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A USSD and android based tea farming information system: a case study of Mungania Tea Factory Company Limited

Kenedy Munene Njeru

Faculty of Information technology (FIT)
Strathmore University

A USSD and Android Based Tea Farming Information System: A Case Study of Mungania Tea Factory Company Limited

Kenedy Munene Njeru

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Faculty of Information Technology

Strathmore University

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Declaration and Approval

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the dissertation contains no material previously published or written by another person except where due reference is made in the dissertation itself.

Kenedy Munene Njeru

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Approval

This dissertation of Kenedy Munene Njeru was reviewed and approved by the following

Dr. Bernard Shibwabo,

Academic Director, Faculty of Information Technology,

Strathmore University

Dr. Joseph Orero,

Dean, Faculty of Information Technology,

Strathmore University

Professor Ruth Kiraka,

Dean, School of Graduate Studies,

Strathmore University

Abstract

Current trends in information and communication technology have led to emergence of smartphones with faster wireless speeds, faster graphics, better screens, and faster chips, virtual and augmented reality. These phones are context-aware, have embedded physical sensors, have data exchange capabilities and allow installation of applications to perform almost any task. Tapping into this technology can lead to development of mobile information systems that promote sustainable farming through timely information access, especially in tea farming. The traditional practice in tea farming has seen dissemination of information through extension officers, Farmer Field Schools, mass media or farmer's own experience. Consequently, this vital information is either accessed too late or when obsolete and sometimes completely lacking. Limited access to information has led to an information gap hence farmers practice poor planning and farming resulting to reduced revenue for both farmers and the Government of Kenya and environmental degradation. This study focused on developing a tea farming information system to meet the information needs of tea farmers. The nature of the study required the researcher to adopt deductive approach so as to compare the data findings against the existing literature through logical reasoning. A case study strategy was employed to gain a rich understanding of the research perspective with the focus being the tea farmers of Mungania Tea Factory Company Limited. Through qualitative and quantitative analysis the research findings can be generalised to all the tea farmers. Agile system development methodology was employed due to its sustainable development having testing integrated throughout the lifecycle. Scrum framework was adopted to allow for faster iteration with quick and accurate response to changes from user feedback. The contribution of this research concerns adoption of a tea farming information system to improve on productivity, service delivery and profitability, decision-making and farmer protection from fraud and losses. Moreover, it facilitates the communication between the factory and the farmers giving easier access to extension services. It further enhances processing of more accurate and comprehensive information and generation of useful reports.

Keywords: Information access, tea farming, information system, Mungania, KTDA, USSD.

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Abbreviations / Acronyms

AFFA	-	Agriculture, Fisheries and Food Authority
GSM	-	Global System for Mobile
ICT	-	Information and Communication Technology
KTDA	-	Kenya Tea Development Agency
OS	-	Operating System
SMPP	-	Short Message Peer-to-Peer
SMS	-	Short Message Service
USSD	-	Unstructured Supplementary Service Data

Definition of Terms

Android – A Linux-based open source OS developed by Google for touchscreen mobile devices such as smartphones and tablets (Christensson, 2016).

API – Application Programming Interface (API) is a set of commands, routines, protocols, and tools for building software applications or interacting with external system (Christensson, 2016).

MySQL – This is an open source relational database management system based on the structure of Structured Query Language (SQL) that is used for adding, removing and modifying database information (Christensson, 2007).

SMPP – A protocol for exchanging SMS messages between Short Message Service Centres and External Short Messaging Entities (SMSGlobal, n.d.).

Acknowledgements

I acknowledge the Almighty God for His favour and grace so far in all my undertakings. I cannot forget to mention the contribution of my family members through the various challenges. Their encouragement has urged me on.

I appreciate my supervisor, Dr. Bernard Shibwabo, for guidance towards preparation of this dissertation.

Dedication

I dedicate this work to my family for their unequivocal support and all the tea-growing farmers of Mungania Tea Factory Company Limited.

Chapter 1: Introduction

1.1 Background

1.1.1 Information Systems and Technology

The advancement in technology has been exceptionally fast in this century. ICTs have become more powerful, more accessible and more widespread contributing heavily to the increase in overall investment and efficiency of labour and capital (Dutta, Geiger & Lanvin, 2001; Pilat & Lee, 2001). Agriculture can tap into ICTs that will save on costs and time resulting to attainment of a competitive advantage. Some of the technological advancements embraced in agriculture include agricultural biotechnology, machinery, and genetically produced plants just to mention a few. This is a pointer to the fact that farmers are ready and willing to adopt technologies that ease their work and boost production.

Mobile technologies have evolved from first generation of analog communication to the Long Term Evolution (LTE) digital communication that supports voice and broadband Internet access. Mobile technologies bring simplicity and rich functionalities making communication easier. These technologies address different aspects of information needs for the farmers. They include applications on market information, weather data, learning or advisory services, and agricultural news among others. Applications like FarmGraze (Chase, n.d.), M-Shamba (Vutagwa, 2014) and Horse Ration App (Farrell, n.d.) demonstrate some of services farmers' access through real-time communication.

Users of the mobile technologies can thus enjoy calls, messages and GPRS/3G services. The immense contribution by mobile technologies notwithstanding, they have been locked with controversies an example being that cell phones could cause brain cancer due to exposure to Radiofrequency (RF) radiations. However, no consistent evidence of adverse health effects from exposure to radiofrequency fields at levels below those that cause tissue heating (Ahlbom, Green, Kheifets, Savitz & Swerdlow, 2004; Dasdag et al., 2003; World Health Organisation Media Centre, 2014). Moreover, secure communication still remains a concern in mobile computing.

A mobile information system should ensure that the user gets the relevant information based on the physical location, user preferences and time among other factors through context awareness. Mobile handsets have evolved from basic phones, feature phones to smartphones. Current trends in mobile technology have led to emergence of smartphones with faster wireless speeds, faster graphics, better screens, faster chips, virtual and augmented reality (Shah, 2016). These phones are context-aware and adapt to highly dynamic environments, have embedded physical sensors, have data exchange capabilities and allow installation of applications to perform almost any task (Gu, Pung & Zang, 2004; Zheng, Zhang & Yan, 2014). These mobile applications are software application with limited functionality developed for small devices like smartphones and tablets.

SMS provides a service for sending short messages of up to 160 characters. The SMS though common is limited by short messages, high cost and no immediate feedback. The service allows for sending bulk messages. Some of the factors discouraging adoption of SMS-based services include: perceived usefulness, perceived responsiveness, perceived relevance, quality and reliability of the information, trust in the SMS technology, perceived risk to user privacy; perceived reliability of the mobile network and the SMS-based system, trust in the government and perceived quality of public services, perceived risk to money, perceived compatibility, and self-efficacy on using SMS (Susanto & Goodwin, 2010).

USSD on the other hand gives a session-based service that offers simple browsing through a menu driven data interface on a user device. It works on all GSM handsets with messages sent directly over the network signaling channels, which means it does not require application installation. It is more secure than SMS and provides a real time session. USSD and SMS services do not support rich media content hence the need for an installable application. USSD has the shortcomings of time-out period that disconnects the user from system without saving message and limitation of 180 characters per screen up to a maximum of four (4) screens limit (Leung & Leung, 2016; Quirk, n.d.).

The growth in mobile technologies has also been fueled by the development in wireless networks for example cellular network. Wireless network uses radio signal frequency for connecting network nodes. This network has grown in popularity due to convenience, mobility, productivity, security, and reduced cost. A cellular network is a radio network distributed over land through cells where each cell includes a fixed location transceiver known as base station, which transmits common control signals and data signals to mobile users (Niu, Wu, Gong, & Yang, 2010). This gives a subscriber the advantage of larger geographical coverage, low battery power usage, and reduced interference from other signals.

1.1.2 Tea Farming Information Relay

Challenges that keep many small hold farmers locked in poverty stem from a lack of access to market information, technical knowledge, inputs, financing and accessible markets where they can sell their products (Okello, Okello & Ofwona-Adera, 2009; Winter, 2012). This implies that relaying timely information is vital. With the use of mobile technologies, this information will be available at the convenience of the farmer on the go. Moreover, in a research on fertiliser application, it was noted that some farmers use less than or more than recommended fertiliser rates (Mwaura & Muku, 2007). This can be attributed to lack of information. This information gap was the main motivating factor for the researcher to study ways in which it could be mitigated for the tea farmers.

Current communication structures at Mungania Tea Factory Company Limited are through circulars and notices that are prone to mutilation. In some instances information passage is through word of mouth from factory to the members in different green tea leaves collection centres. Moreover, use of printed advice slip and special and annual general meetings reports is prone to tear and ware, misplacement, delay in information access and limits information accessible. The requirement to provide farmers with weekly reports on the prices achieved at Mombasa auction will not be achieved by these communication structures.

