent".

The client application is designed to support the following major features: a simple graphical user interface for data retrieval, easy to understand dialogs, flexible dialog structure support, and support of an internet transport for agricultural practices information retrieval. Unlike the server application, the client application has been designed completely data independent. No portion of the client application is implementation dependent (excluding dialog database access). This provides maximal flexibility for other potential uses for the client application.

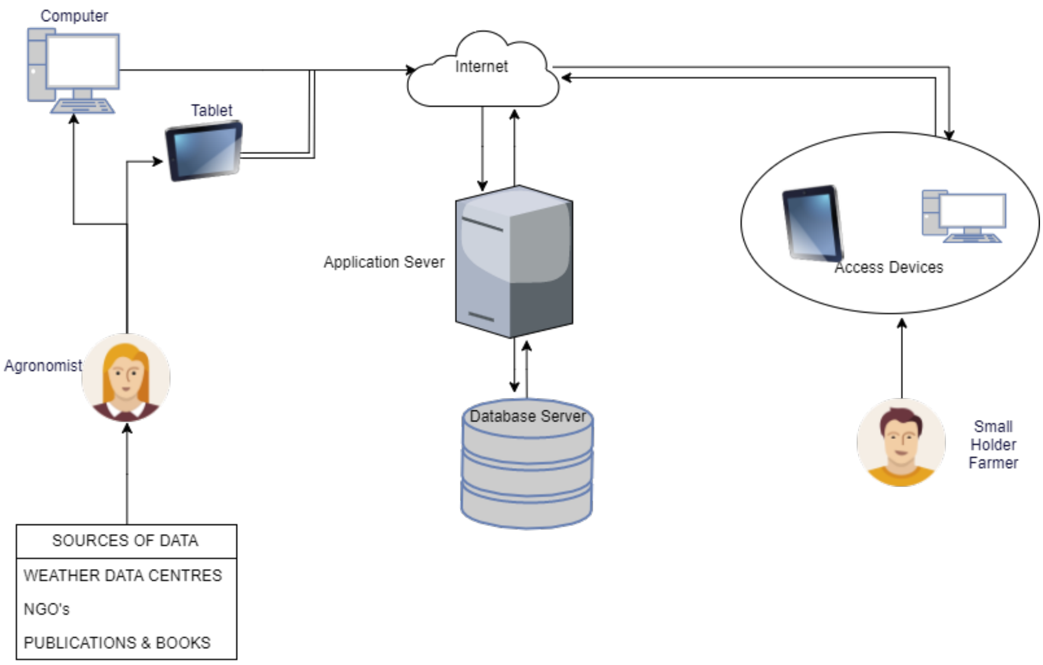

Figure 2: Conceptual framework for Extension support system

The developed horticulture extension support system as the source of all the cultivating information for vegetable growers has been conceptually modeled, where all the information is coming from the right sources such as books and different articles being organized by the agronomist. An agronomist as an authenticated user is responsible to provide the information through the platform and help the farmer to easily choose the type of crops and its required information. The extension officer may also be able to acquire those data and disseminate it to farmers. Fig. 2 shows the conceptual framework for the horticulture extension support system.

3.5.1 Subsystem Architecture

The following are the key major functions of the software:

(i) Providing information to users on average weather data (temperature and precipitation) for various weather stations in Tanzania

(ii) The system provides information on about seven vegetable crops and their requirements for proper cultivation procedures.

(iii) The system provides the information on possible effects and diseases that may affect the specified vegetable crops.

(iv) The system gives users information on the proper period of time to start cultivating and the expected time to harvest.

(v) The system added feature is to provide a forum for farmers to ask questions and get responses from authenticated agronomists/agricultural experts.

(a) Dataflow Model

The subsystem architecture of the developed system provides a diagram that illustrates the data flow in the system and the number of processes that are related to the flow of data. The software developed has been named as agrotool as used on the context diagram below.

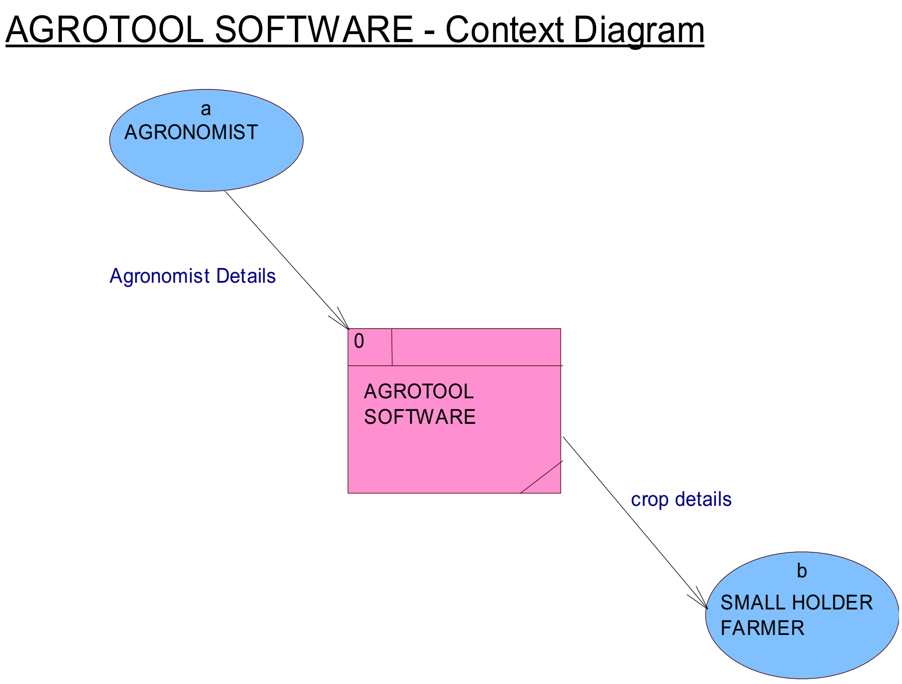

Figure 3: Agrotool context diagram

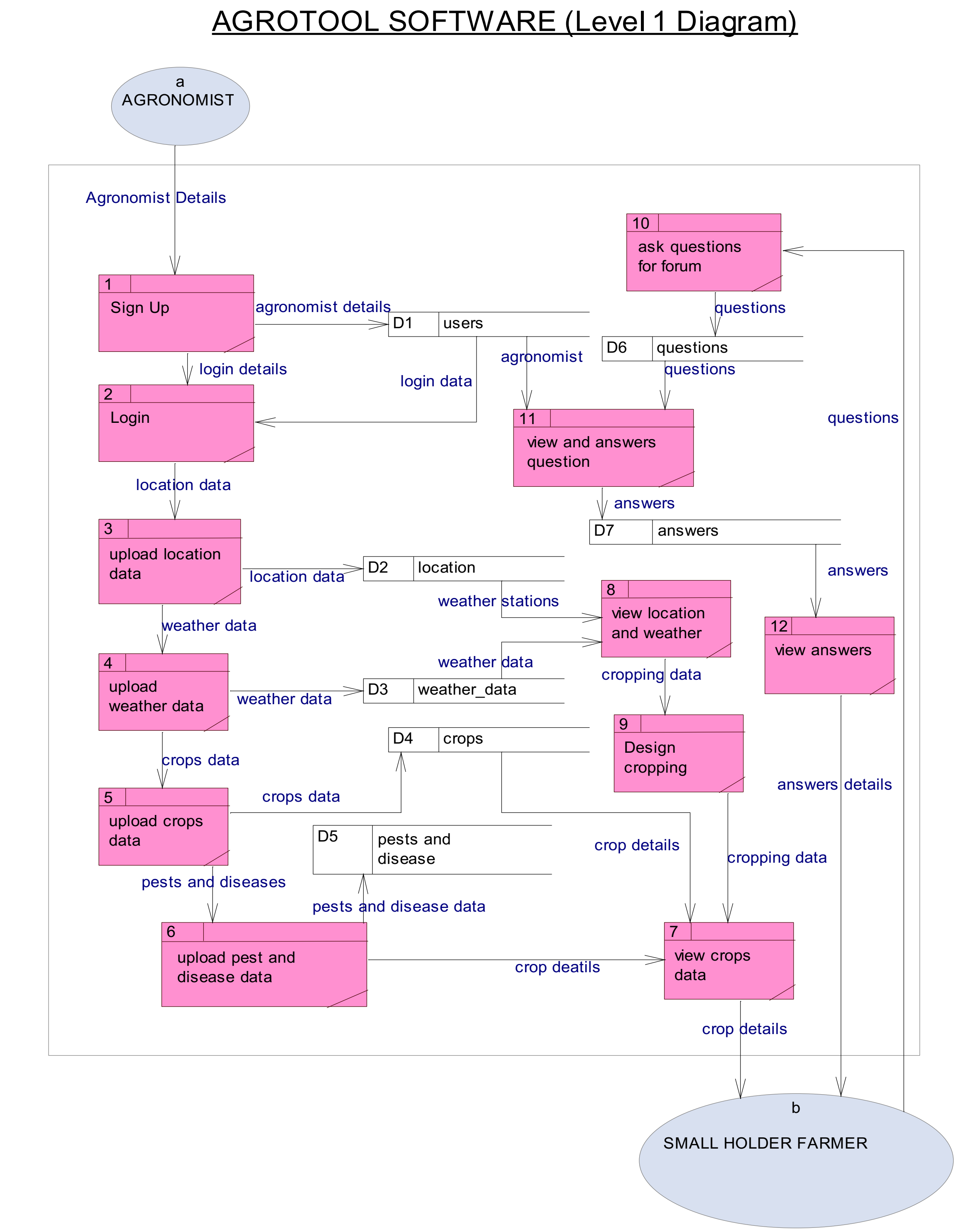

Figure 4 : Agrotool Level 1 Diagram

(b) Database Schema

The following is the schema for the database, which was named “crop_tool”.

Tables

The database comprises of 8 tables. Fig. 5 shows the list of all tables included in the database with their respective attributes.

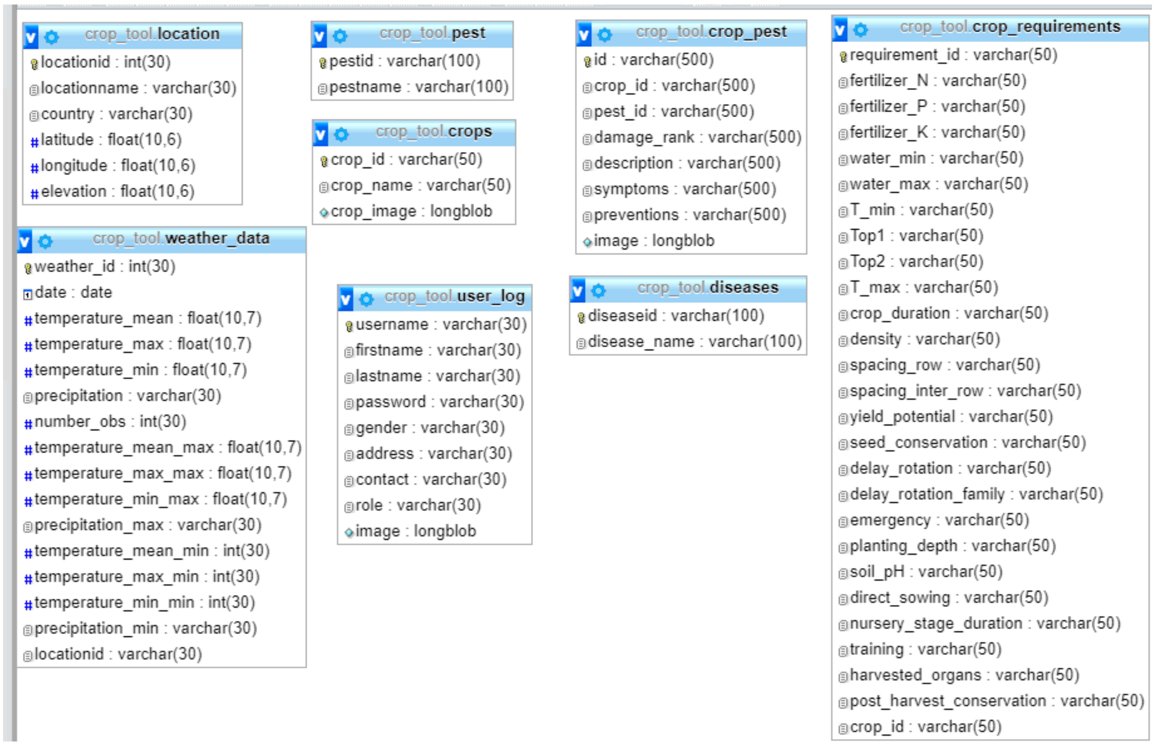

Figure 5: Database Schema

(c) Entity Relationship Model

The relationship mode for the database is shown in the entity relationship on Fig. 6.

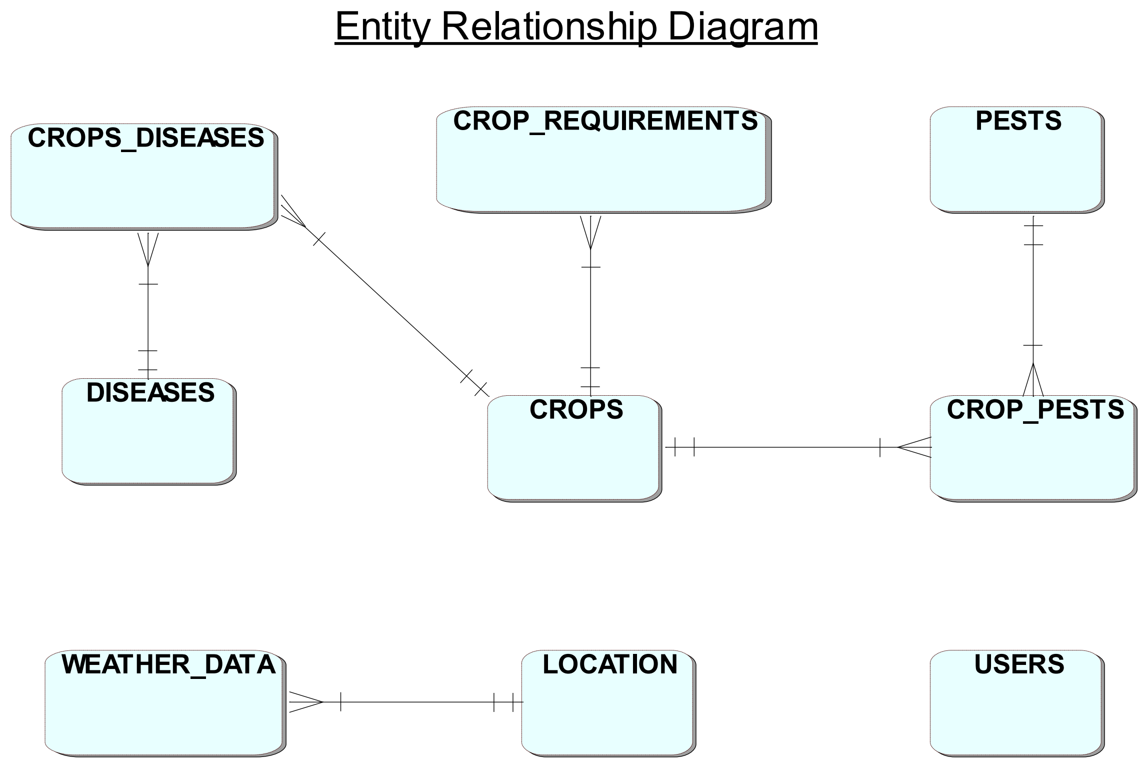

Figure 6: Entity Relationship Diagram

3.5.2 System interfaces

(i) User Interfaces

The user interface for the software is a Graphical User Interface that includes the web pages designed with HTML, CSS and JavaScript languages for the graphical output of the system, and for the mobile application the JAVA and XML languages have been used. A User is able to interact with the system by using the links provided for the web application or acquiring the android based mobile application.

(ii) Hardware Interfaces and Software Interfaces

The developed software product does not require any additional software or hardware interface to function for the intended users. On development part, the hardware required was full functioning computer machine with installed XAMPP, Notepad++ and Android Studio software, which were all open source software. To run the developed mobile application, an android mobile phone was used as the hardware part of the requirements needed.

(iii) Communications Interfaces

The system required HTTP to communicate with the server. The system was configured to be accessed via any available open port such as a default port. The web-based UI is the only means of communication between the user and the system. The system has been programmed to be accessible through a web browser that interacts with PHP and HTML pages.

3.6 Development of Web and Mobile Based Extension Support System

On this section the development process is explained from the assumption made to the methodology used and the programming languages used. Furthermore, on this very specific section of the chapter functions are highly described, including use case diagram illustrating how system actors interrelate on the developed application.

3.6.1 Assumptions and Dependencies

The development of the horticulture extension support system was based on several assumptions for the software and hardware features. Both the server and client applications make the following assumptions about their environments:

(i) The server application has an assumption that, system for running an application will have the required resources available, as it is necessary. This entails to sufficient memory and permanent storage space, an adequate Central Processing Unit (CPU) for the necessary application, and a TCP/IP network connection.

(ii) The client machine will have web browser installed in the machine running, WINDOWS/MACOS/LINUX for the web application, and android operating system for the mobile application users.