1.2 Problem Statement

Information-intensive enterprises including agricultural enterprises require provision of timely information. Mittal and Mehar (2012) noted that information needs are growing rapidly with introduction of modern technologies, hybrid seeds and changing climatic changes hence farmers find traditional knowledge, experience and guesswork in decision making ineffective. The prohibitive high cost of face-to-face interaction and crumbling extension services underscores the need to lay emphasis on the potential of ICTs in disseminating agricultural information to targeted farmers (Fischer, Byerlee & Edmeades, 2009; Mittal & Mehar, 2012). In tea farming this timely information includes but not limited to services by extension staff, seedlings availability, advice on the control of pests and diseases.

Use of circulars, notices and word of mouth in relaying information to the farmers has led to delayed delivery or complete total lack of access to information. Consequently, farmers practice poor planning and farming resulting to environmental degradation and reduced revenue for both farmers and the Government of Kenya. The researcher therefore sought to address the problems faced by the farmers through developing an information system for timely provision of information on the go leading to faster and informed decisions. This would provide for accurate and comprehensive information, generation of useful reports and search for specific information on the system as needed.

1.3 Research Objectives

i. To analyse information needs of tea farmers.
ii. To investigate weaknesses on the existing information systems in tea farming.
iii. To design, develop and test an information system that will meet information needs of tea farmers.
iv. To validate the developed information system.

1.4 Research Questions

The research questions that the researcher seeks to answer include:

i. What is the information needs of tea farmers?
ii. What are the weaknesses to the existing information systems in tea farming?
iii. How will the proposed information system be designed and implemented to address the information needs of tea farmers?
iv. Does the proposed information system meet information needs of tea farmers to affect their decision-making?

1.5 Scope and Limitations

Geographically the research was limited to farmers from Mungania Tea Factory Company Limited, one of the factories managed by KTDA, which processes the green tea leaves for the farmers within Kianjokoma and its environs. Currently, there are about 560,000 small hold tea farmers selling their products in 67 factories managed by KTDA (IFC, 2016). The factory is located on the South Eastern Slopes of Mt. Kenya, Eastern Province, Embu County, Runyenjes Sub-County, Kagaari Location, Kianjokoma Sub location, Kiandong'o Village. It is 20 kilometers from Embu town the County Headquarters and 152 kilometers from Nairobi the capital city of Kenya (KTDA, n.d). The factory currently serves 9, 024 small-scale tea growers.

It is expected that from the measures undertaken in this study, the results herein can be replicated in other factories. The developed information system targeted Android mobile phones for the installable application but had a USSD application that could be used with other phones. The choice for Android platform resulted from its dominance in market share as shown in Figure 1.1 below, for smartphones translating to a higher impact.

Period	Android	iOS	Windows Phone	Others
2015Q4	79.6%	18.7%	1.2%	0.5%
2016Q1	83.5%	15.4%	0.8%	0.4%
2016Q2	87.6%	11.7%	0.4%	0.3%
2016Q3	86.8%	12.5%	0.3%	0.4%

Figure 1.1 Smartphone OS Market Share (Adapted from International Data Corporation, n.d.)

The researcher encountered the following limitations in the quest to carry out the study:

i. Some farmers lacked smartphones hence only accessed limited USSD application services and could not enjoy features of the native Android application.
ii. Some resistance from those not willing to share information but the researcher created a rapport with the respondents. Focus groups were adopted to iron out issues.
iii. Infrastructural improvement and assistance from farmers helped the researcher maneuver the rugged terrain. Inaccessibility of some areas due to rugged terrain and weather changes.

1.6 Justification

Firstly, there has been an increased plantation area under cultivation for the tea by farmers resulting to increased tea production. On the contrary, as shown in the Figure 1.2, the yield (Tonnes/Hectare) has not improved at the same rate indicating a decline in yield per hectare. This in turn translates to reduced revenue to both the farmers and the Government of Kenya. Figure 1.3 further demonstrates a variation in average yield in Kilograms per Hectare between 2010 and 2014.

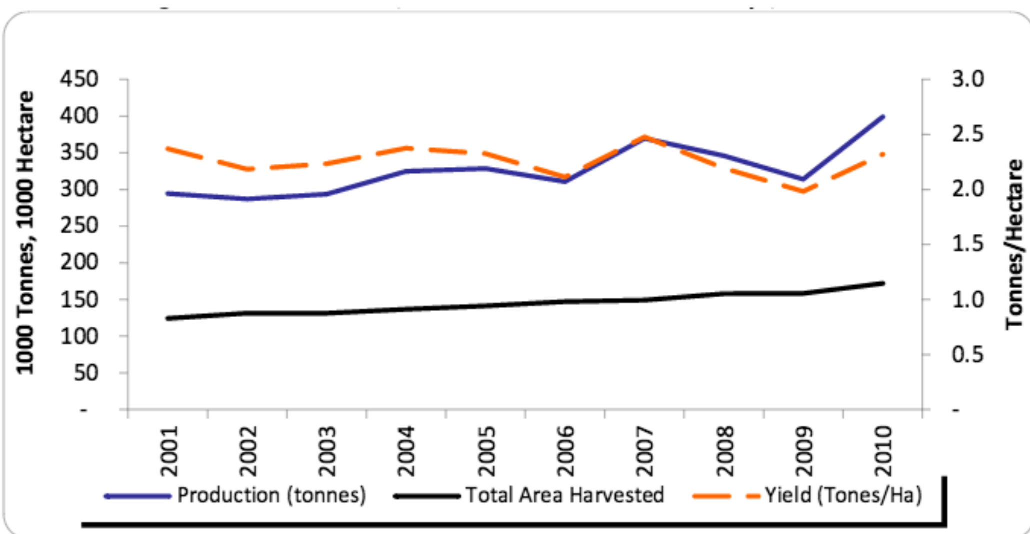


Figure 1.2 Yield of Tea in Kenya 2001 - 2010 (Adapted form Monroy, Mulinge & Witwer, 2013)

Year		2010	2011	2012	2013	2014
Area (Ha) '000	Smallholder	115	123.3	124.9	127.3	128.6
	Estates	56.9	64.5	65.7	71.3	74.4
	TOTAL	171.9	187.8	190.6	198.6	203
Production (Tonnes)' 000	Smallholder	225	218.6	218.5	249.8	262.4
	Estates	174	159.3	150.9	182.6	182.7
	TOTAL	399	377.9	369.4	432.4	445.1
Average Yields (Kg/Ha)	Smallholder	2,291	2,040	2,039	1,900	2,127
	Estates	3,412	3,149	2,953	2,652	2,834

Figure 1.3 Average Tea Yield in Kenya 2010 – 2014 (Adapted from AFFA, 2014)

Secondly, De la Paix Mupenzi et al. (2011) observed that use of organic fertilisers lead to soil acidity and soil degradation especially near tea plantations. Zhang, Wang and Duan (2016) assert that introduction of agricultural informatisation in China, reformed traditional agriculture by ICTs contributing to the significant improvements in agricultural productivity and sustainability. Zhang et al. (2016) describes informatisation as transformation of society and economy by effectively deploying ICTs in business, social and public functions. Tiampati (2015) identified environmental sustainability to be a key mitigation measure in addressing challenges faced in tea production as shown on Table 1.1.

Table 1.1 Tea Farming Strategic Mitigation Measures (Adapted from Tiampati, 2015)

Strategic Mitigation Measures
Business diversification
New products and markets e.g. orthodox tea, purple tea, green tea etc.
Energy cost reduction initiatives

Efficiency improvement
Human capital investment – PKF
Adoption of new technology – SAP
Environmental sustainability

Lastly, trends in the telecom sector place Kenya at a good position in regard to access of mobile phone. 82% of the Kenyan population owns a mobile phone with 37% being connected to Internet (PewResearchCenter, 2014). Teller (2013) in a research finding noted that mobile data continues to dominate the market contributing to 99% of Internet subscriptions These pointers indicate Kenyans' commitment in adoption of mobile technology and consequently consumption of mobile solutions addressing their challenges. In the year 2014, Kenya was found to have a 67% smartphones penetration (TechZim, 2014). Availing information to tea farmers through a native Android application and a USSD application will reach a large group of beneficiaries.

These pointers asserts the need to reform the sector to improve production leading to increased revenue both to the farmer and the Government of Kenya. There is need for agricultural information and there is technological advancement that can be tapped into to make this a reality.

1.7 Organisation of the Study

This dissertation was organised into seven main chapters as indicated below.

Chapter 1: This chapter introduced the reader to the problem that the researcher sets out to investigate and address. A background on the problem was laid down as well as the research objectives and questions to be addressed.