(iii) The client machine will have an appropriate net card installed. This is necessary for connecting the machine to the internet.

(iv) Users, especially the extension officers, have a good knowledge on the use of internet and interaction with computers or smart phones.

3.6.2 Use Case Model

On this study the use case model/diagram gives a narrative description on the behavior of the system on its high level of abstraction.

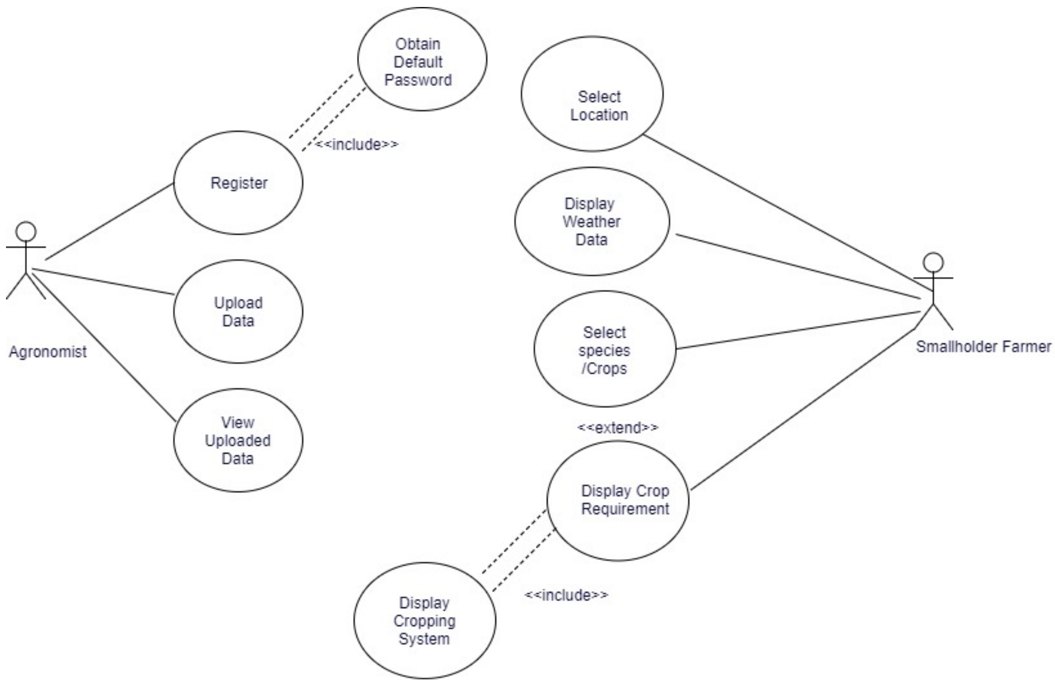

Figure 7: Use Case Diagram for actors of the system

3.6.3 User Classes and Characteristics

There are three types of users on the system.

(i) Agronomist

The first user is an agronomist, given an authorized privilege to gain access to the system. This user is able to upload different types of information such as weather data, requirement of the crops, and any other required information.

(ii) Smallholder Farmer/Extension Officer

The other user class on this system comprises of small holder farmers, extension officers any other person that will be interested on gaining access to the system and access information about vegetable cropping systems. These users can be able to query the information about weather data, types of crops and their requirements, rotation and cropping system, and also pests and diseases information.

(iv) Administrator

The final user is the system administrator who gets higher privileges than other users on the system. An administrator of the system can have the privileges that all users have in the system and is also able to grant some of the privileges other users.

Table 1: User roles and system functionalities

S/N	USER	ROLE
1.	**Administrator**	Input and delete user
		Upload location, weather data, crops and its requirements.
		Upload pests and diseases data
		Edit location data, weather data, pests and diseases data, Crop Requirements Data
		View weather data, location data
		View diseases and pests, user profiles, crops and its requirements.
		View all the crops
		View crop requirements
2.	**Agronomist**	Upload location, weather data, crops and it's requirements
		Upload pests and diseases data
		Edit location data, weather data, pests and disease data
		View weather data, location, crops and its requirements.
		View diseases and pests
3.	**Normal User (Extension Officer /Smallholder Farmer)**	View weather data, pests - diseases data and location data.
		View all the crops and their requirements
		View the crop recommendation procedures
		View the designed cropping system for the selected crops
		View the recommended rotation feature for the crops

3.6.4 System Design Methodology

The developed system was designed based on user requirements comprising of the information stored on the database. These stored data can be retrieved by the agronomists, an extension officer, small holder farmer, or any other agricultural stakeholders.

Agile methodology was used for the software development. This is a software development model that allows developers to build a prototype and demonstrate its functionalities to the user and make refinements according to users' feedback (Connolly, 2002). User interface prototype was useful because it formed means of visualizing how the proposed would look like, and also the system's functionalities to the potential users. This model has been vital for producing fast reliable and efficient system. It allows system end users to be involved in the design and development process by conducting certain activities of testing and evaluation of the working prototype.

PROTOTYPE LIFE CYCLE

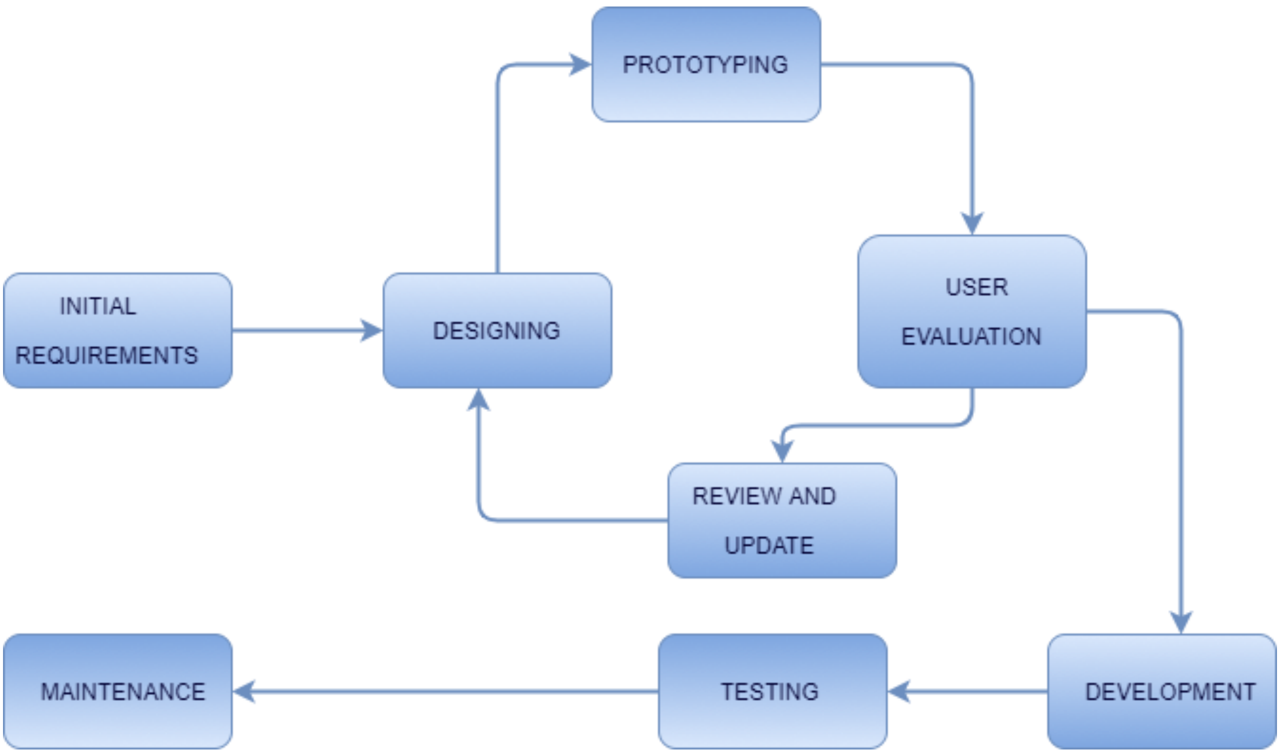

Figure 8: Agile system development lifecycle

3.7 Technologies used (web and mobile application)

Programming languages used for the web application development were HTML, CSS, JAVASCRIPT, PHP; and MySQL for database designing. Database was designed by using MySQL, PHP was the main language communicating with the server side (back end designing). Front end designing of the web application used HTML, CSS and JAVASCRIPT languages for user interaction with the system.

Programming Languages used for mobile application were JAVA and XML. The development of mobile application was acquired from the webview function. This is JAVA predefined function that integrated the web application to the mobile application through the use of Universal Resource Allocator system.

Platforms used for the programming of the applications (web and mobile) were:

(i) Android Studio comprised with JRE and JDK components
(ii) XAMPP and a mobile phone with android operating system
(iii) Notepad++
(iv) Web browser
(v) Computer with windows operating system and Internet connection
(vi) Filezilla for accessing and hosting the application online.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the results acquired from analysis of the data collected from the farmers, agronomists, and extension officers. The analysis of collected requirement based on understanding the use of technological system for managing vegetable cropping system and the available extension support systems. Moreover, the chapter has presented the development of the mobile and web-based application that helps farmers to manage their vegetable cropping system.

4.2 Research Case Study Area Results and Discussion

On the identified case study area, a survey was done to understand the use of information and communication technology devices for extension support systems available to small holder farmers. The survey also intended to find the number of farmers who engage their vegetable cropping activities with the use information and communication technology system through extension services. The survey comprised of the following criteria: gender, education backgrounds, types of vegetables grown on a particular area, use of technological devices, and whether or not the technological systems should be involved on vegetable cropping systems. Tableau platform was used for data analysis due to its powerful feature of presenting the data, it gives the best visual analytics of data that makes easier to interpret data. The results obtained from the survey were analyzed, and are presented as follows:

4.2.1 Education Background

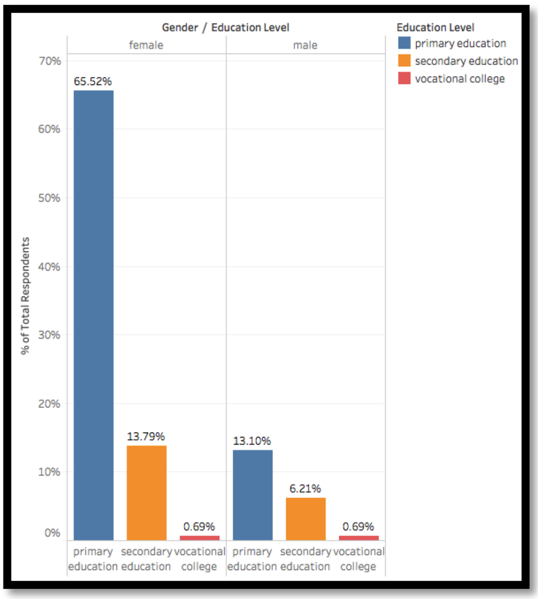

Figure 9: Educational background for female and male small holder farmers (survey for small

holder farmers and extension officers, 2018)

The results obtained on Fig. 9 shows that 79.73% of 145 farmers engaged with vegetable crop production are female farmers. Out of all respondents 65.52% are female farmers with primary education level. Male respondents make a total of 20.27%. The large number of female farmers being engaged with vegetable cropping could more productive if these women were to be exposed on access to information. Based on the fact that women are not highly favored when it comes to extension services there is a need for them to be empowered and be given high priority on knowledge-based resources. Furthermore, Pinthukas (2015) argues that education level and trainings provided to the farmers have very huge impact on enhancing knowledge on farming and vegetable crops production.

4.2.2 Vegetable crops production

Each farmer responded to the types of the vegetable crops that they are dealing with. Most farmers were found to cultivate more than one type of vegetable crops. The consideration was on a major crop being cultivated by the particular farmer, and results were obtained as shown on Fig.10.

	Products Engaged in cultivation of vegetables											
Education Level	african egg plant	amarant..	cabbage	carrot	cucumber	eggplant	french beans	lettuce	okra	spinach	sweet pepper	tomato
primary education	3.45%	6.21%	11.72%	12.41%	6.90%	11.72%	3.45%	0.69%	1.38%	2.76%	6.90%	11.03%
secondary education			0.69%	1.38%	1.38%	3.45%	1.38%	3.45%			4.14%	4.14%
vocational college							0.69%	0.69%				

Figure 10: Types of vegetable crops cultivation with education background among small holder farmers (survey for small holder farmers and extension officers, 2018)

The results shown on Fig. 10 interprets that there are diversified types of vegetables being cultivated, but still few of them are cultivated more than others. It can be observed that tomato is cultivated by 15.17%, eggplant by 15.17%, carrot by 13.79%, cabbage 12.4% seem to be crops that are cultivated with farmers from all the education background. For the cases of crops such as French beans and lettuce are barely cultivated all farmers as far as the education background is concerned.

4.2.3 Use of Technology Devices

The targeted technological devices in use by farmers included smart phones or any other related device for communication purposes. This part of the survey helped to understand the level of farmers engagement on the use technological devices. The following are the results of the responds with regards on the use of technology.

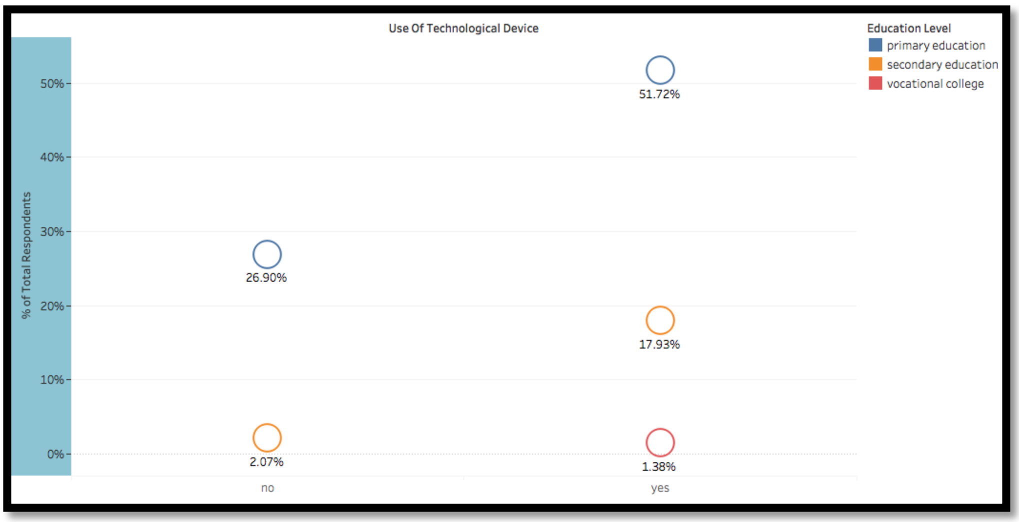

Figure 11: Use of technological devices for small holder farmers in relation to education background (survey for small holder farmers and extension officers, 2018)

The possession of technological devices was analyzed against education backgrounds of the respondents as seen in Fig. 11, in order to establish relations between the two. The results imply that education level has impact on the use of technological devices for small holder farmers. Meanwhile, a large percent, which is about 71.03% out of 145 respondents are using technological devices. However, 26.90% out of 28.90% of the respondents are farmers with primary education level who are not using technological device, but this does not setback any proposed technological solution for the farmers since the extension officers are educated and a large number of them can interact with technological devices.

4.2.4 Benefits for small scale farmers to use technological systems

This part interprets how respondents think of the use technological horticulture extension support system to be proposed for managing their vegetable cropping system. The results on Fig. 12 shows different opinions of respondents, who either agree or disagree to the idea of using technological solution for managing their vegetable cropping systems.

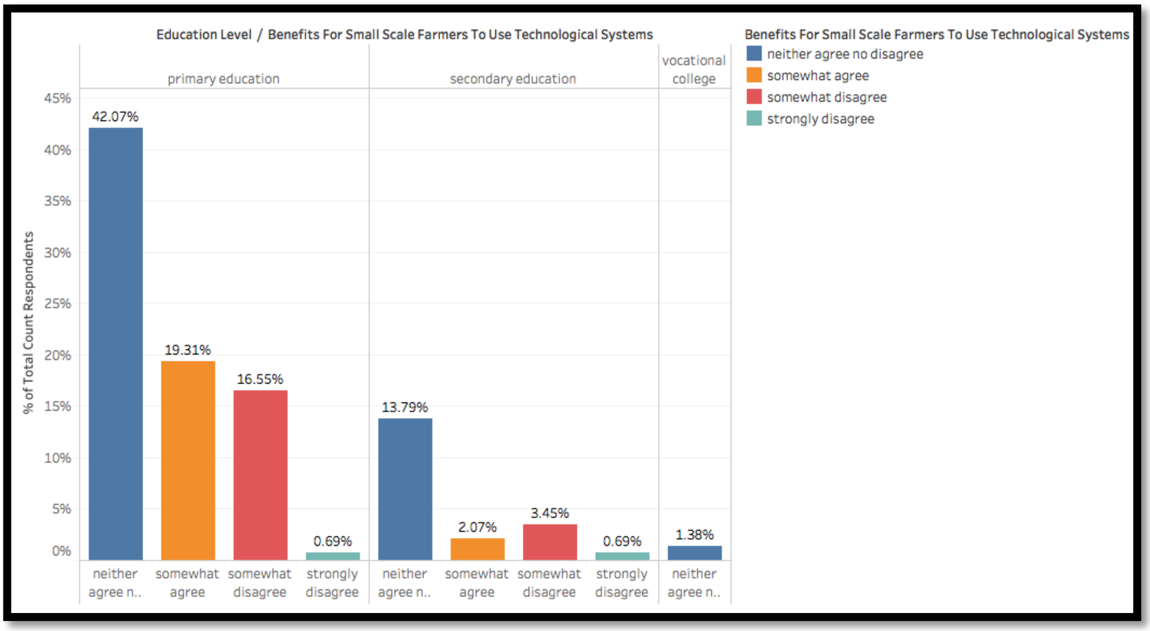

Figure 12: Opinions on use of technological devices for small holder farmers in relation to educational level (survey for small holder farmers and extension officers, 2018)

The results on Fig. 12 shows that about 57.24% of out of 145 respondents neither agree nor disagree that there will benefits on the use of technological systems for small scale farmers to manage the vegetable cropping system. Meanwhile 1.38% disagree and 21.8% somewhat agree to the benefits brought by the use technological system for small scale farmers. From the analyzed results it shows that farmers are ready to engage into technological systems with the expectations that this horticulture extension support system will meet their requirements.