Chapter 2: This chapter delved into review of research or literature that has been undertaken in the area that the researcher was addressing.

Chapter 3: This chapter highlighted the methodologies that the researcher employed to accomplish the research objectives. It further elaborated how data would be collected and how analysis would be carried out thereafter.

Chapter 4: This chapter concentrated on identifying the requirements for the system being developed and designing the system in a manner that met the user requirements.

Chapter 5: This chapter focused on the implementation of the system ensuring that all modules were in place as required. The modules were tested and the results thereof presented. The system was further validated to verify that it met the information needs of tea farmers.

Chapter 6: This chapter elaborated what the test results indicated. More discussions and deductions were provided for the data that the researcher had collected.

Chapter 7: This chapter gave the conclusions and recommendations of the researcher for future work in this area of study.

1.8 Conclusions

In this chapter, the researcher put into perspective the background information regarding the problem that was being addressed. The objectives and research questions were clearly elaborated as well as the justification supporting the need to carry out this study. The proposed information system sought to mitigate the problem of information access leading to informed decisions hence boosting production. Improved production translates to increased revenue to both farmers and the Government of Kenya. The next chapter, literature review, critiqued the research that has already been done in this area of study.

Chapter 2: Literature Review

2.1 Introduction

This chapter provides a comprehensive review of the literature or research related to the problem under investigation. Farmers take their green tea leaves to the collection Centres and expect constant update on their information needs by the factory. However, delayed information and faulty channels of information delivery characterises this crucial duty of the factory. Farmers have also wondered whether the information they receive is adequate. The overall effect is poor production escalated by environmental degradation resulting from persistent poor farming decisions culminating to reduced income to the farmers and government. The importance of tea cannot be over emphasised as World Bank (2016) noted that tea has been a major cash crop and a leading foreign exchange earner for Kenya.

As a result, the researcher set out to identify the information needs of the farmers as well as determine an alternative efficient and effective method of information delivery to the farmers. In its report on Gender and Agriculture in the Information Society, Odame (2002) noted that inadequate use and access to information by rural people contributes to their poor status in economic development. This fueled the need to investigate whether timely provision of information would lead to higher production. Although access to knowledge and information remains least expensive input for rural development, small hold farmers lack economic capability to access and use relevant information (Balit, 1998; Gundu, 2006).

2.2 Information Needs in Tea Farming

2.2.1 What is an Information Need?

Belkin (1978) argues that information need is prevalent when a person recognises their state of knowledge has an anomaly and seeks to solve it. McGarry (1993) defines it as a lack of something which if present will further our welfare or ease attainment of our objective. Information need could be further defined as a state of lack of desirable information necessary to deal with a situation accordingly or achievement of a genuine or legitimate information purpose (Derr, 1983; Kaniki, 1992). Consequently, information need could be described as a gap resulting from uncertainty caused by lack of necessary knowledge to handle something. For instance, a farmer who wants to apply fertiliser in the farm but does not know the fertiliser's acreage rate will require this information to accomplish the task.

2.2.2 Tea Farming

About 35 countries of the world cultivate tea where China, Sri Lanka, India, Indonesia and Kenya are the major tea exporters with Kenya being the world leader (Basu, Bera & Rajan, 2010; Hicks, 2009). Small hold tea farmers drive tea production in many countries. Ganguli (2014) observed that small holders account for 76% of total production in Sri Lanka, 62% in Kenya, 43% in China, 23% in Indonesia and 26% in India. Smallholder's tea farmers are those who do not have the power to own a tea processing factory in Kenya, cultivates 20.2 hectares or less of land in Sri Lanka, cultivates 10.12 hectares or less of land in India and cultivates about 2 hectares or less in Indonesia (Ganguli, 2014; Tittonell, Vanlauwe, Leffelaar, Shepherd & Giller, 2005).

The small hold farmers sell their green leaves through middlemen, stand-alone privately-owned processing units, integrated plantation units and/or cooperative/collectively-owned units with small hold farmer's participation. CPDA (2008) noted that the managerial service of KTDA involved advising farmers on best practices through extension officers, provision of inputs, collection and transportation of green tea leaves, processing and marketing of final product. According to Kenya Human Rights Commission (2008), tea research was initiated in 1949 by Brooke Bond limited that later became Research Institute of East Africa (TRIEA) and then Tea Research Foundation of Kenya (TRFK) in 1980. The researcher thus seeks to provide a channel to share findings on technologies, crop improvement and management, sustainable ecosystem and conservation, value addition among other things.

2.2.3 Information Needs of Tea Farmers

Ozowa (1995) categorically grouped information needs into agricultural inputs, extension education, agricultural technology, marketing and agricultural credit. This is further supported by Odini (2014) who indicated that farmers needed relevant and adequate information on agricultural inputs, marketing, selection of variety of seeds, high yield crops, pest control, fertiliser applications and problem solving skills as demonstrated on Table 2.1. Agricultural inputs include the consumable and capital inputs required for organic farming. For instance seeds, fertilisers, agrochemicals, machineries and levelers.

Table 2.1 The Kind of Information Needs (Adapted from Odini, 2014)

Kind of Information	Respondents (F)	Percentage (%)
Agricultural inputs	120	80
Improved variety of seeds	103	67
Access to credit	100	67
Marketing	97	65
Weed control	87	58
Cultivation techniques	87	58
Harvesting techniques	86	57
Animal husbandry	80	53
Home economics	78	52
Crop management	72	48
Farm management	72	48
Soil conservation	66	44
Farm mechanisation	64	42
Land ownership	59	39

The required Extension education refers to the practical skills on how various technologies or agricultural practices are to be carried out. Farmers further require information on technologies that make-work easier and boost production as well as access to those agricultural technologies. In addition, farmers need to be trained and informed on how they could have access to credit to boost their production or purchase needed technological inputs. Lastly, to market their produce, information about market prices helps eliminate middlemen as well as give the farmer a choice of where to sell products leading to higher returns. Having ready markets eliminates post-harvest losses.

2.3 Existing Information Systems in Use

2.3.1 Information Seeking Patterns

Information seeking is the process of identifying, choosing and establishing provider to satisfy the information need. Prasad (1992) asserts that information seeking is concerned with integrative utilisation of three basic resources, which are people, information and systems. Hence for a farmer seeking for farming information, they may turn to their personal sources like friends and relatives or formal information systems such as libraries and the Internet. A study by Odini (2014) discovered that farmers sought information by asking friends, neighbors, talking to relatives or those thought to be having right information, listening to radio and others using mobile phones as demonstrated on Table 2.2. A stable reliable information system ought to be in place to counter bias.

Table 2.2 Information Seeking Patterns (Adapted from Odini, 2014)

Seeking Behaviour	Respondents	Percentage (%)
Asking people such as friends, neighbours and relatives	93	62
Listening and talking	87	58
Discussions with those who have information	80	53
Listening to radio	77	51
Watching TV	30	20
Use of mobile phones	23	15
Consulting extension officers	7	4
Browsing internet	3	2
Sending email	1	0.6

2.3.2 Determinants of Agricultural Information and Technology Access by Farmers

Age, farm size, gender, literacy levels, land ownership, credit access and desire to produce more can be identified as some of the factors influencing information access and technology adoption. According to Katungi, Edmeades and Smale (2008) older farmers seemed less likely to engage in information receiving and providing which could be due to their low ability to communicate. Hite, Hudson and Intarapapong (2002) observed that farm size, farming experience and education influence the adoption of technologies. Male farmers are engaged in more geographically dispersed social networks, thus giving them a greater chance to access information (Haddad & Maluccio, 2003). Large families tend to seek more information due to the need for satisfying family consumption as well as higher number is exposed to get information.

Manda (2002) noted that interventions by international NGOs, overdependence on foreign funding for research and development in agriculture and private sector involvement could further increase information gap between the haves and the have-nots. On the contrary, the researcher is of the view that, these interventions have immensely contributed to the development of agriculture. Coordination of research, information sharing and dissemination is what ought to be addressed. Agricultural innovation is largely affected by information available on the innovation and how well that knowledge is passed to the stakeholders (Arumapperuma, 2008; Barrios, Ryan & Daquis, 2011; Baumuller, 2012; Ogutu, Okello & Otieno, 2014). This calls for a reliable and efficient information system that is not subject to the enumerated limitations.

2.3.3 Agricultural Dissemination Channels

Monu (1982) categorically stated that information dissemination is the basic sociological process leading to agricultural change and development through the adoption of new farming technology. Effective information access requires dissemination channels to be oriented towards the user's needs, as well as the types and levels of information and in forms and language preferred by the user (Barbara & White, 2001). Manda (2002) identified that information was delivered to farmers through monthly magazine, agricultural radio programmes, films and posters by extension agents and agricultural shows and competitions organised at different administrative levels.

Moreover, websites, social media, newspapers, notice boards, use of leaflets, exhibits, public campaigns, banners, visual aids and radio programs were employed (Asenso-Okyere & Mekonnen, 2012; Bertot, 2012; Oxford University, 2003; Ozowa, 1995; Vance, 2009). These methods come with delays, lack convenience and may not be relevant to the specific needs of the farmer. The major contribution by extension officers has been promotion of good management practices with farmers using field days, demonstrations and direct advice but they have suffered from limited numbers and cultural inhibitions (Asenso-Okyere & Mekonnen, 2012; Mitei, 2011). Whereas mass media is effective in creating awareness of an innovation it might have limited influence on their adoption.

Mitei (2011) further observed that a successful implementation of Farmer Field Schools resulted to better empowerment, access to information, personal development, conflict resolution, and relationship with the factory and leadership ability (Mitei, 2011). Moreover, Zhang et al. (2016) identified more agricultural information dissemination models such as web portal, voice-based service, text (SMS) based service, self-support online community, interactive video conferencing service and mobile Internet based service. A Web portal host a collection of relevant websites hence gives easy access to extensive information to the farmer.

Voice based service disseminates information through phones and online voice calls giving an interactive and individualised service to farmers. Text based services disseminate information through mobile phone texts bringing on board efficiency, effectiveness and timely information. Online community provides an interactive platform with membership of farmers and experts that derives its success on stakeholders' participation. Interactive video conferencing service also demands interactive communication since information dissemination is by online conferencing. Use of mobile phone technology to deliver agricultural information is on the increase as demonstrated on Table 2.3.

Table 2.3 Technology Used to Deliver Agricultural Information (Adapted from Gakuru, Winters & Stepman, 2009)

Technology Used	Number of Projects
Internet	47
Radio	17
Television	2
CD-Rom/Video/DVD	6
Mobile phone	22
IVR	4
SMS	16
Telephone (Call - in)	4
Dial – Up radio	1
GIS	1

2.3.4 Mobile Technologies in Agriculture

Mobile technology has made communication and information access convenient and timely to users. This has led to development of smartphones with many features and capabilities. Smartphones have gained popularity due to individuality, user friendliness, timeliness, portability, interactivity and connectivity. However, this comes with some limitations like limited computational power, limited battery life, inconvenient input and output interface, and insufficient contents. Various ICT-based initiatives have been developed to provide information to farmers in areas like market information, financial information, effective agricultural practices, research, and weather among others.

Applications like FarmGraze (Chase, n.d), M-Shamba (Vutagwa, 2014) and Horse Ration App (Farrell, n.d) demonstrate some of services farmers' access through real-time communication. FarmGraze is an Android application that helps the farmer to measure, record and manage grazing by saving time, and unnecessary feeds and fertiliser as shown in Figure 2.1. It mainly deals with dairy cows, beef cattle and sheep. HorseRATION helps the farmer to accurately calculate the amount of feed to give to the horse helping to save money and repercussions that would result from overfeeding. M-Shamba is an Android application that further includes SMS and web platforms that enables farmers to access information on crop production as well as link them to the market.

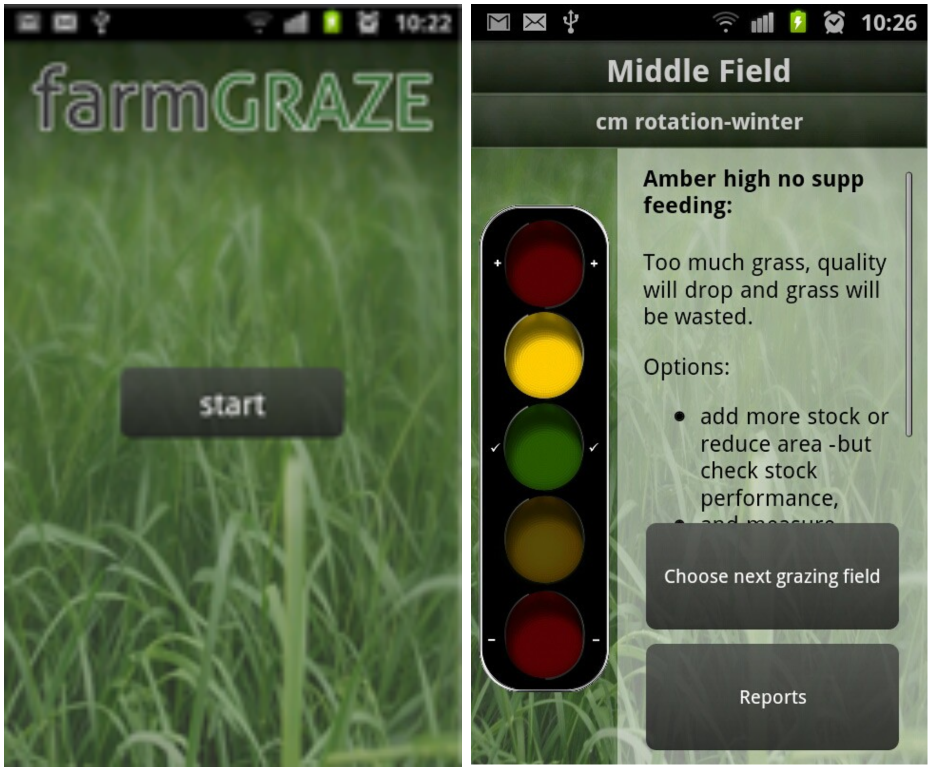


Figure 2.1 Screenshots for the FarmGraze (Adapted from MobileFarm, 2013)

Moreover, USSD based applications have been employed to disseminate information to farmers due to their real time and instant messaging capability offering a better and cheaper performance than SMS for two-way transactions. An example is Dialog Tradenet (Dialog, 2009) that disseminates agricultural information though SMS, USSD and web.

2.3.5 Mobile Technologies in Tea Farming

WeFarm (Barthorpe, 2016) is one of the services that seek to address the issues of tea farmers. WeFarm allows farmers to share information via SMS. A farmer can ask question on farming and receive a crowd-sourced answer from other farmers around the world in minutes as shown in Figure 2.2. Virtual City (Thuo, 2016) has helped KTDA to keep track of green tea leaves leading to an increased delivery yield per farmer. This is done through tracking quantities and qualities delivered to the collection centres as shown in Figure 2.3. WeFarm suffers from the weaknesses of an SMS service and that the crowd sourced solutions might not be applicable in a given locality. Moreover, Virtual City only tracks the delivery of the farmer yield but does not meet information needs for farming. These needs are being addressed by this research.

Figure 2.2 How WeFarm Works (Adapted from WeFarm, n.d.)