4.2.5 Weaknesses of available extension support system(s) and development of technological extension support system

The results shown on Fig. 13 explain the data that was acquired from the agronomists through questionnaire, to give a picture on the available extension support system(s) for small holder farmers. A total of 78.71% out of 30 agronomists agreed that there are weaknesses on the available extension support systems and there is a need for developing a technological extension support system.

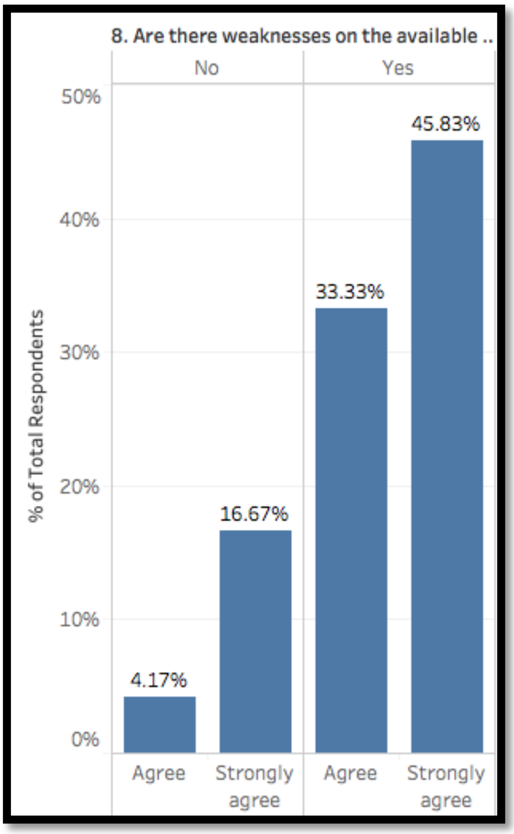

Figure 13: Weaknesses on the available extension support system for small holder farmers (survey for agronomists, 2018)

4.2.6 Usefulness of technological extension support system

Results on Fig. 14 show that the idea of extension support system in not new to some of the agronomists, but to some is a very new idea. In all of the given responses there are not more than two extension support systems used by the agronomists. These agronomists support the fact that extension support systems are useful for small holder farmers.

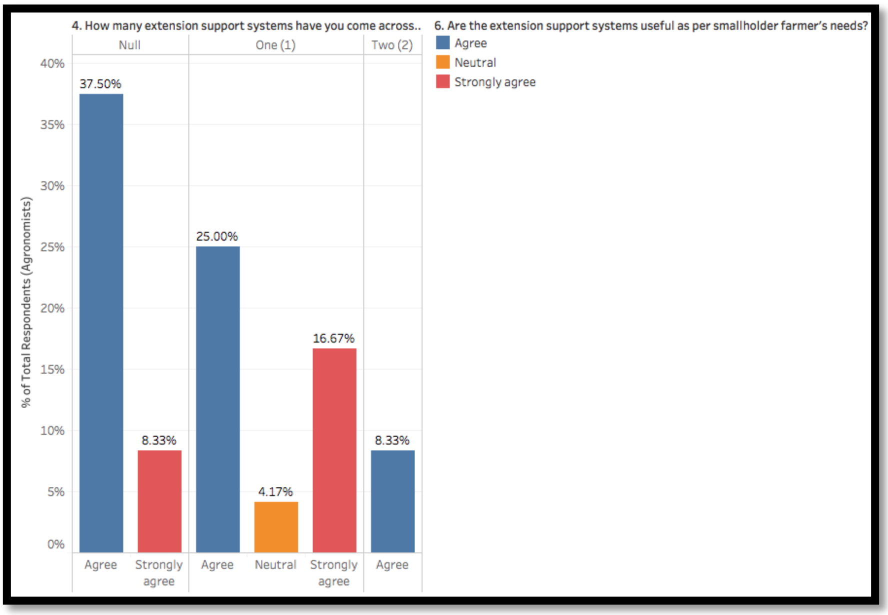

Figure 14: Usefulness and number of extension support system as per agronomist's experience (survey for agronomists, 2018)

4.2.7 The need for weather and crop requirements data to be incorporated in extension support system

The results shown on Fig. 15 explain the need for weather data to be incorporated in the development of a technological system for extension support to small holder farmers. The results show the relation between weather data and vegetable cropping activities. Respondents who are the agronomists showed that there is indeed a need for incorporating weather data in the development of technological extension support system.

Figure 15: The need for weather and crop requirement data to incorporated in the extension support system (survey for agronomists, 2018)

4.2.8 Experience on the use of available extension support system

The results on Fig. 16 show the respondents' experience on using the available technological extension support system. Out of 30 agronomists, 45.83% have experienced a great value and 45.83% of the users have nothing to say since they have not come across any of the technological extension support system. On a very few percentage, the agronomists have come across poor value of technological extension support system not meeting the required needs.

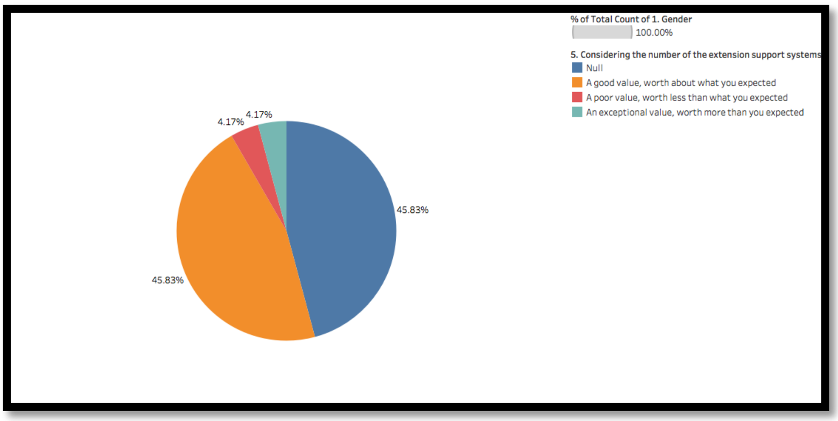

Figure 16: Experience for the agronomists on the use of available extension support system (Survey for agronomists, 2018)

4.3 Developed web extension support system platform

4.3.1 System layout features

The implemented solution of the extension support system is currently on the web application and the mobile application. The web application is comprised of the functionalities as shown on Fig. 17 to Fig. 23. Fig. 17 displays the home page of the Agrotool software where guest users have access to viewing data and authorized users (agronomists) have access to viewing and uploading the data to the system through the given link (login).

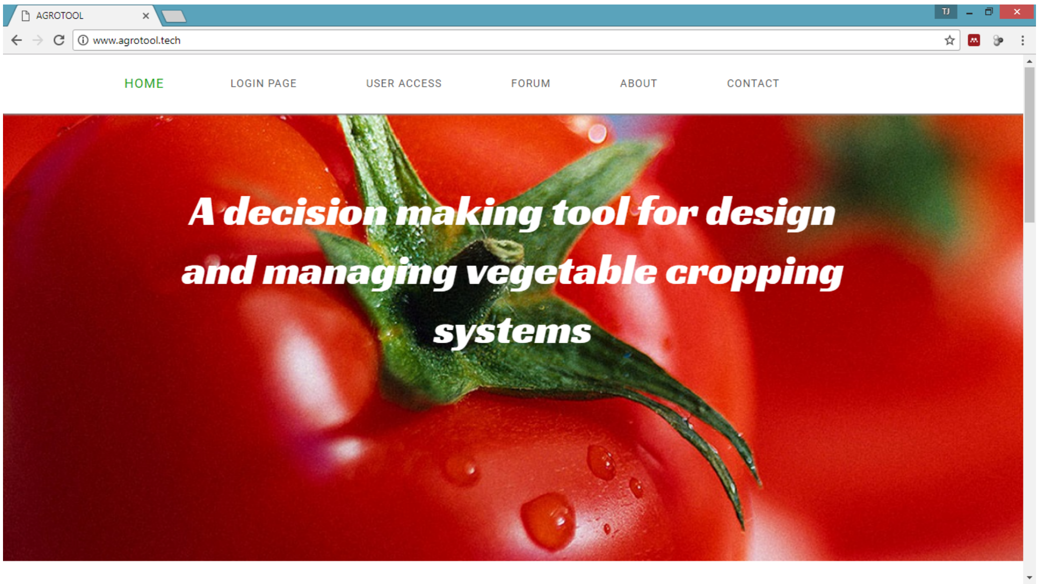

Figure 17: Agrotool home page

The system interface on Fig. 18 displays the weather stations for different locations in Tanzania and the neighboring countries' locations for the recorded temperature weather data in the database. For each marked location user can choose and get the view of temperature data in the whole year.

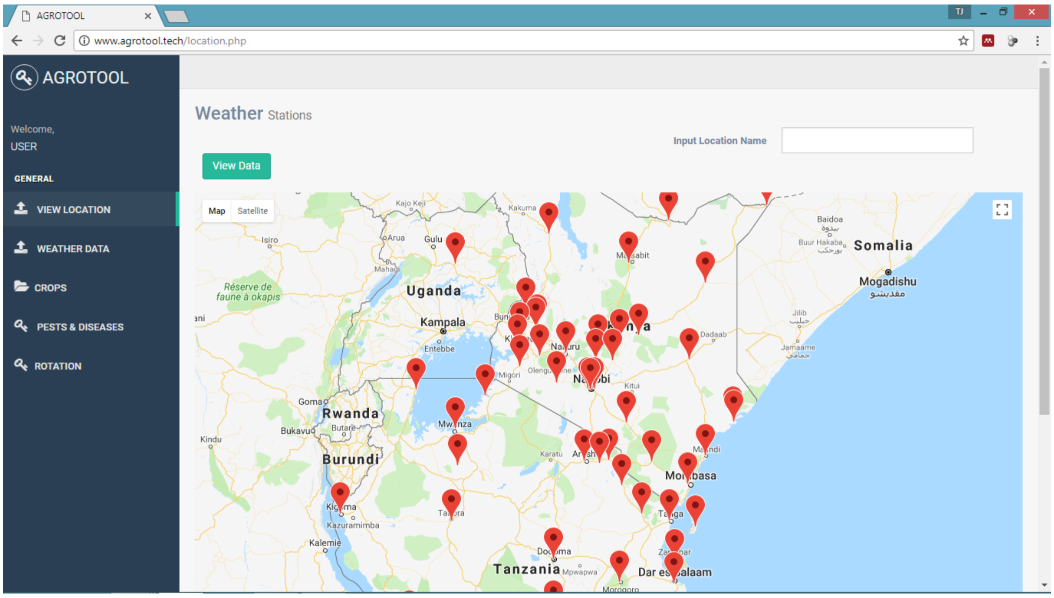

Figure 18: Weather stations storing temperature data

Once a user has selected the location from the given markers on Fig. 18, he/she has to select one type of the crop among the stored crops in the database and date they intend to start sowing so that the platform can automatically give the expected harvesting period as displayed on Fig. 19.

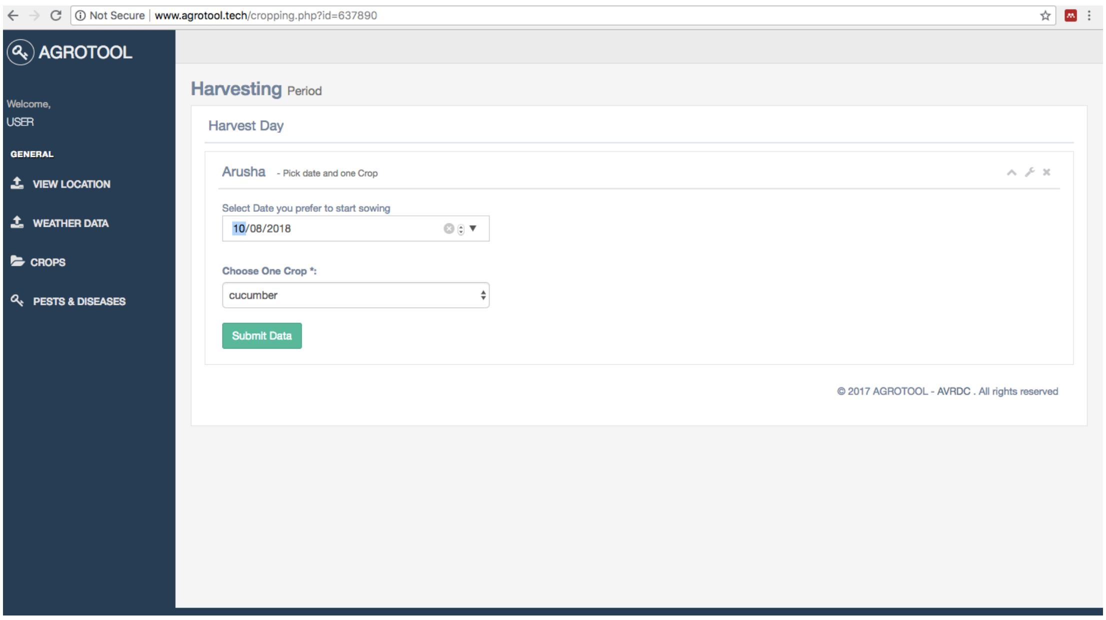

Figure 19: A page for input details to get harvesting period

On choosing the sowing date and crop, the output is the harvest day/period. This kind of information gives a farmer a picture on when the crops could be harvested based on temperature data in a particular location as shown on Fig. 20.

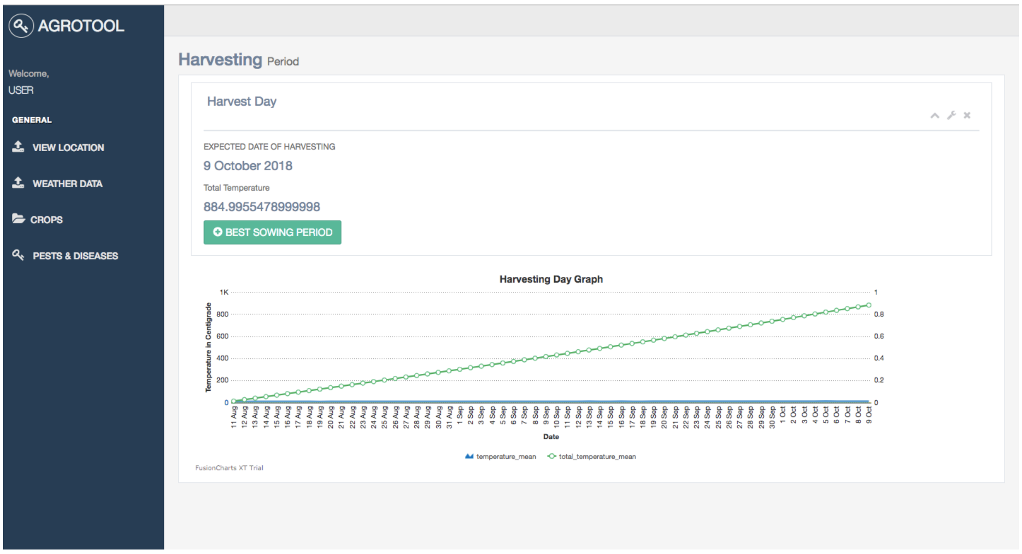

Figure 20: A page for displaying crops harvesting period

Shown on Fig. 21 is the system suggesting the best sowing period for a specific crop in a particular area. The graph shows the period for cultivation and temperature data in that location through that period.

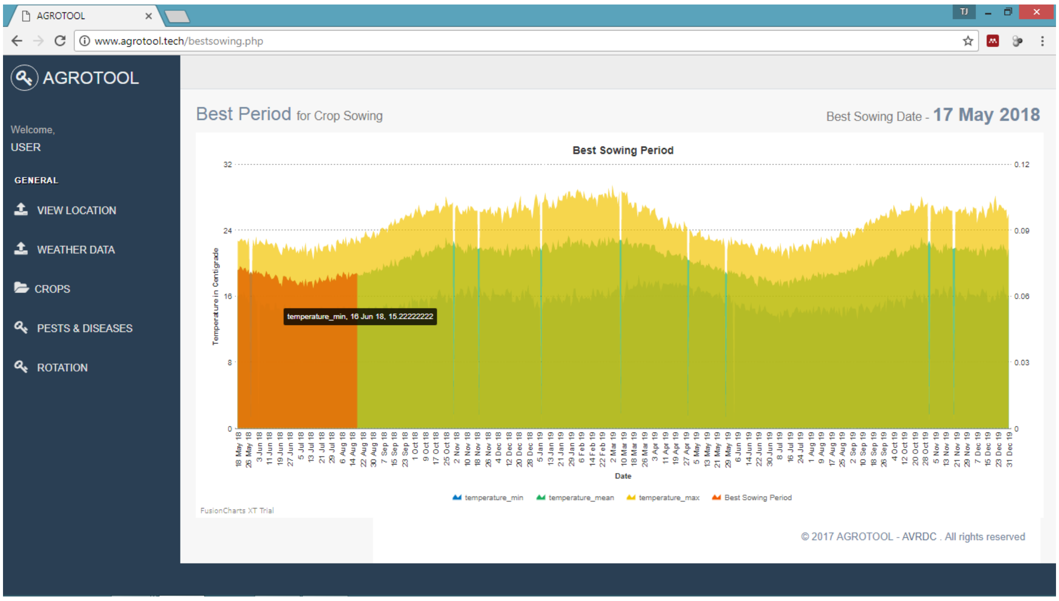

Figure 21: Graph for Best Sowing Period

Fig. 22 shows the displayed number of crops, which are cabbage, sweet pepper, cucumber, tomato, eggplant, French beans and lettuce. The information available includes each crop respective requirements, possible pests and diseases, and best practices to be applied by the farmers when cultivating those vegetable crops.

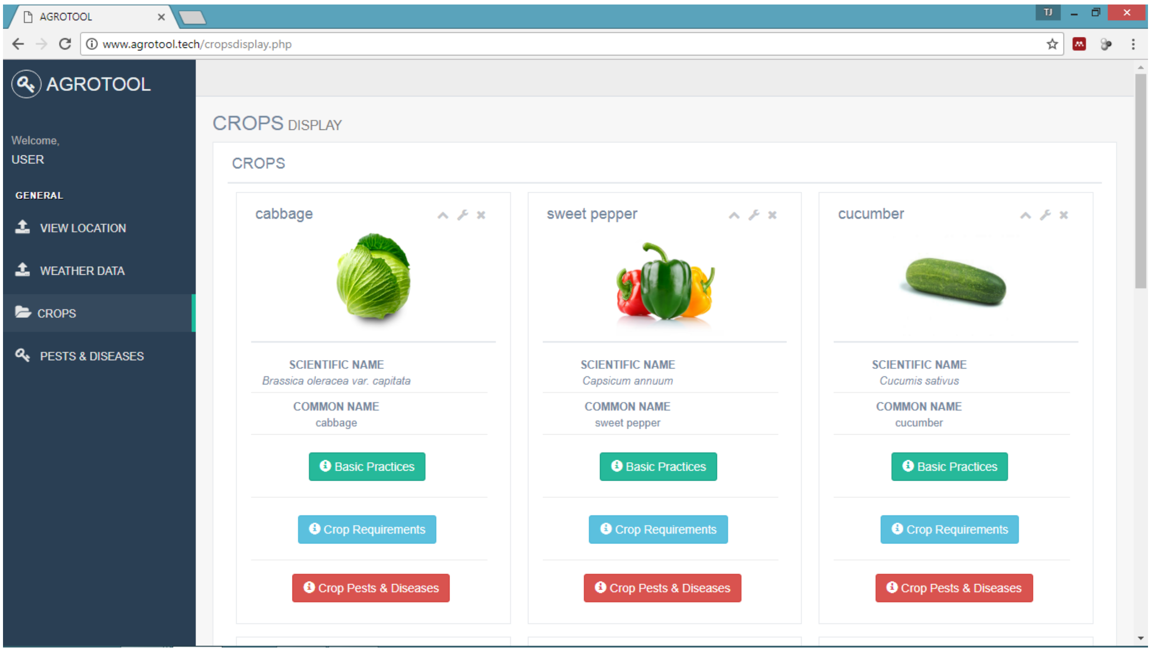

Figure 22: Page for displaying crops

4.4 Developed mobile extension support system platform

The development of the software also included a mobile application, which performs the same functionalities as the web application. The mobile application was developed through the android studio platform. Languages used were XML and Java, mainly of the codes written was to convert the web application to a mobile application by using webview defined function. All the pages on the mobile application are loaded through the given URL, http://www.agrotool.tech. Both the applications give users access to the interaction with the platform in different devices.

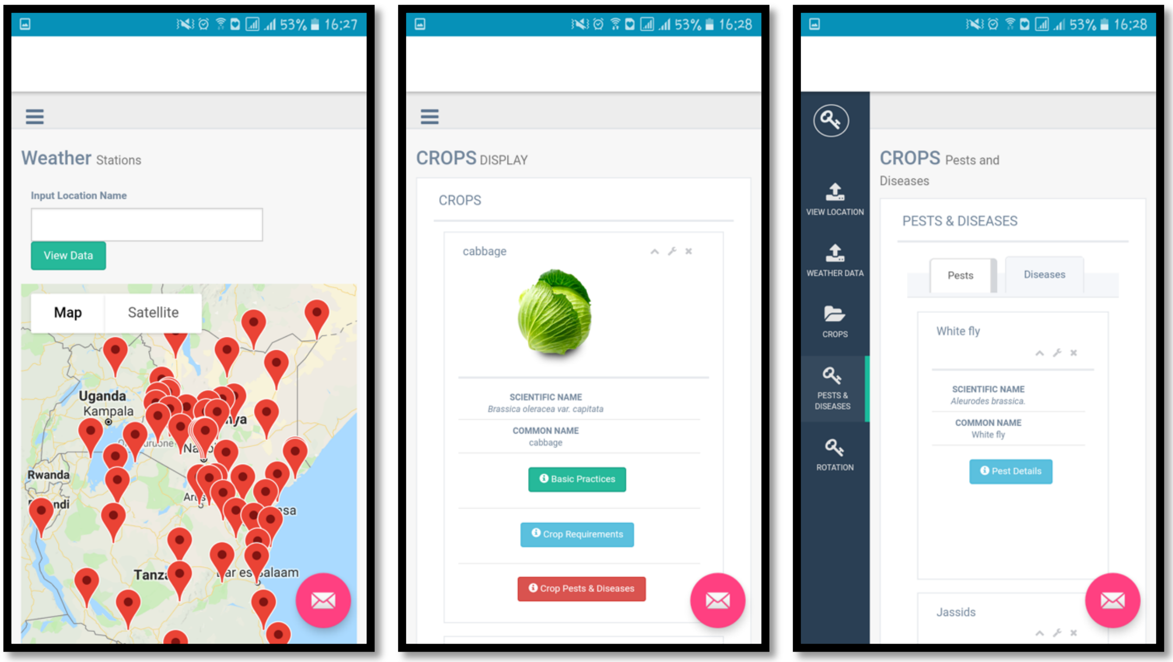

Figure 23: View of the application on a mobile-based platform

Shown on Fig. 23 is the system layout features that has been arranged respectively from the page displaying weather locations, to the page that shows number of crops stored on the database and lastly is the page that show pests details that may affect a particular crop.

4.5 System validation

This section of the chapter clarifies on the consideration parts involved during testing and implementation of the horticulture extension support system. During implementation of the system several procedures were taken into account. The following are the types of the testing phases that was performed:

4.5.1 Unit testing

On this phase, individual parts of the software were tested. This included the database and running of single pages for accomplishing the specified functionalities. Each programmed function was tested before being compiled up to form a complete application for users. Each table in the created database was tested from the attributes creation and its relation with several data entities.

4.5.2 Integration testing

Integration testing on this part of system validation was used as an extension to unit testing. Components were tested before running the whole application. Some of the testing done was among the connection to the database through the localhost, so that data could be accessed to complete the functionalities of the system. The subsystems were also tested to make sure they could communicate and pass data amongst themselves, and to and from the database.

4.5.3 System testing

System testing on this study included checking the whole functioning of the software, and it was used as the final testing stages to ensure that the functionalities and specifications are met. The testing has been done to check if the remote connection with the hosting servers is performing well to ensure that the system can be accessed remotely as depicted on Fig. 24. The connection was successfully established.

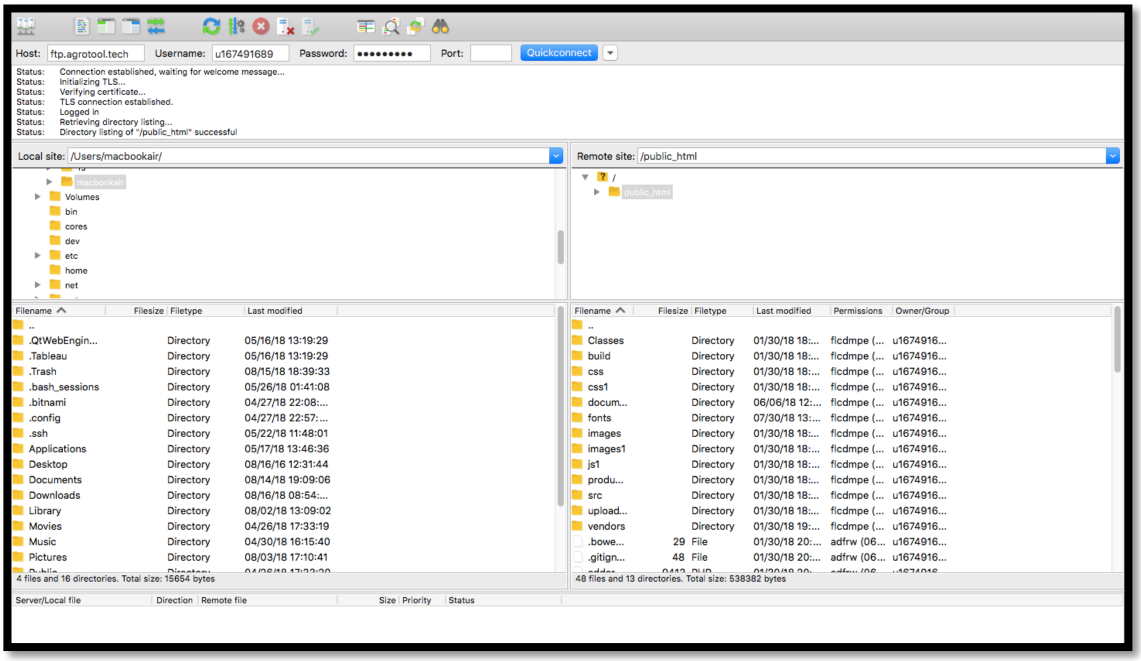

Figure 24: System connection to the remote servers for user access

4.5.4 System Evaluation

The evaluation of the system focused on examining the user acceptance and usability of developed extension support system. The evaluation process also helped to identify the design variations that could be implemented to improve the developed extension support system.

(i) User Authentication

The developed system has a feature to allow only authenticated users to access the forum before posting questions and answers shown on Fig. 25. For the agronomist part where information is stored to the database, the user (an agronomist) is required to register and log in by using username and password for both web and mobile applications.

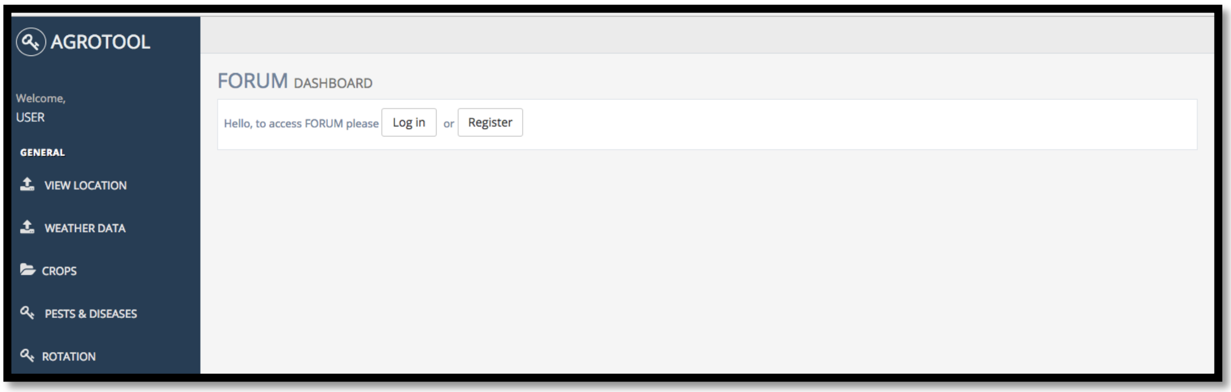

Figure 25: User authentication to get access in the forum dashboard

For non-authenticated users the system is able to provide an alert to provide the right passwords and usernames for access to the system shown on Fig. 26.

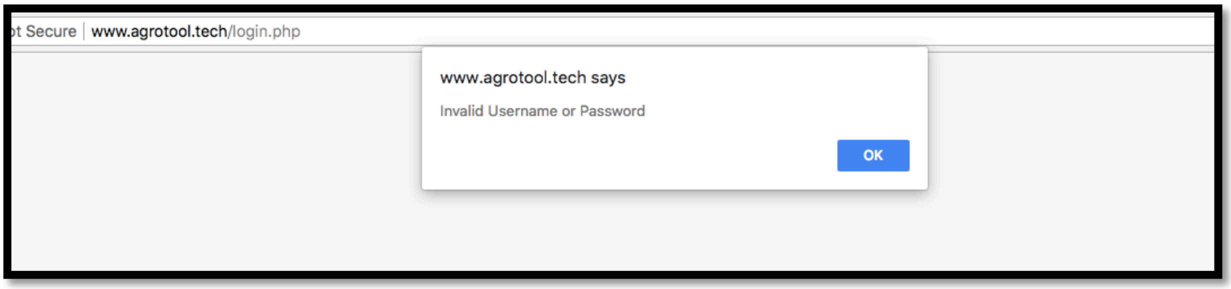

Figure 26: Alert to deny access for non-authenticated user

(ii) User Acceptance

On this section the system was tested based on users' perception for the developed horticulture extension support system. A feature was implemented on the web application to count the number of users that are visiting the application from March 2018 up to date, and on Fig. 27 is the number of users that have been visiting the system as of September 2018.

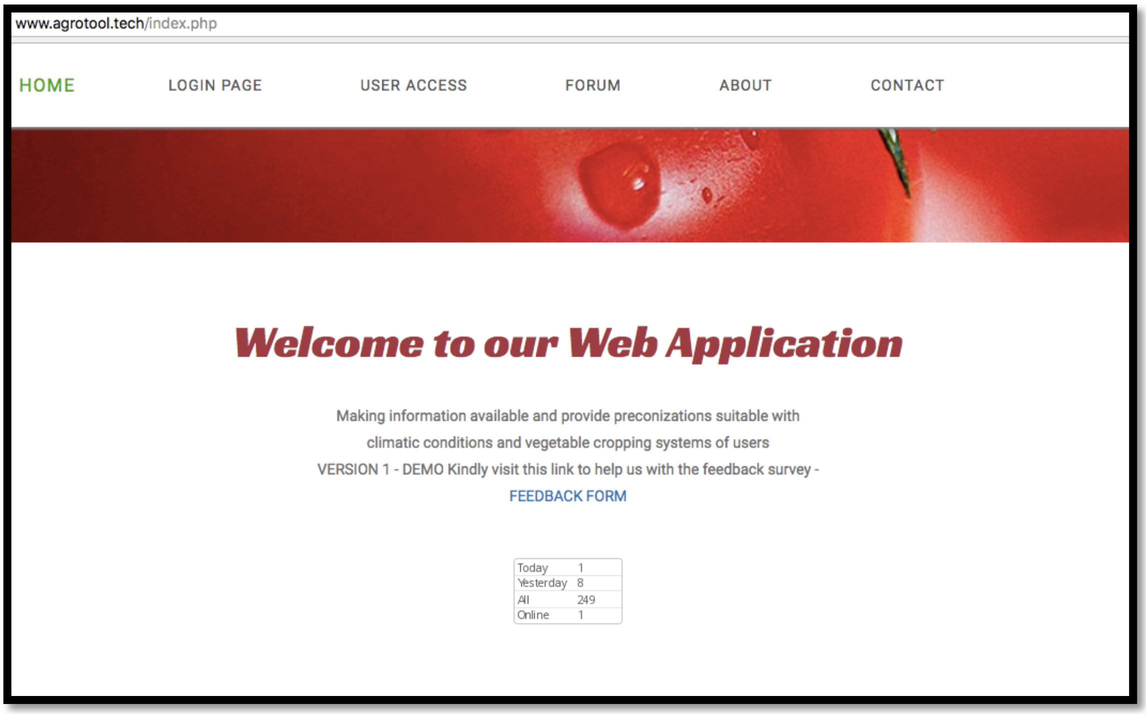

Figure 27: A feature to count number of visitors on the application

Another technique used for studying user acceptance was the implementation of a questionnaire that was acting as a feedback form. Users responded to number of questions and summary results are shown on Fig. 28.