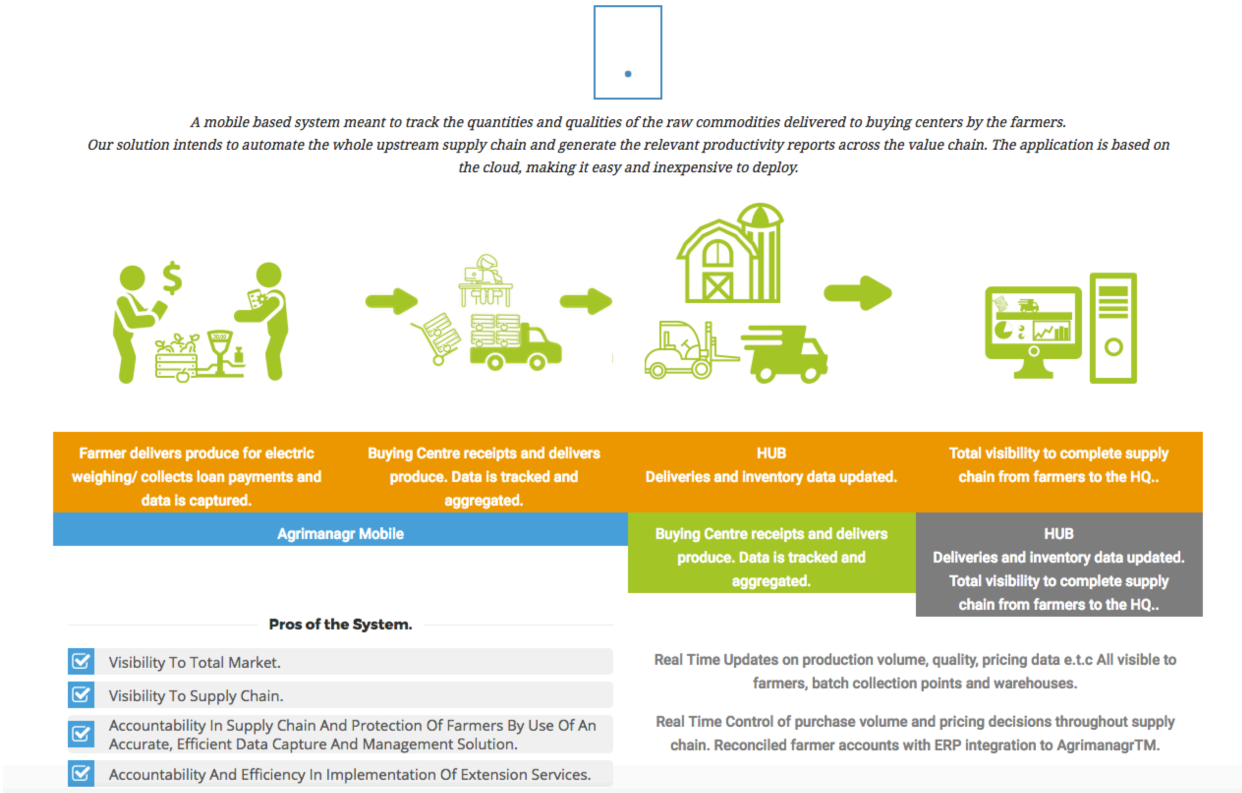


Figure 2.3 How Virtual City Works (Adapted from Virtual City, n.d.)

KTDA also adopted the use of M-PESA, which is a fast, secure and convenient way to transact on mobile, for Factory Door Sales (FDS). This enabled them to curb loses related with cash transactions, facilitate audit on money raised and utilised through FDS, increase accountability and transparency as well as save time on financial reconciliation since M-PESA is automated (KTDA, n.d.).

2.3.6 Existing System Weaknesses

The researcher observed several existing gaps which when handled could put in place an efficient and effective system in relaying information to farmers resulting to increased technology adoption. Extension officers have a limited reach to the farmers due to their few numbers and cultural inhibitions for interaction with women farmers (Asenso-Okyere & Mekonnen, 2012; Sibanda, 2012). The officers need to create content in line with the farmer's feedback from interactions with them. Most of the extension officers are also not trained on how to handle the local communities. Zulberti (n.d.) further argues that extension officers have inadequate resources, insufficient communication capacity, limited knowledge and skills and they are affected by poor infrastructure and farmers lack of basic farm resources.

Mass media like radio, television, film, video, magazines, leaflets, audiocassettes, newspapers, leaflets and posters may not address specific farmer needs since it is not tailored to the needs of rural populations. There is also issue of poor reception, and coverage in some areas. Limited reach and technical language used may be restricting or incomprehensible to the farmer. In addition, agricultural shows have poor attendance by farmers and many are structured as avenues for showcasing rather than training. Oakley and Garforth (1985) observed that mass media could not offer personal advice and support, teach practical skills or answer questions immediately.

Farmer Field Schools (FFS) are also common in delivery of information and were taken to replace the traditional top-down extension method. Khatam et al. (2010) observed that FFS suffered from being expensive to implement, time consuming and having a difficult weekly routine to attend school. Besides FFS requiring the presence of extension officers or experts for coordination and lack of institutional support they are not effective when taken to scale. The use of libraries is limited by their location in urban areas hence farmers do not see them as potential providers of useful information. A Web portal represents a one for all information with no customisation making them irrelevant to specific farmers' needs.

Voice based services are more expensive, time consuming, less efficient, require human involvement and machine to produce voice, lack pictorial illustration and not readily embraced by farmers (Gakuru, Winters & Stepman, 2009; Zhang et al., 2016). Moreover, text based service are limited in information they carry to provide comprehensive and in-depth information to address specific needs, require basic level of literacy besides being relatively costly. Online communities and interactive video conferencing require interactive communication with experts making them time consuming and less efficient. They are costly and limited to members. Relying on social media for information access leads to identity misuse, privacy and security issues and invalid information dissemination causing misunderstanding (Bertot, 2012).

2.4 Mobile Coverage in Kenya

2.4.1 Mobile Ecosystem

This refers to the various players like mobile network operators, application developer, users, financiers, content developers like government departments, service providers and platform among others required for a mobile application. A platform is a software architecture that serves as the foundation for other applications and includes security features and rules that applications must comply with. Examples include Android, Windows Phone and Apple's IOS. The researcher chose Android that is open source and dominance as shown in Figure 1.1.

2.4.2 Mobile-cellular Subscriptions in Kenya

There has been a rise in mobile-cellular subscriptions in the country as shown in Figure 2.3. This rise in mobile cellular subscription has consequently increased the use of smartphones. Users of these phones have used these devices to access Internet in their search for information and accessing social media sites. According to a report by Communications Authority of Kenya (2016), the mobile penetration had grown to 88.2% with the mobile subscriptions standing at 38.9 million subscriptions as shown in Figure 2.4. Under the same period of review, the Internet/data subscriptions stood at 25.6 million subscriptions that represented 99% of the subscriptions. This can be attributed to affordability of smartphones and data bundles offered by the service providers.

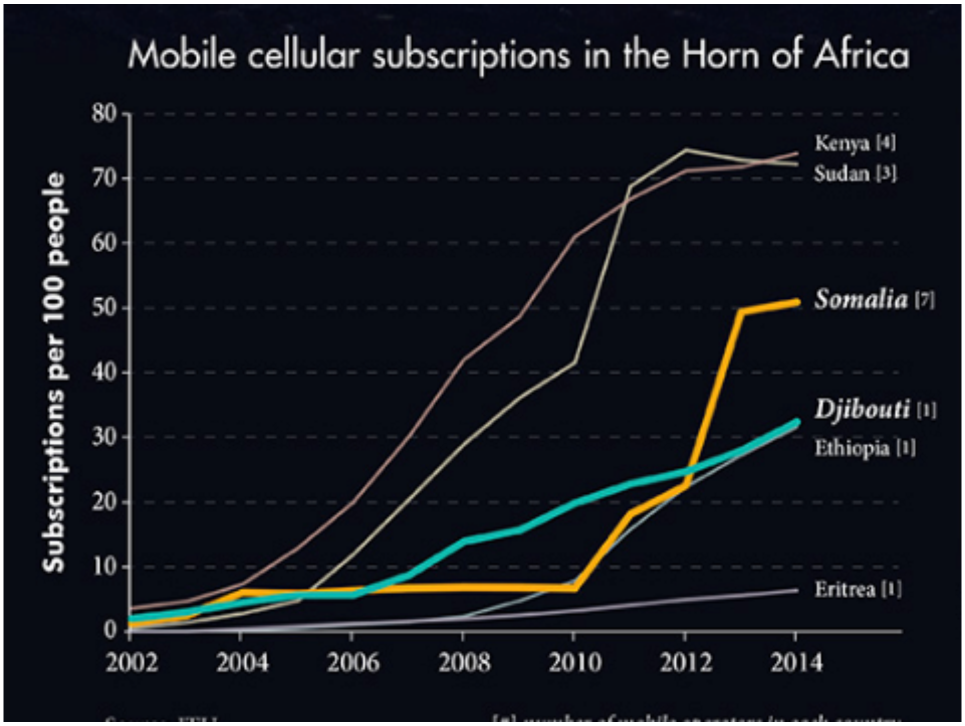


Figure 2.4 Mobile Cellular Subscriptions (Adapted from World Bank, 2016)

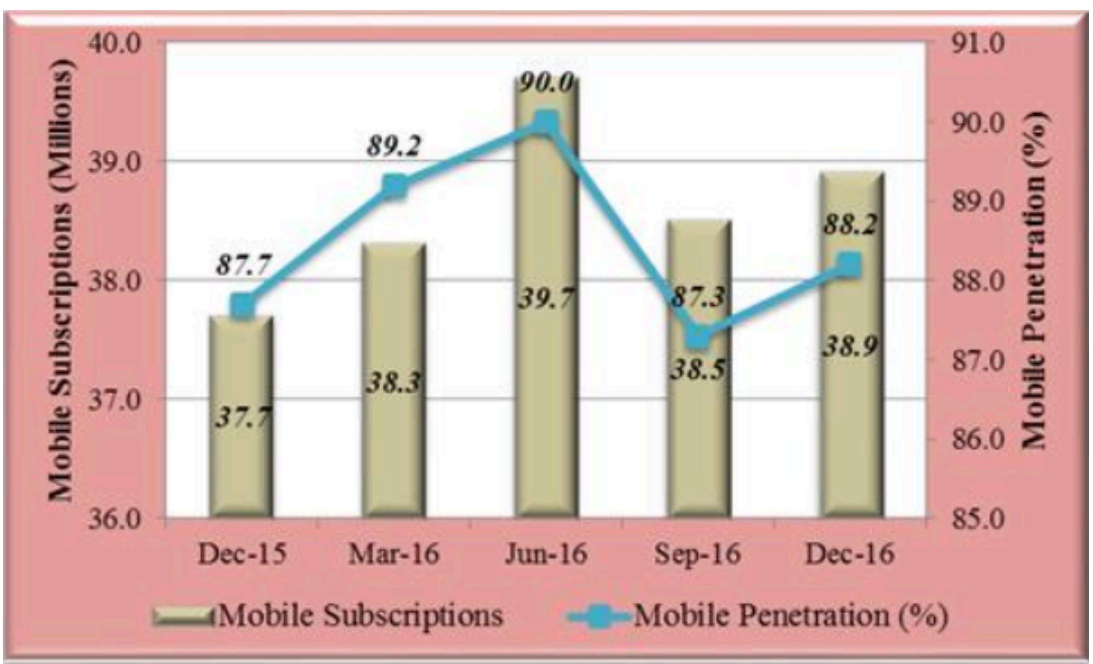


Figure 2.5 Mobile Subscriptions in Kenya (Adapted from Communications Authority of Kenya, 2016).

According to a report conducted by Pew Research Center, Poushter (2016) noted that 26% own a smartphone in Kenya. With the high penetration rates, this number is expected to continue growing. Developing an application that targets smartphones is therefore a feasible solution.

2.5 Conclusions

Although small-scale farmers are dynamic and respond to socio-economic opportunities influenced by goals of the households, resources and factors of production available lack of information relevance is a limiting factor. Availing resources with exclusion of information would not address poor farming methods. This can be demonstrated by some farmers using less than or more than the recommended fertiliser rates. Productivity on smallholder averaging at 2, 000 Kilograms of made tea per hectare is lower compared to large estates, which average at 2,600 Kilograms pointing to a need to empower small hold farmers.

This could be linked to limited access to information on production technologies and innovations. Hence, providing information to the farmers will make them aware of improved technologies, which in turn will enhance their adoption. The information needs of the farmers were identified as agricultural inputs, extension education, agricultural technology, marketing and agricultural credit. Ensuring easy and timely access to information, knowledge and experts via mobile technologies will lead to improved production and revenue, reduced digital gap, better practices and increased awareness of government policies and support. It can further be deduced that lack of information or inadequate information is a major contributor to skill gap and lack of adoption to available technologies.

Moreover, other shortcomings were identified and would be addressed in this research. Applications like farmGraze and horseRATION targeted dairy cows, beef cattle, sheep and horse hence failed to reach out to tea farmers. Virtual city helps farmer's track delivery quality and quantities but not information on improving production. M-Shamba, Dialog Tradenet and M-Farm had their focus on connecting buyers and sellers thus providing an online market place but limited information on farming. WeFarm on the other hand uses SMS platform to relay information to the farmers hence suffers from the limitations of an SMS service. In addition, lack of targeted and customised information, high cost of services like voice based and online communities and limited access to extension officers' services will be addressed.

Mobile Internet based service has shown potential for growth hence requires to be tailored to the specific needs of the farmers. This chapter has partially covered two research questions that is what is the information needs of tea farmers and what are the weaknesses to the existing information systems in tea farming. This extensive review of systems and available literature would form a basis for developing an information system to meet the farmer needs. The next chapter will expound on the methodologies employed by the researcher to undertake this study.

Chapter 3: Research Methodology

3.1 Introduction

In the previous chapter, the researcher partially answered the questions on the information needs of tea farmers and weaknesses to the existing information systems in tea farming from review of selected research literature on information needs of farmers and existing information systems. This study sought to address issues of information access faced by farmers through timely provision of information that would lead to faster and informed decisions. This chapter discusses the methodologies applied in answering the four (4) research questions. What is the information needs of tea farmers? What are the weaknesses to the existing information systems? How will the proposed information system be designed and implemented to address the information needs of tea farmers? Does the proposed information system meet tea farmer's information needs?

The research was conducted through literature review, interviews, surveys and questionnaires to give a clear outlook on a system that could handle the problems faced by tea farmer. The interviews and questionnaires were conducted to ascertain the user perspectives and their information needs. This culminated with design and development of an information system providing quick access to information on the go for quality decision-making. Agile software development with Scrum framework was employed to attain flexibility and rapid delivery of software product. Moreover, surveys were used to validate the system.

3.2 Software Development Methodology

SVITS (2012) defined software development process as a structure imposed on the development of a software product. This study sought to design, develop and test an information system to meet information needs of tea farmers. The researcher employed Agile system development methodology with Scrum due to flexibility and rapid delivery of software product. This methodology is a better way of developing software that promotes sustainable development through quick, flexible and adaptable rapid change (Abrahamsson, Salo, Ronkainen, & Warsta, 2002; Highsmith, 2001). The researcher employed Scrum framework due to its speed and flexibility in product development through iterative feedback loop and time-boxed sprints (Takeuchi & Nonaka, 1986; Schwaber, 1997).

The cycle of activities undertaken under Scrum involved Planning, Analysis, Design, Implementation, Unit and Acceptance testing. Planning phase incorporated stakeholders' identification, determining the population sample and preparing and executing documents reviews, questionnaires and interviews. Visual Studio Team Foundation Server was used to determine the tasks to be carried out. During Requirement Analysis phase the researcher analysed, presented and interpreted the collected data using Microsoft Excel 2011. This was useful in identifying the information needs of the farmers and existing system weaknesses as well as required system features. A conceptual model for the information system with the required features was formulated during the Design phase.

Architectural design, UML diagrams, Database and wireframes were also developed by use of creately.com and draw.io. The modules and components of the information system were developed during the Implementation phase. These phases were carried out iteratively to ensure that the final product met the user needs. The tools used included Android Studio, Sublime Text, Apache, Bootstrap and MySQL. Finally the Unit and Acceptance Testing phase was conducted through functional testing, usability testing and compatibility acceptance testing and the results documented. Tools used included Android Emulator, Postman Client and a questionnaire to get the feedback from the users. A validation was undertaken to verify that the system managed to address the problem as envisioned. Survey questions were used to ascertain the level of satisfaction with the application from the users.

3.3 Research Design

Kothari (2004) defined research design as the conceptual structure within which the research is conducted from data collection, measurement to analysis. The research sought to understand the information needs of tea farmers, existing information systems and their weaknesses as well as determine the applicability of a mobile information system in relaying information. Qualitative design was used in determining the information needs of the farmers as well as evaluating the existing system weaknesses and was conducted through interviews and document review. According to the handbook on qualitative research by Denzin and Lincoln (2005), qualitative research is an interpretive naturalistic approach to the world. Document reviews were carried out under literature review.

The researcher also used quantitative design through the use of a questionnaire to carryout system testing. The analysis of the results of this questionnaire determined whether the developed system met the user requirements. Surveys were also issued to determine whether system managed to accomplish the purpose for which it was developed.

3.3.1 System Analysis

This involved identifying, modelling and documenting the data requirements, data movements in the system and the events that affect each entity during the sequence that the events occurred. The researcher applied document review and interviews, as discussed below, to identify and document the requirements (see Appendix A). Based on the requirements that were outlined a roadmap to develop the information system was conceptualised. The study was carried out in Embu County at Mungania Tea Factory Company Limited. The researcher chose this location due to being well versed with the terrain of the area providing a higher probability of getting cooperative respondents.

The information system developed targets to ease information access and avail it on the go to all the tea farmers in Kenya. It was expected that the results of this study could be generalised to all tea farmers. The study population accessible to the researcher was made up of tea farmers who sell their green tea leaves at Mungania Tea Factory Company Limited that currently serves 9,024 farmers. It should be noted that some of the farmers are also employees of the factory. They offered information on technologies, inputs, credit and marketing. The researcher focused on a sample size of 43 farmers. This was determined from a study population size of 9,024 farmers by selecting a confidence level of 95% and a confidence interval of 15. The sample size (SS) was given by the formula (Naing, Winn & Rusli, 2006) below:

$$SS=\frac{Z^2*(P)*(1-P)}{C^2}$$

Where:

Z = Z value

P = Percentage picking a choice, expressed as decimal

C = Confidence Interval expressed as decimal

$SS = \frac{1.96^2 * (0.5) * (1-0.5)}{0.15^2} = 42.68$

Approximated to 43 farmers.

The researcher used qualitative and quantitative techniques to collect data. Questionnaires, interviews, surveys and document reviews were employed. The data collected was on information needs of tea farmers, current system weaknesses and validation of the developed mobile information system.