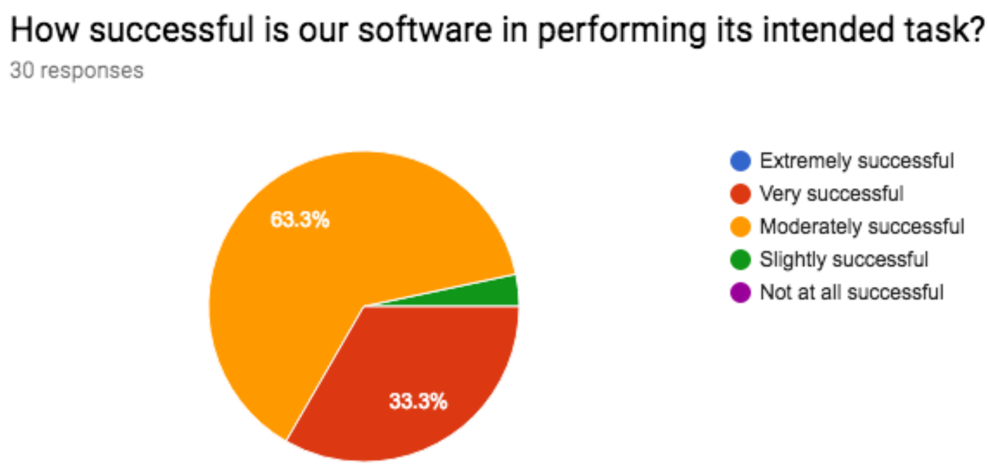

Figure 28: Feedback on software performance

The results of Fig. 28 imply that on a large percentage the software is useful but requires some of improvements for it to perform extremely successful.

The software in general has been promoted and exposed through media and exhibition activities to farmers and several agricultural stakeholders so as to create awareness on the existence of this tool. The following video link shows one of the promotion activities being featured in the news reported at the Voice of America media - https://www.youtube.com/watch?v=eRxuzmtf4cY.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion of the study

Results from the analyzed survey data depicted that the existence of ICT enabled extension support system for small holder farmers is quite not yet well adopted by the small holder farmers, extension officers and agronomists. The perception of small holder farmers who responded to the survey towards the use technological system for their vegetable cultivation activities is quite mixed nevertheless both small holder farmers and agronomist still believe that its useful and beneficial to adopt the ICT enabled extension support system. Meanwhile for the few agronomists who have come across few ICT enabled extension support system for farmers as per fig. 16, find that there is a need for adapting to more systems to help farmers manage their day to day vegetable cropping system since the available system do not yet meet the needed requirements.

Currently many of the small holder farmers have better common practices for managing their vegetable cropping system such as the use of mixed cropping, irrigation system to obtain proper yield. Yet, there are few constraints on the proper flow of information on how to plant based on weather data and best crop requirements for their vegetable needs. ICT enabled extension support solution needs to adopted for better yielding.

On the developed extension support system whose requirements specifications and functionalities have been narrated earlier gives a clear flow of data and helps to provide farmers a better solution for their day to day cultivation procedures. By taking advantage of internet penetration in the country and the use of technology, this application is directly going to benefit the small holder farmers. Given information from the application will include the best sowing periods and harvesting time. Farmers who are the majority will be supported by extension officers on the access to this information.

On the business perspective, development of this extension support system is going to help all the important stakeholders for the vegetable cultivation to have the appropriate system for managing their cropping system. The application will be able to give the best practices information for the crops cultivation and build knowledge ability for farmers to be able to fight against pests and diseases through natural ways. From these given facts the implementation of this ICT – enabled extension support system will enable smallholder farmers to come up with the highly produced vegetables of great potential and directly help them to win the market not just within the country but also on the international market. The designed system is user friendly and does not really need for users to have special skills on interacting with the system except for computer basic skills.

5.2 Recommendations

The study has succeeded to include few regions in Tanzania for the weather data storage in the database and for future work more regions should be included. The weather data that has been used to give the harvesting period output and best sowing period has only been maximum temperature, minimum temperature and mean temperature without humidity data. The study can be improved by using the real time data instead of using the historical weather data for accurate prediction. Lastly, the followings are the areas that can be implemented for future study:

(i) More crops should be included for the purpose of crops diversity since information for other crops was not easily obtained.

(ii) Humidity should be included to help on calculating an accurate sowing period in particular locations.

(iii) The system is currently implemented in English language only and for future work Swahili language should be implemented.

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APPENDICES

Appendix 1 : Questionnaire for farmers (Swahili Version)

DODOSO KWA WAKULIMA WADOGO

JIBU MASWALI YAFUATAYO KWA KUJAZA SEHEMU ZILIZO WAZI AU WEKA ALAMA YA TIKI (√)

1. Jinsia yako

Me ☐ Ke ☐

2. Kiwango cha elimu yako

- Msingi ☐
- Sekondari ☐
- Chuo cha ufundi ☐
- Chuo kikuu ☐

3. Ni mazao gani unajishughulisha nayo katika kilimo cha mboga mboga?

……………………………………………………………………………..

……………………………………………………………………………..

……………………………………………………………………………..

4. Je unafahamu matumizi ya kifaa chochote cha kiteknolojia kama kompyuta au simu? (ndiyo/hapana)

……………………………………………………………………………

5. Je unafahamu mfumo wowote wa kiteknolojia unaosaidia shughuli za kilimo cha mboga mboga? (Taja)

………………………………………………………………………………

………………………………………………………………………………

6. Je umewahi kutumia mfumo wowote wa kiteknolojia katika uendeshaji wa kilimo cha mboga mboga? (Ndiyo/ Hapana)

…………………………………………………………………………………

Kama ndiyo jibu maswali yafuatayo

i. Mfumo wa kiteknolojia uliowahi kutumia unaitwaje?

……………………………………………………………………………………

7. Je unadhani kuna faida kwa wakulima wadogo kutumia mifumo ya kiteknolojia katika kulima mazao yao?

- Ninakubali kabisa ☐
- Ninakubali kiasi ☐
- Wala kukubaliana au kutokubaliana ☐
- Ninakataa kiasi ☐
- Ninakataa kabisa ☐

8. Je unadhani kuna hasara kwa wakulima wadogo kutumia mifumo ya kiteknolojia katika kulima mazao yao?

- Ninakubali kabisa ☐
- Ninakubali kiasi ☐
- Wala kukubaliana au kutokubaliana ☐
- Ninakataa kiasi ☐
- Ninakataa kabisa ☐

Appendix 2: Questionnaire for farmers (English Version)

Answer the following questions by filling empty sections or check mark (√)

1. Your gender

Male ☐ Female ☐

2. Your education level

Primary Education ☐

Secondary Education ☐

Vocational college ☐

University Education ☐

3. What products are you engaged with in cultivation of vegetables?

…………………………………………………………………………..

…………………………………………………………………………..

…………………………………………………………………………..

4. Are you aware of the use of any technology like computer or mobile phone?

(Yes / No)

…………………………………………………………………………

5. Do you know of any technological system that help agricultural businesses of vegetables? (Specify)

……………………………………………………………………………

……………………………………………………………………………

…………………………………………………………………………….

6. Have you ever used any technological system in the operation of the farming vegetables?

(Yes/No) ……………………………………………………………………………

If yes, answer the following questions

i. What is the name of the technological system you have ever used?

…………………………………………………………………………………

7. Do you think there are losses for small-scale farmers to use technological systems in their agricultural activity of vegetables?

- Strongly agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐
- Somewhat disagree ☐
- Strongly disagree ☐

8. Do you think there are benefits for small-scale farmers to use technological systems in their agricultural activity of vegetables?

- Strongly agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐
- Somewhat disagree ☐
- Strongly disagree ☐

Appendix 3: Interview Questions for Agronomists

1. Gender (put a tick in the box)
   - Female ☐
   - Male ☐

2. Your level of education
   - Diploma ☐
   - Bachelor ☐
   - Post graduate ☐
   - Above ☐

3. What are the available extension support system used for vegetable cropping activities for small holder farmers?
4. How many extension support systems have you come across?

1. One (1) ☐
2. Two (2) ☐
3. Three (3) ☐
4. Four (4) ☐
5. More ☐

5. Are the extension support systems useful as per smallholder farmer's needs?
   - Strongly agree ☐
   - Somewhat agree ☐
   - Neither agree nor disagree ☐
   - Somewhat disagree ☐
   - Strongly disagree ☐

6. Are there weaknesses on the available extension support systems? (Yes / No)

   ……………………………………………………………………………

7. Do you think there is a need for developing an extension support system for vegetable cropping system for small holder farmers?

- Strongly agree ☐
- Somewhat agree ☐
- Neither agree nor disagree ☐
- Somewhat disagree ☐
- Strongly disagree ☐

8. Is there any relation between weather condition and crop cultivation practices?

   (Yes / No)

   …………………………………………………………………………………

9. Do you think this type of information (weather data and crop requirements data) should be incorporated into the extension support system for the farmers?
   - Strongly agree ☐
   - Somewhat agree ☐
   - Neither agree nor disagree ☐
   - Somewhat disagree ☐
   - Strongly disagree ☐

Appendix 4: Questionnaire for system evaluation and feedback

This questionnaire has been designed for acquiring the feedback on how the agrotool software meets the stakeholders' needs. The link to online access of the software is www.agrotool.tech

* Required

How likely would you recommend this software to a farmer or an extension officer? * *Mark only one oval.*

	1	2	3	4	5	
Not at all likely	◯	◯	◯	◯	◯	Extreme Likely

How satisfied are you with the user interaction and the software? * *Mark only one oval.*

	1	2	3	4	5	
Not at all satisfied	◯	◯	◯	◯	◯	Extremely satisfied

How satisfied are you with the look and feel of the software? * *Mark only one oval.*

	1	2	3	4	5	
Not at all satisfied	◯	◯	◯	◯	◯	Extremely satisfied

How satisfied are you with the clarity of information? * *Mark only one oval.*

1 2 3 4 5

Not at all satisfied ◯ ◯ ◯ ◯ ◯ Extremely satisfied

How successful is our software in performing its intended task? * *Mark only one oval.*

◯ Extremely successful

◯ Very successful

◯ Moderately successful

◯ Slightly successful

◯ Not at all successful

How satisfied are you with the overall performance? * *Mark only one oval.*

1 2 3 4 5

Not all satisfied ◯ ◯ ◯ ◯ ◯ Extremely satisfied

Appendix 5: Codes for displaying crops

```
<?php
    $hostdb = "mysql.hostinger.com";  // MySQl host
  $userdb = "u167491689_root";  // MySQL username
  $passdb = "123456789_crop";  // MySQL password
  $namedb = "u167491689_crop";  // MySQL database name
// Establish a connection to the database
  $dbhandle = mysqli_connect($hostdb, $userdb, $passdb, $namedb);
/*Render an error message, to avoid abrupt failure, if the database connection parameters are
incorrect */
  if (!$dbhandle) {exit("There was an error with your connection: ".mysqli_connect_error()); }
          ?> <!DOCTYPE html>
<html lang="en">
 <head>
   <meta http-equiv="Content-Type" content="text/html; charset=UTF-8">
   <!-- Meta, title, CSS, favicons, etc. -->
   <meta charset="utf-8">
   <meta http-equiv="X-UA-Compatible" content="IE=edge">
   <meta name="viewport" content="width=device-width, initial-scale=1">
<title>AGROTOOL </title>
<!-- Bootstrap -->
   <link href="vendors/bootstrap/dist/css/bootstrap.min.css" rel="stylesheet">
   <!-- Font Awesome -->
   <link href="vendors/font-awesome/css/font-awesome.min.css" rel="stylesheet">
   <!-- NProgress -->
   <link href="vendors/nprogress/nprogress.css" rel="stylesheet">
   <!-- jQuery custom content scroller -->
   <link href="vendors/malihu-custom-scrollbar-plugin/jquery.mCustomScrollbar.min.css"
rel="stylesheet"/>
   <!-- Custom Theme Style -->
   <link href="build/css/custom.min.css" rel="stylesheet">
 <body class="nav-md">
   <div class="container body">
```

```
      <div class="main_container">
        <div class="col-md-3 left_col menu_fixed">
          <div class="left_col scroll-view">
            <div class="navbar nav_title" style="border: 0;">
              <a href="index.php" class="site_title"><i class="fa fa-key"></i>
<span>AGROTOOL</span></a>
            </div>
<div class="clearfix"></div>
<!-- menu profile quick info -->
            <div class="profile clearfix">
<div class="profile_info">
                <span>Welcome,</span>
                <h2>USER</h2>
              </div>
            </div> <!-- /menu profile quick info --> <br /> <!-- sidebar menu -->
            <div id="sidebar-menu" class="main_menu_side hidden-print main_menu">
              <div class="menu_section">
                <h3>General</h3>
                <ul class="nav side-menu">
                    <li><a href="location.php"><i class="fa fa-upload"></i> VIEW LOCATION</a>
                                        <li><a href="userviewlocation.php"><i class="fa fa-upload"></i>
WEATHER DATA</a>
                                         <li><a href="cropsdisplay.php"><i class="fa fa-folder-
open"></i>CROPS</a>
<li><a href="pestsabddiseases.php"><i class="fa fa-key"></i> PESTS & DISEASES</a>
              </div>
</div>
</div>
            <!-- /sidebar menu -->
</div>
        </div>
<!-- top navigation -->
        <div class="top_nav">
          <div class="nav_menu">
```

```
          <nav>
            <div class="nav toggle">
              <a id="menu_toggle"><i class="fa fa-bars"></i></a>
            </div>
</nav>
        </div>
      </div>
      <!-- /top navigation -->
 <!-- page content -->
      <div class="right_col" role="main">
        <div class="">
          <div class="page-title">
            <div class="title_left">
              <h3>USER <small> DASHBOARD<strong></strong></small></h3>
            </div>
          </div>
        </div>
<div class="x_panel">
              <div class="x_title">
                <h2>CROPS</small></h2>
<div class="clearfix"></div>
              </div>
<?php
$query1="SELECT * FROM crops";
$result3 = mysqli_query($dbhandle,$query1);


   while($row3 = mysqli_fetch_array($result3))
   {
   $crop_id=$row3['crop_id'];
   $crop_name=$row3['crop_name'];
  $crop_image=$row3['crop_image'];
    ?>
```

```
<div class="col-md-4 col-sm-4 col-xs-12">
            <div class="x_panel tile fixed_height_420 overflow_hidden">
             <div class="x_title">
              <h2><?php echo $crop_name ?></h2>
              <ul class="nav navbar-right panel_toolbox">
               <li><a class="collapse-link"><i class="fa fa-chevron-up"></i></a>
               </li>
               <li class="dropdown">
                <a href="#" class="dropdown-toggle" data-toggle="dropdown" role="button" aria-
expanded="false"><i class="fa fa-wrench"></i></a>
               </li>
               <li><a class="close-link"><i class="fa fa-close"></i></a>
               </li>
              </ul></br>
               <div class="clearfix" align="center">
                                                                <?php echo '<img
src="data:image/jpeg;base64,' . base64_encode($row3['crop_image']) . '" width="150"
height="130">';?>
                                                                </div>
             </div>
            <div class="x_content">
                     <div>
                      <ul class="list-inline widget_tally">
                       <li>
                         <p align="center">
                          <strong><span class="month">SCIENTIFIC NAME </span></strong>
                         <i> <span class="month"><?php echo $crop_id ?></span></i>
                         </p>
                        </li>
                        <li>
                         <p align="center">
                          <strong> <span class="month">COMMON NAME </span></strong>
</br><span class="month"><?php echo $crop_name ?></span>
                         </p>
```

```
                              </li>
<li>
<br>
<p align="center">
 <?php echo "<a class='btn btn-success' href='tips.php?id=".$row3['crop_id']."'><i class='glyphicon glyphicon-info-sign icon-white'></i> Basic Practices</a>";?>
  </p>
</li><li>
<br><p align="center">
<?php echo "<a class='btn btn-info' href='crop_requirement.php?id=".$row3['crop_id']."'><i class='glyphicon glyphicon-info-sign icon-white'></i> Crop Requirements</a>";?>
 </p> </li></ul>
</div>
                        </div>
<p align="center">
 <?php echo "<a class='btn btn-danger' href='crop_pestanddiseases.php?id=".$row3['crop_id']."'><i class='glyphicon glyphicon-info-sign icon-white'></i> Crop Pests & Diseases</a>";?>
  </p>
</div>
           </div>
<?php
 }
?>
<br>
 </div> <footer>
         <div class="pull-right">
                                       <p>© 2017 AGROTOOL - <a href="https://avrdc.org/about-avrdc/new-locations/eastern-southern-africa/">AVRDC</a> . All rights reserved</p>
                          </div>
         <div class="clearfix"></div>
       </footer>
       <!-- /footer content -->
     </div>
   </div>
```

```
<!-- jQuery -->
    <script src="vendors/jquery/dist/jquery.min.js"></script>
    <!-- Bootstrap -->
    <script src="vendors/bootstrap/dist/js/bootstrap.min.js"></script>
    <!-- FastClick -->
    <script src="vendors/fastclick/lib/fastclick.js"></script>
    <!-- NProgress -->
    <script src="vendors/nprogress/nprogress.js"></script>
    <!-- jQuery custom content scroller -->
    <script src="vendors/malihu-custom-scrollbar-
plugin/jquery.mCustomScrollbar.concat.min.js"></script>
<!-- <script async
defersrc="https://maps.googleapis.com/maps/api/js?key=AIzaSyDBYLZr55gEXIVEn5q8u2N2nDpXaQ
LI0XY&callback=initMap">
    </script>-->
    <script src="build/js/custom.min.js"></script>
  </body>
</html>
```

RESEARCH OUTPUTS

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Extension System for Improving the Management of Vegetable Cropping Systems

Theofrida J. Maginga [1]*, Thibault Nordey [2], Mussa Ally [1]

[1] *Department of Information Technology and System Development, The Nelson Mandela African Institution of Science and Technology,* Arusha, TANZANIA
[2] *The World Vegetable Center,* Arusha, TANZANIA

*__Corresponding Author:__ tjmaginga@gmail.com

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ABSTRACT

Horticulture as the part of agriculture sector plays the role for food security, economic growth and nutrition improvement. In developing countries where agriculture is regarded as the backbone of most countries' economy it draws attention for most governments as the main source of employment and livelihood for the majority. Agricultural extension has been the key facilitator for achieving high crop productivity and an enabler to knowledge resources for these countries. However, lack of clear information for vegetable cultivations, crop requirements, climatic information, pests and diseases to constantly help farmers to come up with proper potential yield of the vegetable crops reduce the potential of horticulture in improving the farmers livelihood and countries economic gain , Therefore, this study aims at bringing the ICT- enabled extension support system for farmers to help them make decision on proper ways of cultivating their crops based on locations' and timely climatic condition.

Keywords: extension system, web and mobile application, horticulture, vegetable cropping system

INTRODUCTION

For the past decades horticulture production including the vegetable farming has been the major drivers for change towards sustainable agriculture (Mabaya, 2015). In Tanzania, the strategy for horticulture development for 2012-2021 along with the establishment of Horticultural Development Council of Tanzania (HODECT, 2012) is demanding for the fast growing opportunities of the market in the country and abroad so as to improve nutritional status, increase incomes and reduce poverty while increasing productivity and quality of the products (Kang et al., 2009).

In other developed countries such as United States, Finland and China to mention a few also have a mechanism to help farmers for managing their crops through computer aided extension systems to maximize their output (Yan-E, 2011). According FAO reports, weak extension support systems explained in part the under productivity of cropping systems in developing countries (Kalim, 2005). In common given range, the production yield of vegetable crops like tomatoes can range between 40 - 100 t/ha depending on agroecological conditions and practices, but average tomato yields in sub Saharan countries (including Tanzania) are under 19.4 t/ha less than minimum production standard except for South Africa. In this given context there is a need for the country like Tanzania to adopt the use of ICT enabled extension system of which it will help farmers to enter into the foreign or international markets.

Therefore this paper main focus is to bring the idea of using ICT- enabled extension support system for farmers, we hypothesize that the development of a new ICT will help farmers to better manage their vegetable cropping systems and maximize output and improve the yield potential of the vegetables to smallholder farmers and presented in this paper is the need for the developed extension support system for small holder farmers in order to help them make decision on ways of properly cultivating their crops in their areas based on locations' the climatic condition.

Horticulture in Developing Countries

In developing countries where agriculture is regarded as the backbone of these countries' economy, it draws attention of the governments as the main source of the population employment and livelihood (Ajapnwa et al., 2017). The horticulture sub-sector has grown efficiently and resulted into to food crops and source of exports (ISHS, 2015).

The development of the agricultural sector in Tanzania is being reinforced by several strengths including suitable soils, diverse climatic condition suitable for cultivation of a large range of horticultural crops. The crop production is mostly influenced by climatic changes and pests, crop pests and disease has become a serious threat to global food security and made life of farmers difficult (Kang et al., 2009). However the agricultural extension has been the key facilitator for achieving high crop productivity and an enabler to knowledge resources which can manage pests and crop diseases and most governments and agricultural stakeholders are trying to rejuvenate their extension systems (Raj, 2013).

The availability of clear information for vegetable cultivations, on crop requirements, the climatic information, pests and diseases and adaptation of these information to their location can help farmers to come up with proper potential yield of the vegetable crops, also it plays a very important role of improving the horticulture subsector of the agriculture (HODECT, 2012).

Currently the extension support system is being facilitated by the local methods being achieved by extension officer visits, conducting workshops and trainings given by the non-governmental organizations. Development of the ICT- enabled extension support system in relation to making information available will act as an agent to change agricultural situation and improve farmers' access to knowledge sharing and access to information. It is believed that ICT enabled extension nurture opportunities has the potential for helping farmers (Raj, 2013), and according to Tanzania Communication Regulatory Authority (TCRA) ICT sector overview, it shows that by the year 2017 internet users have progressively increased to 23 million people which is about 45% of the Tanzanian population being served by multiple internet service providers (ISPs) (Zacharia, 2018). The figure includes estimates of internet café users, organization/institution use, household and individual use (Hill, 2010).

From these given statistics, the development of the ICT- enabled extension support system in Tanzania can reach a large extent of the population and solve the information flow of the extension services provided to horticulture farmers.

Extension Support Systems

The extension support system concept talks of scientific techniques that includes new knowledge practices through education provision to farmers. In agriculture perspective it encompasses communication and training activities organized for people in the rural areas from different discipline of agriculture so as to facilitate interaction and foster collaborations within information system which includes agricultural research, agricultural education and information provision (Colen and Performance, 2013).

Agricultural extension services in Tanzania lies beneath the responsibility of the government, conducted locally by the Village Extension Workers. The whole structure is not adequate enough to reach about 2 villages of 1000 farmers for every extension officer and thus results to overwhelming division of works also these local extension systems are comprised with the other barriers such as transport and other limitations related to cultural taboos where women are denied access to extension services and from that fact the focus tend to deviate from all farmers to male farmers which means an extension officer cannot work as much perfect as they are supposed to work with every farmer (ISHS, 2015).

Other Related Works

The study conducted by Ngowi (Ngowi, 2015) had the objective to deliver a working prototype that will support agricultural stakeholder to have better flow of information. The study came up with an integrated web-based system to help small holder farmers getting information on the market channels for crops where by it allows farmers to upload the pictures for their crops to easily market their crop products and to bridge the gap between farmers and vendors.

According to Camilius, (Camilius, 2016) the need of ICT to support farmers has increased, in Tanzania some of the solutions that have been implemented by other researchers for the agricultural practices is the Agro-Advisory platform widely known as Ushauri Kilimo. The platform in an integrated system that has web based advisory information system that gives farmers access to advices in different agriculture issues like agronomic practices, livestock husbandry and other agricultural related information related to marketing information by sending any question through an SMS and get a response from an agricultural expert but currently the platform is not actively in use.

Tigo Tanzania has also introduced a solution for small holder farmers which is called mobile Tanzania farming app. To help farmers get up to date market information on how a farmer can get connected to the crop buyers which in turns will help farmers to make better decisions (Tanzania Invest, 2014).

Existing information systems for helping small holder farmers are farmer connect and Kilimo Salama. On the farmer connect application, agencies help farmers to tackle various challenges that are facing in their day to day agricultural practices but also the weather forecast information. The platform is also integrated with other portals to get accurate information on the policies for agricultural practices (Tanzania Invest, 2014). Kilimo Salama platform also has not diverged much from the farmer connect platform where by small holder farmers who are dealing with maize and wheat in this platform gets to receive insurance for their farm against drought and too much rain. With an information integrated from the weather stations the information acquired helps to calculate rainfall formula and in the end the payout to farmers is obtained. (Kilimo, 2010).

PROPOSED SOLUTION

The development of an extension support system is being presented as the solution for farmers access to information, where by this system is going to cover all the weather located regions in Tanzania and the expected platforms are going to be a web application and a mobile application in that context when a web application is being used it will help to acquire the feedback and help to incorporate in the mobile application. This methodology is supported by an iterative way of software development that will act as a roadmap for the development process because it allows the incorporation of the feedback.

Extension Support System Modelling

The extension support system as the source of all the cultivating information for vegetable growers has been modelled where all the information is coming from the right sources such as books and different articles being organized by the agronomist. An agronomist is going to provide the information through the platform from there data will be disseminated to farmers through extension officers and help the farmer to easily manage their cropping systems. Figure 1 shows the conceptual framework for the extension support system.

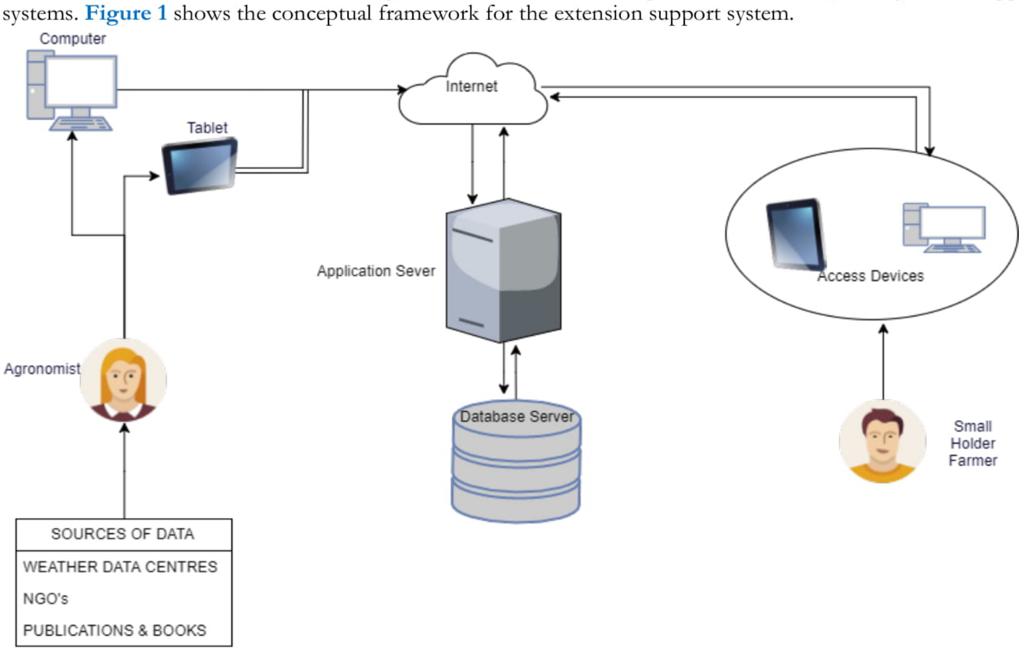


Figure 1. Conceptual framework for Extension support system

System Layout Images

The implemented solution of the extension support system is currently on the web application comprised of the functionalities as shown on the pictures below. Figure 2 displays the home page of the software where users and authorized users (agronomists) have access to viewing and uploading the data for the system. On Figure 3 the system interface displays the weather stations for different location in Tanzania and the neighboring countries for the recorded temperature weather data in the database. Figure 4 the system picture to display number of crops available with their respective requirements, pests and diseases and best practices to be applied by the farmers when cultivating their vegetable crops. Figure 5 is the system picture showing the suggested best sowing period for a specific crop in a particular area, this graph shows the period for cultivation and the temperature data in that location through that period.

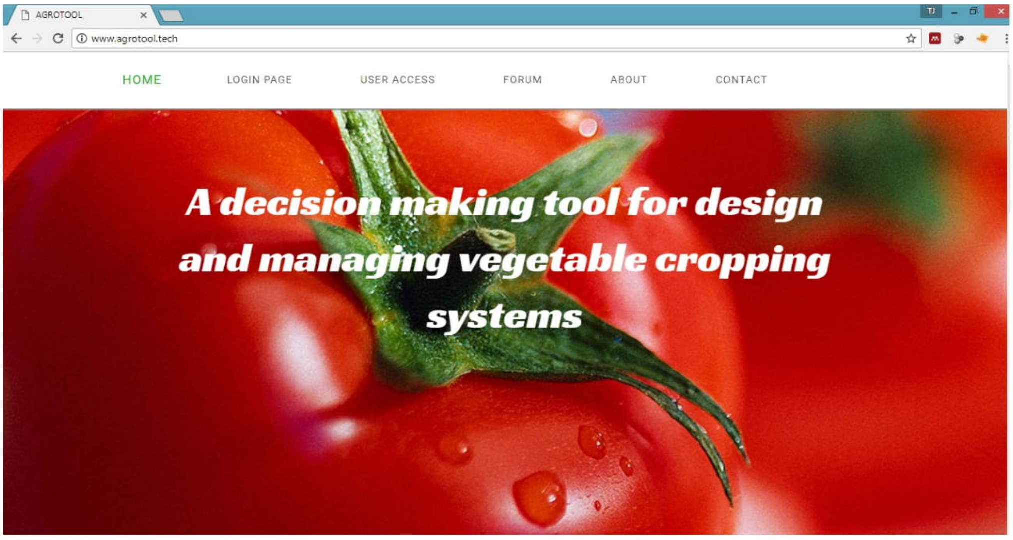


Figure 2. Home page for giving access to users for interacting with the system

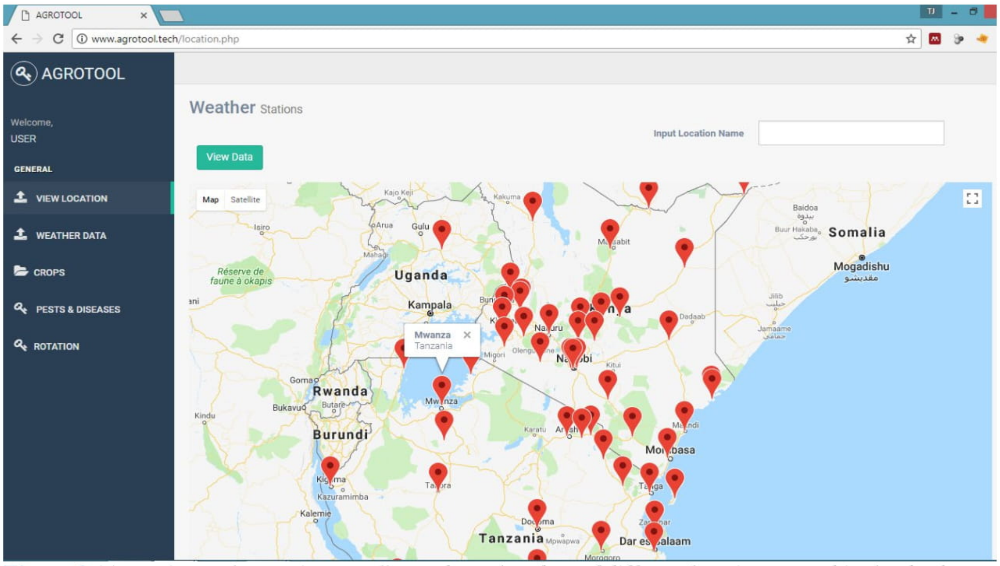


Figure 3. Tanzania weather stations to allocated weather data of different locations stored in the database

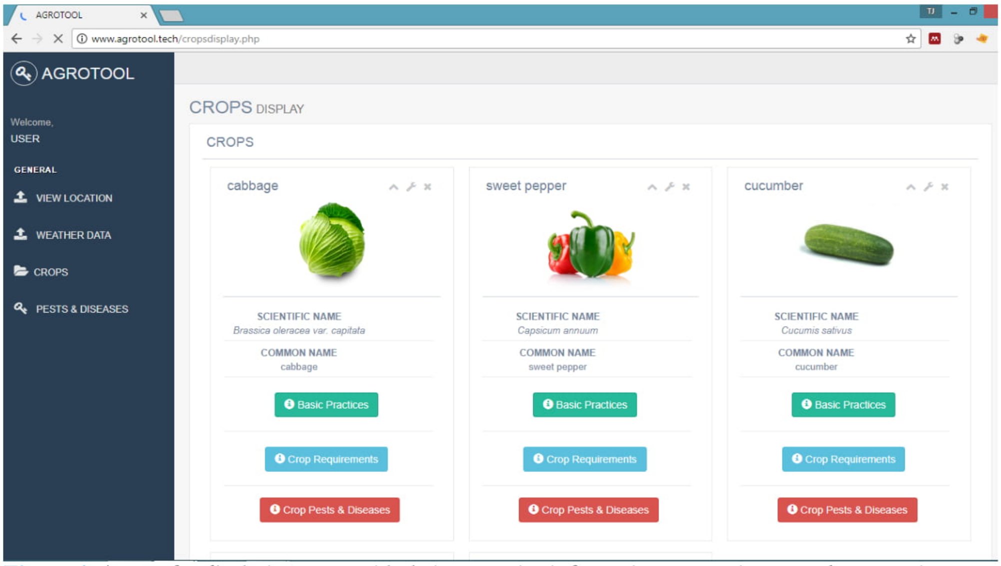


Figure 4. A page for displaying crops with their respective information on requirements, best practices, pests and diseases

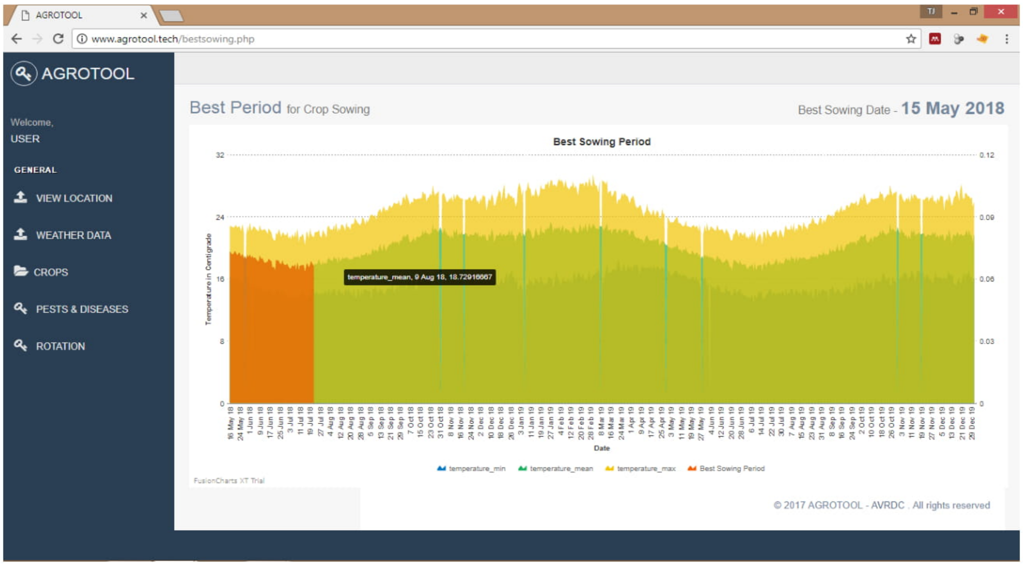


Figure 5. Graph for giving user a best sowing period suggestion based on the weather data in a particular selected location

Features of the System

The software will be able to operate on any computer machine with an access to the internet via web browser and also the mobile application to be developed will include all the features to operate on the mobile smart phones. The database will be installed on a remote machine and so it will require for users to have an access on the internet. The requirement specifications for the software development involve functional and non-functional requirements. Functional requirements capture the intended behavior of the system to perform the following functions. The functions depend on the user's level and permission package, Functional requirements will include user main functionalities as described on **Table 1**.