Document Review

This information was reviewed under literature review. Books, journals, company's database and articles were used to collect secondary data. The review purposed to identify existing system weaknesses as well as identify some of the information needs of tea farmers.

Interview

Qualitative interviews were used whose aim was to provide in-depth findings through discussions with the respondents on the information needs of tea farmers. The interviews were conducted on 43 farmers who sell their tea Mungania Tea Factory Company Limited selected at random. The findings helped in design of the system. The researcher used a structured interview seeking to obtain answers to carefully worded questions (see Appendix B).

3.3.2 System Design

A conceptual model for an information system with the required features was formulated. This was accomplished through coming up with an architectural design, use case diagram, Dataflow diagram, System Sequence diagram, Data model and website wireframe by use of creately.com and draw.io.

System Architecture

This represented the conceptual model that comprises the different components of the system. It defined the structure of the components, their behaviour and interaction with one another.

Use Case Diagrams

Use case diagrams show a list of actions important in identifying and organising system requirements by showing a set of possible interactions between the system and the users

(Jacobson, Booch, Rumbaugh, Rumbaugh & Booch, 1999). This demonstrated the interaction between the system and the various users of the system indicated as actors.

Data Flow Diagrams

Data flow diagrams depicts logic models and expresses data transformation in a system (Chen, 2009; Ward, 1986) This illustrated how data is processed by focusing on the flow of information, where the data comes from, the output and how it is stored. Context level diagram, level zero diagram and level one diagram were developed.

System Sequence Diagram

System sequence diagram clearly illustrates the input and output events related to the system being designed (Briand, Labiche & Madrazo-Rivera, 2011). This demonstrated how information flows between the different entities of the system and the messages exchanged between them.

Data Model

Database schema represents a logical configuration of a database by illustrating the set of rules that govern the organisation of data within the database (Batini, Ceri & Navathe, 1989; Batini, Lenzerini & Navathe, 1986). The Database Schema illustrated tables consisting of fields, data types and descriptions that relate to the database entities of the system under construction. It defined how the data was organised as well as the relationships of the associations. Entity Relationship Diagrams shows relationship of the various entities of a system (Batini, Ceri & Navathe, 1989; Chen, 1976). Entity Relationship Diagrams were generated from the schema to show logical structure of the databases.

Wireframes

A wireframe is a structural skeleton allowing visualisation of the navigations and layout of a system (Kang, Cho & Kim, 2015). The website wireframe showed a detailed skeleton of the important elements of the final website. The main groups of contents, structure and user interaction with the interface were demonstrated.

3.3.3 System Implementation

The implementation phase involved developing of various modules and components of the proposed system. The proposed tea information system includes an installable Android application, USSD, Database and an Administrator Backend. These were aimed at working together to give the farmer the best look and feel as well as satisfy information needs on the go. The tools employed include Android Studio, Sublime Text, Apache, Bootstrap and MySQL.

3.3.4 System Testing

Unit and Acceptance Testing phase ascertained that the developed system met the user requirements. This was conducted through questionnaire administered to thirty (30) respondents to help test the functionality, usability and compatibility of the system and the lessons learned documented. The quantitative questionnaire required the respondents to state their opinion or preference for a particular question. These results were quantifiable and measurable and were analysed accordingly through Microsoft Excel 2013. The questionnaire was formulated and disseminated by hand to the respondents. The questions took both closed and open-ended responses (see Appendix C).

The installable Android application was first tested through the Android emulator before testing on a real device. The researcher further tested how farmers would consume the USSD code by placing requests on any of the services and expecting appropriately formatted response through the Postman client (Belotserkovskiy, Kaufman & Sachdeva, 2015). This helped to gauge the users' acceptance of the system based on its functionality, ease of data entry, ease of navigation, application appearance, feedback of the system, and compatibility with various Android versions and smartphone models.

3.3.5 System Validation

System validation is a testing done to ascertain that the code meets all of its requirements in the target system or platform (Jacklin, 2015). The researcher undertook system validation by determining and documenting system requirements, system testing, issuing a survey and providing an installation protocol. All the requirements specifications (see Appendix A) identified were included in the final system that was successfully tested to ascertain that the system solved the problem identified.

A survey was issued to help the researcher assess whether the system met its intended purpose (see Appendix D). The survey was issued via email to thirty (30) respondents who had a chance to use and interact with the system that had been developed. Analysis of the survey results gave the application an excellent overall rating. The native Android application would be downloaded and installed from Google Play Store whereas the USSD module required dialing a short code.

3.4 Validity

Kothari (2004) described validity to be the degree to which an instrument measured what it was supposed to measure. An adequate sample was selected for this study with the intention of generalising the results to the target population. The review of existing literature formed a basis for developing relevant interview questions (see Appendix B), questionnaire (see Appendix C) and a survey (see Appendix D) seeking to address all the objectives of this study. The researcher pretested the interview questions, questionnaire and survey used in data collection by piloting them with a control group of fifteen respondents. The test questions had a mix of positively and negatively worded questions seeking information on various aspects of the system. The questions were later reviewed to eliminate errors and ambiguities occasioned by related and negatively worded questions that impaired response accuracy on the pilot test.

3.5 Conclusions

This chapter highlighted the methodologies adopted in undertaking the study. The methods for data collection and analysis were highlighted which would guide the researcher in making deductions from the evidence collected and thus answer the research questions. The tools employed were also highlighted.

Chapter 4: System Analysis and Design

4.1 Introduction

This chapter presents a detailed view of how the tea farming information system was designed. The researcher used the use case diagram, data flow diagrams, system sequence diagram and data modeling to illustrate different aspects of the tea farming information system.

4.2 Requirements Analysis

The requirements specifications (see Appendix A) of the tea farming information were identified through interviewing various stakeholders in the tea farming. The analysis below gives the results of the findings from the interviews conducted.

4.2.1 Information Needs

The research question on the information needs of tea farmers was partially answered under literature review. The researcher thus designed the interview with an aim to gain a clear understanding on these needs from the farmers. Table 4.1 clearly indicates the kind of information that tea farmers mostly seek. Based on the results, the researcher deduced the information needs of tea farmers as agricultural inputs, marketing information, technology information, credit information and extension education. Some of the primary sources of the information by the farmers are also highlighted on Table 4.2 that included close relatives and friends, guess work, experience, FFS, extension officers and announcements at the collection centres. These methods were limiting, caused delay and lacked efficiency.

Table 4.1 The Kind of Information Sought by Tea Farmers

Kind of Information Sought	Respondents	Percentage
Fertiliser application	41	95
Hybrid seeds	38	88
Marketing information	24	56
Pruning techniques	36	84

Access to credit	33	77
Herbicides application	39	91
Access to high yield clones	35	81
Pest and disease control	30	70
Farm mechanisation	5	12

Table 4.2 The Primary Source of Information for Tea Farmers

Primary Source	Respondents	Percentage
Relatives and close friends	42	98
Guess work	23	53
Traditional knowledge	36	84
Experience	37	86
Mobile phones	31	72
Posters	15	35
Extension officers	19	44
FFS	9	21

Some of the respondents noted that they rarely receive any updates on farming information either due to limited access to extension officers, failure to access FFS and torn or misplaced circulars and notices. They further enumerated the various modes through which they receive farming information as shown on Table 4.3. It was indicated that, some of the circulars and notices were not certified hence were open to abuse. Moreover, word of mouth and advice from relatives and close friends was limited by lack of trust amongst farmers. Radio, television, magazine and newspapers were available to a few farmers in addition to lacking feedback or consultation.

Table 4.3 Mode of Receiving Information by Tea Farmers

Mode of Receiving Information	Respondents	Percentage
Circular and notices	40	93
Word of mouth	42	98
Relatives and close friends	39	91
Advice slip	43	100
Radio and Television	24	56
Magazine and newspapers	12	28
Extension officers	10	23
FFS	5	12

The researcher also noted that some of the farmers did not receive information from the primary source that they sought information from hence had to resort to other mechanisms. The respondents also highlighted hardship in retrieving specific content over the Internet hence the need for focused online sites for tea farming information.

4.2.2 Existing System Weaknesses

The researcher conducted an interview to affirm the existing system weaknesses as had been discovered under literature review. Some of the challenges that farmers face while seeking to obtain farming information are highlighted on Table 4.4. These results rated the current structures of information delivery as being average as can be shown on Table 4.5 hence the need for an improved information delivery system. The farmers also identified a mobile application, web application and SMS as some of the ways they would prefer to receive information citing them as being faster, easier and convenient as shown on Table 4.6.