Table 1. System main functionalities

Functionality	Description
View Map for Weather Stations (Locations)	There is a list of locations, which has plan (map). This function allows the user with appropriate view the locations in map by using google map feature by comparing the information of location data from the database. When user moves the mouse, could see the location weather stations by markers.
View Weather Data	The application will allow users to get average weather data for the whole year displayed in graphical format of minimum, mean and maximum temperature per each month.
Designing a cropping system	The system will help user to choose a type of crop they want to plant and specify the sowing date, through this functionality user will be able get the feedback on harvesting day and even the best sowing period.
Viewing information on crops	For this feature of the application user will have an access to information for each crop on best practice, crop requirements and pest and diseases information.

User Classes and Characteristics

There are three types of users on the system.

Agronomist

The first user will be an agronomist to be given an authorized privilege to gain access to the system, this user will be able to upload different types of information such as weather data, requirement of the crops and any other required information.

Smallholder Farmer/Researcher

The other user will be a small holder farmer or any user that will be interested on gaining access to the system. This user will be able to query the information on the weather data, types of crops and their requirements, rotation and cropping system also the pests and diseases information.

Administrator

The final user will be the system administrator who will be having the higher privileges than other users on the system, an administrator of the system can have all the privileges that all users have in the system and may also be able to grant some of the privileges to the users.

Software Architecture

The following are the key major functions of the software

- Providing user data on average weather data (temperature & precipitation) on various weather stations in Tanzania
- A system will provide information on about seven vegetable crops and their requirements for proper cultivation procedures.
- The system will provide the information on possible effects and diseases that may affect those crops.
- The system will give user data on when is the proper period of time to start cultivating and the expected time to harvest but also the best sowing period for start sowing.
- The system added feature will be to provide a forum platform for farmers to ask questions and get response from the agronomists.

METHODOLOGY

Study Area

This study has been conducted in the country of Tanzania which endows almost 44 million hectares suitable for agriculture, only 14 million ha is cultivated according to Agricultural Sector Development Strategy due to the fact that some of the areas have low soil fertility, land degradation and drought. Until recently agriculture in Tanzania has been more based on land expansion for cultivation rather than focusing of high yield productivity.

Data Collection

The study conducted had different areas focused for data collection which includes regions such as Mwanza, Morogoro and Arusha based on the following criteria, these regions are located in the zones considered as the most horticultural production areas. Zones includes Northern Zone (Kilimanjaro, Tanga, Manyara and Arusha), Coastal Zone (Dar es salaam, Coast and Morogoro) and Lake zone (Mwanza) other zones includes central zone, Zanzibar and southern highland as shown on **Figure 6**. Data from farmers and extension officers has been collected for by using questionnaire since this method gave opportunity for farmers to provide feedback on their experience anonymously (Cohen et al., 2014) together with discussions with key informants and also data has been collected from agronomists through questionnaire and interviews and analyzed through tableau platform for data analysis.

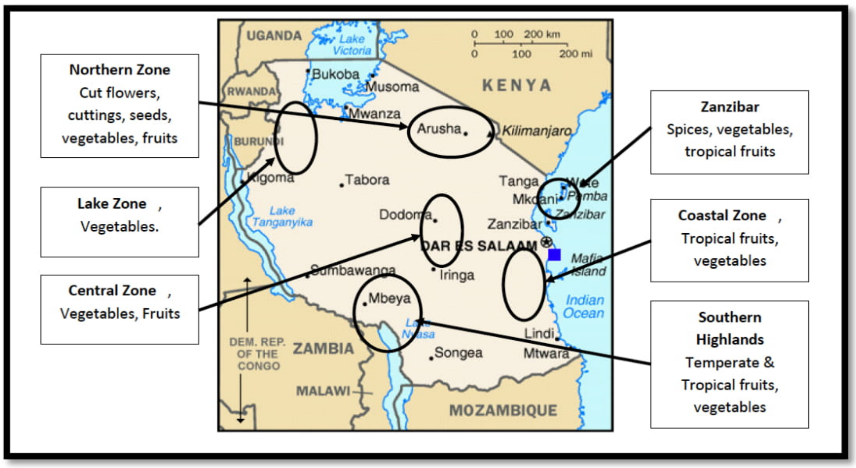


Figure 6. Tanzania map indicating main horticultural zone areas (Netherland, 2015)

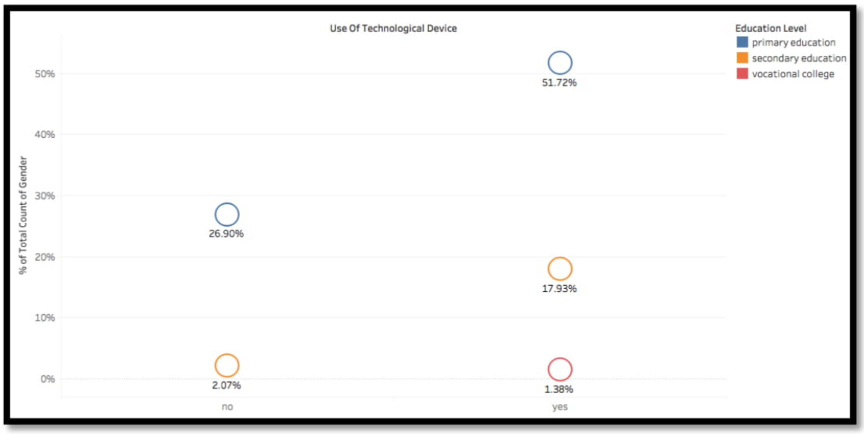
RESULTS & DISCUSSIONS

The study was focusing on an attempt to understand the use of information and communication technology devices for extension support systems to small holder farmers during managing their vegetable cropping systems. The researcher selected about 180 respondents residing in areas specified above 150 of them were small holder farmers which includes the small holder farmers and 30 were the agronomists, the survey was carried out to find the number of farmer who engage their vegetable cropping activities with the use information and communication technology for managing their vegetable cropping system through extension services. The results obtained from the survey were put through analysis platform called Tableau and presented as follows:

Use of Technology Devices

The use of technological devices for farmers included smart phones or any other related device for communication purposes, the following are the results of the responds to the question.

The results on **Figure 7** imply that education level has impact on the use technological devices for meanwhile a large percent which is about 71.03% of users are using technological devices but 26.90% out of 28.90% are farmers with primary education level who are not using technological device but it doesn't setback any proposed technological solution for the farmers.

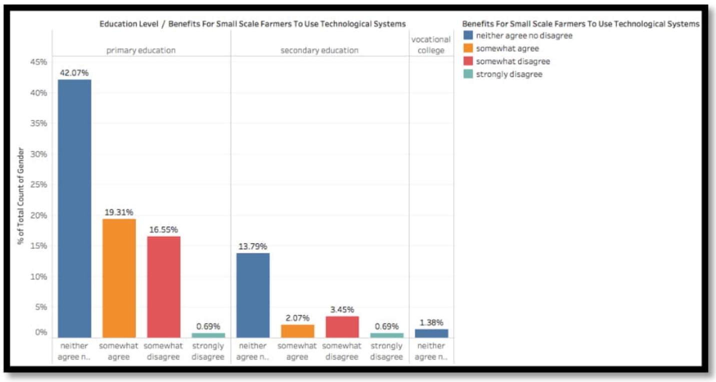


Source: survey for small holder farmers and extension officers (2018)

Figure 7. Use of technological devices for small holder farmers with education background

Benefits Small Scale Farmers to use Technological Systems

This part includes on how respondents think of the solution to be proposed for managing their vegetable cropping system. The results on figure vary from respondents to either agree or disagree to the idea of using technological solution for managing their vegetable cropping systems.



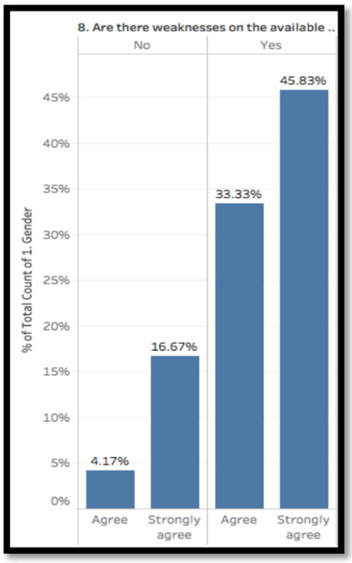
Source: survey for small holder farmers and extension officers (2018)

Figure 8. Benefits on the use of technological devices for small holder farmers with their educational level

The results on **Figure 8** show that about 57.24% of the respondents neither agree or disagree with the benefits on the use of technological systems for small scale farmers to manage the vegetable cropping system. Meanwhile 1.38% disagree and 21.8% somewhat agree to the benefits brought by the use technological system for small scale farmers.

Weaknesses on Available Extension Support System and Development of Technological Extension Support System

The results shown on **Figure 9** explain the data that was acquired from the agronomists through questionnaire to give a picture on the available extension support system for small holder farmers of which a total of 78.71% said yes, there are weaknesses and regardless of the response types all respondents agree that there is a need for developing a technological extension support system.

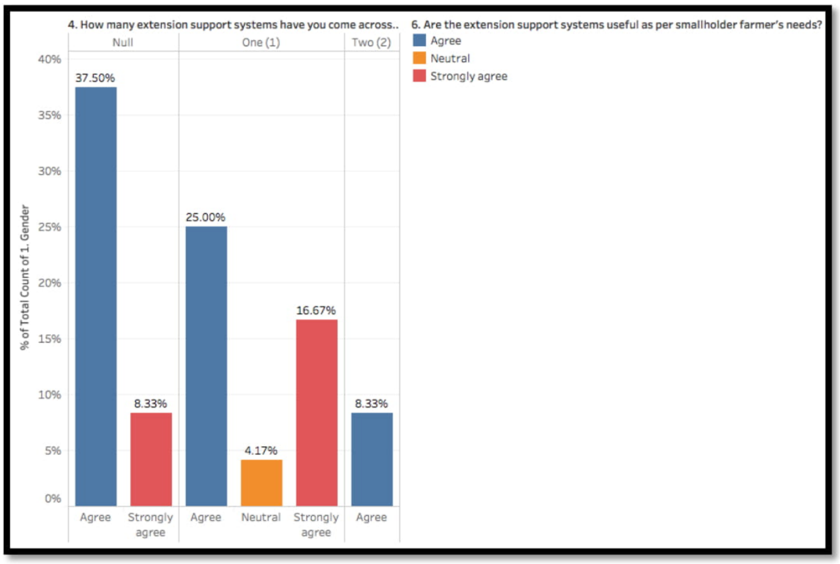


Source: survey for agronomists (2018)

Figure 9. Weaknesses on the available extension support system for small holder farmers

Usefulness of Technological Extension Support System

Results on **Figure 10** shows that the ideas of extension support system in not new to some of the agronomist but to some is a very new idea, in all of the given respondents there are not more than two extension support system seen by the agronomists and also these agronomists still support the fact that extension support system are useful for small holder farmers.



Source: survey for agronomists (2018)

Figure 10. Usefulness and number of extension support system as per agronomist's experience

CONCLUSION

The developed extension support system whose requirements specifications and functionalities have been narrated on this paper gives a clear flow of data and helps to provide farmers a better solution on how to use the given information for their day to day cultivation procedures. By taking advantage of internet penetration in the country and the use of technology, this application is directly going to benefit the small holder farmers with the support from of the extension officers on acquiring information about the best sowing periods and harvesting time with regards to its development farmers who are the majority will be supported by extension officers on the access to this information.

On the business perspective, development of this extension support system is going to help all the important stakeholders for the vegetable cultivation to have the appropriate system for managing their cropping system from best sowing period, calculating the harvesting period and being able to get the best practices information for their crops and to build knowledge ability for farmers to be able to fight against pests and diseases through natural ways. From these given facts the implementation of this ICT – enabled extension support system will enable smallholder farmers to come up with the highly produced vegetables of great potential and directly help them to win the market not just within the country but also on the international market. The designed system is user friendly and does not really need for users to have special skills on interacting with the system except for computer basic skills.

ACKNOWLEDGEMENT

This work is a part of the project supervised by The World Vegetable Centre AVRDC in Tanzania funded by CIRAD in France. However this work has also been facilitated by The Nelson Mandela African Institute of Science and Technology.

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Adoption of ICT enabled extension support system for vegetable crop production among small holder farmers: A case of Tanzania

Theofrida J. Maginga[a] and Dr. Mussa Ally[b]

Department of Information Technology and System Development

Nelson Mandela African Institution of science and technology

Arusha, Tanzania

tjmaginga@gmail.com[a] mussa.ally@nm-aist.ac.tz[b]

Abstract - *The study focuses on farmers adoption to ICT enabled systems for managing vegetable cropping activities. It ranges on how farmers use technological devices to the acquiring of information through extension support systems. A total of 150 small holder farmers of three regions from three main horticultural zones in Tanzania were randomly selected from vegetable crops farmers and 30 agronomists from different areas across the country. Data were collected through questionnaires and interviews and analyzed through tableau platform. In order to fulfill the focus described above. The findings depicted that a number of farmers had previous experience on the use technological devices but not so familiar with ICT enabled extension support systems for helping them to acquire data on best weather condition and requirements for their vegetable crop production, moreover small holder farmers and agronomist still believe that its useful and beneficial to adopt the ICT enabled extension support systems.*

Keywords: ICT, extension support system, small holder farmer, vegetable, cropping system

Introduction

ICT in agriculture has been identified as the key dimension to agricultural sector growth all around the world, in response to that meanwhile the establishment for e-Agriculture community plays an important role on improving decision making, sharing knowledge, improving the livelihoods of the individuals by managing the crop management activities through building sustainable food security and agricultural practices (Sylvester, 2013).

Apart from ICT providing a fast way for interaction some mobile payment systems provide farmers with the ability to acquire information services that provides access to critical data such a weather and diseases outbreaks. Access to the timely and right information gives farmers the ability to make well informed decisions that impacts on their livelihood and ensures food security. ICT is currently being considered as a tool for change for small holder's farmers specifically for women, it brings out a huge profit for agriculture value chain when rightly induced in day to day practices of agriculture (Palmer, 2012).

According to (Jones *et al*., 2011) greater efficiencies on the use of diverse natural resources such as soil nutrients, water, fertilizers and energy has been enabled through introduction of new information and communication technologies by using an information and knowledge-based approach rather than input intensive agriculture. Effective use and access of timely information helps to improve manage inputs, throughputs and outputs from crop activities, some of the initiated technologies have gone further on monitoring good agricultural practices, trace the farm products and manage pests and diseases.

In Tanzania where horticulture is the mainstay of development with annual growth of 4.2% it contributes to at least three quarters of employment for Tanzanian workers, due to growth of population in this area by more than a million people each year food security is significant (NEA, 2015). Recent studies have focused on examining the importance of technology adaptation in agriculture for several households in Tanzania, results have shown several constraints to the adaption of technology such as access to information and human capital (Kinuthia *et al*., 2017).

However, the main focus of this paper is to access the adaptability of the information and communication technologies used for managing the cropping activities for vegetable production and also to dig deep through the data collected by analyzing the use of technological devices by the small holder farmers in relation to the available extension support system used for vegetable cropping system.

A. Extension services

In Tanzania the extension services for agricultural practices are undertaken through ministry of agriculture with the local procedures where it is free of charge including services such as farm visits, organizing field days supported mostly by initiatives funded internationally with organization like USAID. Meanwhile there are still number of steps to be taken for improving the services since effectiveness and knowledge are very important factors in agricultural activities (NEA, 2015).

During previous times before the massive use of ICT for helping farmers in various agricultural activities extension services has always adapted to a linear model where information is being passed from the research institutions through extension officers and lastly to farmers (Review, 2005). In the years 1960s to 1970s radio was used to deliver information to farmers.

Currently common methodologies used are training and visit approach which turned out to be working for some places and also the face to face approach where it has been costly in terms of resources such as finances, logistics, skilled experts and not easily sustained. In that context most extension services have been about common practices not paving ways for farmers to solve complex issues faced in their farms instead the focus is only on the obvious practices such as high yielding, pests' management, application of chemical fertilizers and pesticides of which in turn growth in agricultural activity became stagnant for most areas. Linear extension model has not been yet successful to support farmers for dealing with complex farm issues and so knowledge-based farming is a way through for farmers to be able to participate in a highly competitive market and global agricultural environment (Sylvester, 2013).

B. ICT in Agriculture

Information and computer technology (ICT) is rapidly changing across the globe. Digital technologies that allow people to be interconnected and share the information are being adapted all over the world at high speed (Janssen *et al*., 2017).

In agricultural practices where, small holder farmers who have been planting same crops over long period of time on the very same soil conditions and weather patterns change faces diseases and pests that come and go (Nordey *et al*., 2017). Farmers need updated information that will allow them to cope with these changes and be able to benefit from them. The biggest challenge is on the provision of these information and such knowledge needs to tailored specifically as per distinct conditions due to agricultural localized nature (Jones *et al*., 2011).

In Africa where agriculture is practiced in traditional ways by most of the small holder's farmers, this agricultural type is comprised with many challenges such as low yielding production, it is rain fed and lacks access to timely and critical information for market facilitation(François Laureys, 2016). On such challenges if ICT gets to be embedded in stakeholder systems may help to bring growth and economic development and also bridge the knowledge gaps for better agricultural practices. Currently there is massive ownership of personal ICT devices such as mobile phones and Tablets among different individual of which it has brought an advantage to the application developers and meanwhile mobile technology is highly adopted as the number one choice of technology for delivering ICT solutions (WorldBank, 2012).

METHODOLOGY

A. Study area

This study has been conducted in the country of Tanzania which endows almost 44 million hectares suitable for agriculture, only 14 million ha is cultivated according to Agricultural Sector Development Strategy due to the fact that some of the areas have low soil fertility, land degradation and drought. Until recently agriculture in Tanzania has been more based on land expansion for cultivation rather than focusing of high yield productivity.

B. Data Collection

The study conducted had different areas focused for data collection which includes regions such as Mwanza, Morogoro and Arusha based on the following criteria, these regions are located in the zones considered as the most horticultural production areas. Zones includes Northern Zone (Kilimanjaro, Tanga, Manyara and Arusha), Coastal Zone (Dar es salaam, Coast and Morogoro) and Lake zone (Mwanza) other zones includes central zone, Zanzibar and southern highland as shown on figure 1. Data from farmers and extension officers has been collected for by using questionnaire since this method gave opportunity for farmers to provide feedback on their experience anonymously (Cohen, L., Manion, L. and Morrison, 2014) together with discussions with key informants and also data has been collected from agronomists through questionnaire and interviews and analyzed through tableau platform for data analysis.

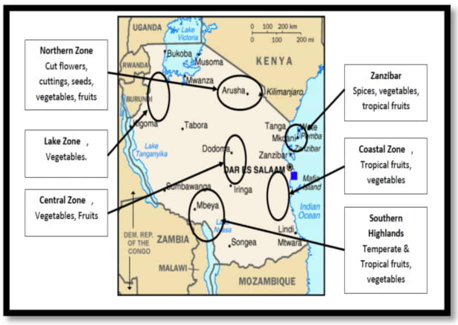


Figure 1: Tanzania map indicating main horticultural zone areas

Source: (NEA, 2015)

RESULTS AND DISCUSSION

The study was focusing on an attempt to understand the use of information and communication technology devices for extension support systems to small holder farmers during managing their vegetable cropping systems. On this study the primary aim of the researcher is to understand on how much technological devices are used by the small holder farmers. The researcher selected about 180 respondents residing in areas specified above 150 of them were small holder farmers which includes the small holder farmers and 30 were the agronomists, the survey was carried out to find the number of farmer who engage their vegetable cropping activities with the use information and communication technology for managing their vegetable cropping system through extension services.

The survey criteria comprised of the followings gender, education backgrounds, types of vegetables grown on a particular area, use of technological devices and whether should the technological systems should be involved on vegetable cropping systems or not. The results obtained from the survey were put through analysis platform called Tableau and presented as follows:

A. Education Background

The results obtained on Fig. 2 shows that 79.73% of 145 farmers engaged with vegetable crop production are female farmers. Out of all respondents 65.52% are female farmers with primary education level. Male respondents make a total of 20.27%. The large number of female farmers being engaged with vegetable cropping could more productive if these women were to be exposed on access to information. Based on the fact that women are not highly favored when it comes to extension services there is a need for them to be empowered and be given high priority on knowledge-based resources. Furthermore, Pinthukas (2015) argues that education level and trainings provided to the farmers have very huge impact on enhancing knowledge on farming and vegetable crops production.

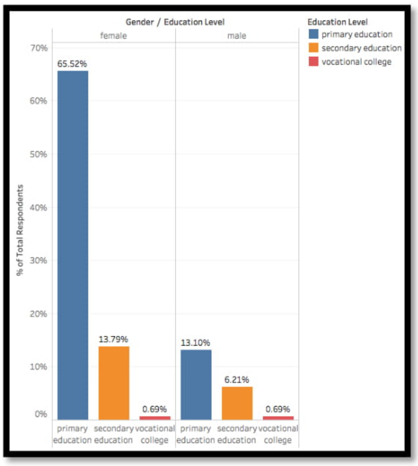
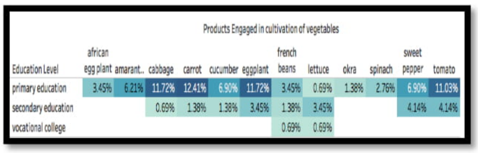


Figure 2: Educational background for female and male small holder farmers

Source: survey for small holder farmers and extension officers (2018)

B. Vegetable crops production

Each farmer responded to the types of the vegetable crops that they are dealing with. Most farmers were found to cultivate more than one type of vegetable crops. The consideration was on a major crop being cultivated by the particular farmer, and results were obtained as shown on fig. 3,



Products Engaged in cultivation of vegetables

Education Level	african egg plant	amarant..	cabbage	carrot	cucumber	eggplant	french beans	lettuce	okra	spinach	sweet pepper	tomato
primary education	3.45%	6.21%	11.72%	12.41%	6.90%	11.72%	3.45%	0.69%	1.38%	2.76%	6.90%	11.03%
secondary education			0.69%	1.38%	1.38%	3.45%	1.38%	3.45%			4.14%	4.14%
vocational college							0.69%	0.69%				

Figure 3: Types of vegetable crops cultivation with education background among small holder farmers.

Source: survey for small holder farmers and extension officers (2018)

The results shown on Fig. 3 interprets that there are diversified types of vegetables being cultivated, but still few of them are cultivated more than others. It can be observed that tomato is cultivated by 15.17%, eggplant by 15.17%, carrot by 13.79%, cabbage 12.4% seem to be crops that are cultivated with farmers from all the education background. For the cases of crops such as French - beans and lettuce are barely cultivated all farmers as far as the education background is concerned.

C. Use of Technology Devices

The targeted technological devices in use by farmers included smart phones or any other related device for communication purposes. This part of the survey helped to understand the level of farmers engagement on the use technological devices. The following are the results of the responds with regards on the use of technology.

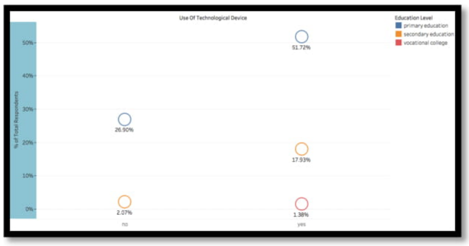


Figure 4: Use of technological devices for small holder farmers

Source: survey for small holder farmers and extension officers (2018)

The possession of technological devices was analyzed against education backgrounds of the respondents as seen in Fig. 4, in order to establish relations between the two. The results imply that education level has impact on the use of technological devices for small holder farmers. Meanwhile, a large percent, which is about 71.03% out of 145 respondents are using technological devices. However, 26.90% out of 28.90% of the respondents are farmers with primary education level who are not using technological device, but this does not setback any proposed technological solution for the farmers since the extension officers are educated and a large number of them can interact with technological devices.

D. Weaknesses on available extension support system and development of technological extension support system

The results shown on Fig. 5 explain the data that was acquired from the agronomists through questionnaire, to give a picture on the available extension support system(s) for small holder farmers. A total of 78.71% out of 30 agronomists agreed that there are weaknesses on the available extension support systems and there is a need for developing a technological extension support system.

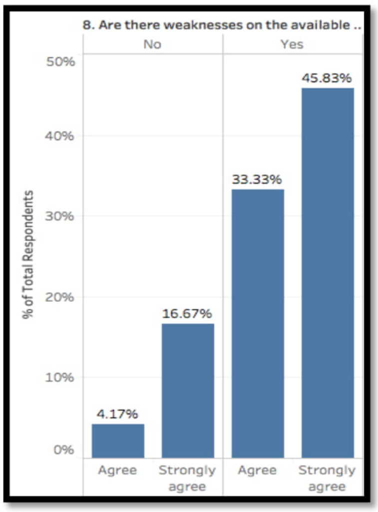


Figure 5: Weaknesses on the available extension support system

E. Experience on the use of available extension support system

The results on Fig. 16 show the respondents' experience on using the available technological extension support system. Out of 30 agronomists, 45.83% have experienced a great value and 45.83% of the users have nothing to say since they have not come across any of the technological extension support system. On a very few percentage, the agronomists have come across poor value of technological extension support system not meeting the required needs.

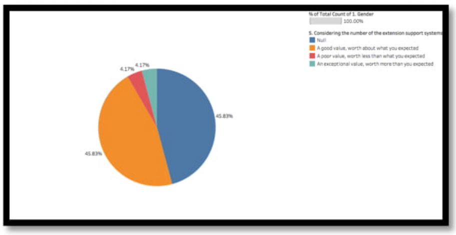


Figure 6: Experience for the agronomists on the use of available extension support system

Source: survey for agronomists (2018)

Proposed solution

The development of an extension support system is being presented as the solution for farmers access to information, where by this system is going to cover all the weather located regions in Tanzania and the platforms is a web application. The following are the key major functions of the proposed solution.

- Providing user data on average weather data (temperature & precipitation) on various weather stations in Tanzania
- A system will provide information on about seven vegetable crops and their requirements for proper cultivation procedures.
- The system will provide the information on possible effects and diseases that may affect those crops.
- The system will give user data on when is the proper period of time to start cultivating and the expected time to harvest but also the best sowing period for start sowing.
- The system will provide a forum platform for farmers to ask questions and get response from the agronomists.

IV.CONCLUSION

Results from the analyzed survey data depicted that the existence of ICT enabled extension support system for small holder farmers is quite not yet well adopted by the small holder farmers, extension officers and agronomists. The perception of small holder farmers who responded to the survey towards the use technological system for their vegetable cultivation activities is quite mixed nevertheless both small holder farmers and agronomist still believe that its useful and beneficial to adopt the ICT enabled extension support system. Meanwhile for the few agronomists who have come across few ICT enabled extension support system for farmers as per figure 7, find that there is a need for adapting to more systems to help farmers manage their day to day vegetable cropping system.

Many of the small holder farmers have better common practices for managing their vegetable cropping system such as use mixed cropping, irrigation system to obtain proper yield. Yet there are few constraints such proper and information on how to plant based on weather data and best crop requirements for their vegetable needs to be adopted through ICT enabled extension support solution for better yielding.

ACKNOWLEDGEMENT

This work is a part of the project supervised by The World Vegetable Centre AVRDC in Tanzania funded by CIRAD in France. However, this work has also been facilitated by The Nelson Mandela African Institute of Science and Technology under the African Development Bank sponsorship.

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Authors' Profiles

Miss. Theofrida J. Maginga has been a Masters student at Nelson Mandela African Institution of Science and Technology taking a degree program in Information and Communication Science and Engineering since 2017.

During her research which is titled as Development of horticultural extension support system for small holder farmer, she has received a recognition certificate for an innovative research given by the NM-AIST. She has received a Bachelor degree in Information Technology of Stefano Moshi memorial University College at Kilimanjaro Tanzania in 2016.

Dr. Mussa Ally Dida has been a Lecturer of NM-AIST since 2017 and an Academic manager of Centre of excellence for ICT in East Africa (CENIT@EA) also hosted by NM-AIST. Before his promotion, he has previously he has been an Assistant Lecturer at NM-AIST from April 2012 to June 2017. He received his PhD in Communication Engineering at Beijing Institute of Technology in June 2017 and Masters of Science in Telecommunication Engineering at University of Dodoma in 2011 and Bachelor of Science in Computer engineering and Information Technology from university of Dar es salaam in 2008. His research interests include Tanzania digital signal processing, Physical layer security, and embedded system for agriculture.

POSTER PRESENTATION

DEVELOPMENT OF HORTICULTURE EXTENSION SUPPORT SYSTEM FOR SMALL HOLDER FARMERS: A CASE OF TANZANIA

Theofrida J. Maginga[a], Dr. Mussa Ally[a] & Dr. Thibault Nordey[a]

[a]The Nelson Mandela African Institution of science and technology, Arusha, Tanzania ; [a]The World Vegetable Center, Arusha, Tanzania

Introduction

Horticulture plays the role for food security, economic growth and nutrition improvement for many small holder farmers.

The availability of clear information flow for vegetable cultivations, crop requirements, climatic condition, pests and diseases information based on locations constantly help farmers to come up with proper potential yield of the vegetable crops, also plays a very important role in improving the horticulture subsector of the agriculture.

Development of the ICT- enabled extension support system in relation to making these information available will act as an agent to change agricultural situation and improve farmers' access to knowledge sharing and access to information.

System Functionalities

The main focus of the application is to help farmers in Tanzania to design and manage their vegetable cropping system. The followings are the specific functions:

- Providing user with data on average weather information (temperature & precipitation) from various weather stations in Tanzania
- The system provides information on seven common vegetable crops and their requirements for proper cultivation procedures including, rotation.
- The system provides information on possible effects of pests and diseases that may affect crops and its preventive measures.
- The system gives user data on when is the expected time to harvest crops and the best sowing period for vegetable crops.
- The system provides a forum platform for farmers to ask questions and get technical advices from the agronomists or experienced personnel.

Methodology

The system has been developed from the collection of user requirements data through questionnaire and interview methods.

- Data were analyzed and agile methodology has been used to develop the horticultural extension support system.

- Programming Languages used were MySQL, PHP, JavaScript, CSS and HTML.

System Implementation

The main parts of the system developed are user interface, application server, database server and access device.

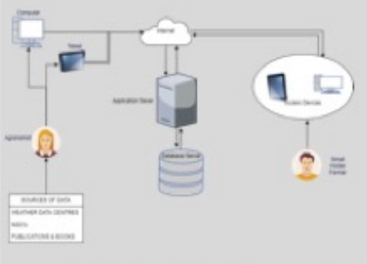

Figure 1: Application Design Framework

Figure 2: Home page for users to interact with the system

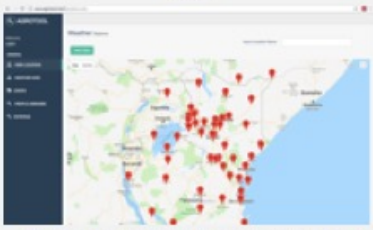

Figure 3: Weather station for allocated weather data in the database

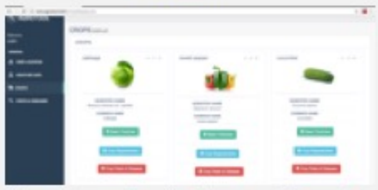

Figure 4: Page various displaying crops with respective requirements

Conclusion

This research primarily intends to help small holder farmers to get clear flow of information on how to plant vegetable crops based on weather data and best crop requirements through ICT enabled extension support system.

Results from the analyzed survey data depicted that the existence of ICT enabled extension support system for small holder farmers is quite not yet well adopted by the small holder farmers, extension officers and agronomists.

Despite the slow adoption, the initial implementation of the extension support system developed showed that agricultural stakeholders are willing to use the system due to the number of users who visits the the hosted web application.

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Contacts

THEOFRIDA J. MAGINGA

NELSON MANDELA AFRICAN INSTITUTION OF SCIENCE AND TECHNOLOGY
+255 718 918 885
Email: magingat@nm-aist.ac.tz