Table 4.4 Challenges Faced by Farmers in Accessing Information

Challenge	Respondents	Percentage
Lack of verification method	29	67
Delays in delivery	34	79
Inadequate information	29	67
Complexity of FFS	23	53
Limited access to extension officers	15	34
Limited access to finance	40	93
Information sources	33	77
Family setup	20	47
Level of literacy	12	28

Table 4.5 Rating on the Existing Models of Delivering Farming Information

Rating	1 (Inefficient)	2	3	4	5	6	7	8	9	10 (Very efficient)
Respondents	1	1	2	10	25	2	2	0	0	0

Table 4.6 Preferred Method of Accessing Farming Information

Method	Reason	Respondents	Percentage
Native application	Efficient	26	60
Web application	Flexibility	12	28
SMS	Faster	5	12

It can be deduced from the above results that farmers are faced by several challenges in their quest to access farming information. In addition, the farmers have less confidence in the ability of current systems satisfying their information needs as they are. However, the farmers demonstrated their preparedness to adopt mobile technology to ease access to information.

4.2.3 Need for a Mobile Information System

The researcher sought to understand whether the farmers would require a mobile information system to satisfy their information needs. The respondents were also required to indicate the features that they expected the mobile application to have. The researcher further sought to understand the type of operating system common with the farmers. The interviews conducted showed that 88% percent of the respondents would love to have a mobile information system developed to meet their information needs as shown in Figure 4.1. The remaining 12% were a bit skeptical on relevance of a mobile application in tea farming citing costs as the main concern.

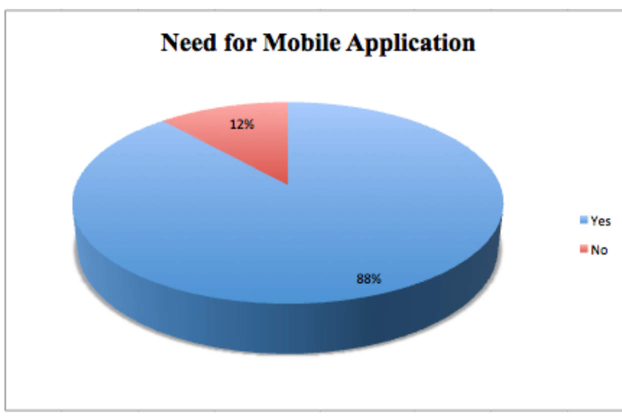


Figure 4.1 Support for the Need of a Mobile Application

Some of the features that were identified as being important to farmers are shown in Table 4.7. It was also discovered that the highest number of the respondents used Android OS as shown in Figure 4.2. These results are a testament for the importance of a mobile information system for tea farmers. The features that were identified by the respondents revolve around the main classification of agricultural information needs enumerated earlier. That is agricultural inputs, marketing information, technology information, credit information and extension education. The choice to develop for Android platform is vindicated as majority of the respondents use Android based phones.

Table 4.7 Suggested Features for a Mobile Information System

Feature	Respondents	Percentage
Information on fertiliser	41	95
Information on hybrid seeds	39	91
Pruning technique	35	81
Reporting malpractices	30	70
Firewood sale updates	20	46
Access to finance	40	93
Market information	22	51
Pest and disease control	35	81

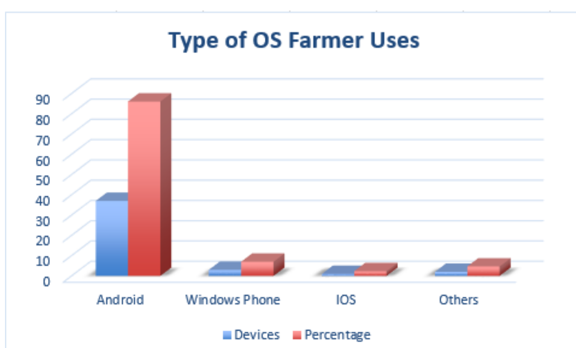


Figure 4.2 Type of Operating System a Farmer Uses on their Smartphone

4.3 System Architecture

4.3.1 General Architecture

The general architecture of the system is a mobile and USSD client for collecting and receiving data and a web application and database server for processing and storage of data respectively. An overview of how the application works is shown in Figure 4.3. Users download and install the application on any Android based phone. The users then register themselves on the system before they can login. The information required for registration is grower number, email address and password. Once a member has been registered they will have to await approval from the factory staff so that their details can be verified. Once approved the user can then login into the application. After a user is logged in, they can access information on inputs, marketing, extension education, agricultural technology and credit and report on an identified issue.

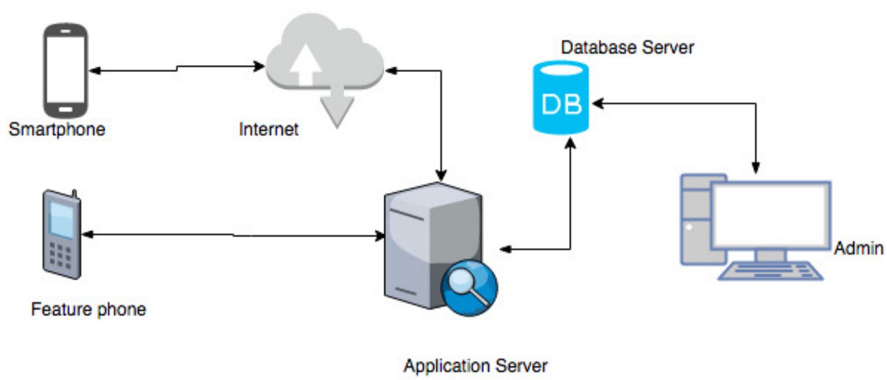


Figure 4.3 Tea Farming Information System Architecture

4.3.2 USSD Architecture

USSD is a real time session initiated between the mobile user and the USSD application platform when the service is invoked allowing data to be sent back and forth until the session is terminated. USSD can be implemented as either a push service which is network initiated service or a pull service which is mobile subscriber initiated service (Sanganagouda, 2011). Figure 4.4 shows a USSD architecture of implementation. The proposed USSD flow fit into the tea farming information system as has been demonstrated in Figure 4.3 above. The service resides as an independent application server that is connected through a USSD Gateway using SMPP.

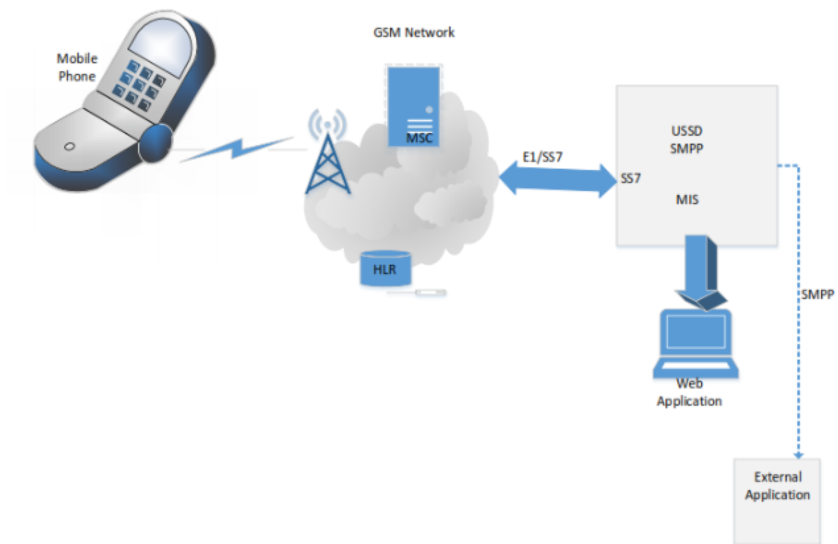


Figure 4.4 Architecture of USSD Implementation (Adapted from Sanganagouda, 2011)

4.4 System Requirements and Analysis

The researcher used use case diagrams to demonstrate the functional requirements that were identified as shown below.

4.4.1 Use Case

Pressman (2005) noted that system requirements and analysis phase helps one to better comprehend a problem they are solving. Gomaa (2011) highlighted that use case modelling is used to describe the functional requirements of a system as well as depict the software from the user's viewpoint. In a use case diagram, users or devices are external to the system and are represented as actors that interact with the system whereas user requirements are represented as ellipses/use cases. The actors of the tea farming information system are farmers and the administrator who could be an extension officer, factory staff or any other person authorised to carry out administrative tasks on the system. This is demonstrated in Figure 4.5.

As shown by the use case, the farmer can view agricultural information and notices that is provided on the system. This includes information on fertiliser application, pest control, seedlings, credit and finance, pruning, auction details and firewood sale. Moreover, the farmer can book an event they would consider attending, they can report illegal practices by other farmers as well as reserve seedlings sale. In addition, they can search for specific information and view various reports. On the other hand, the administrator registers and approves the users of the system as well as creating and updating agricultural information on the system.

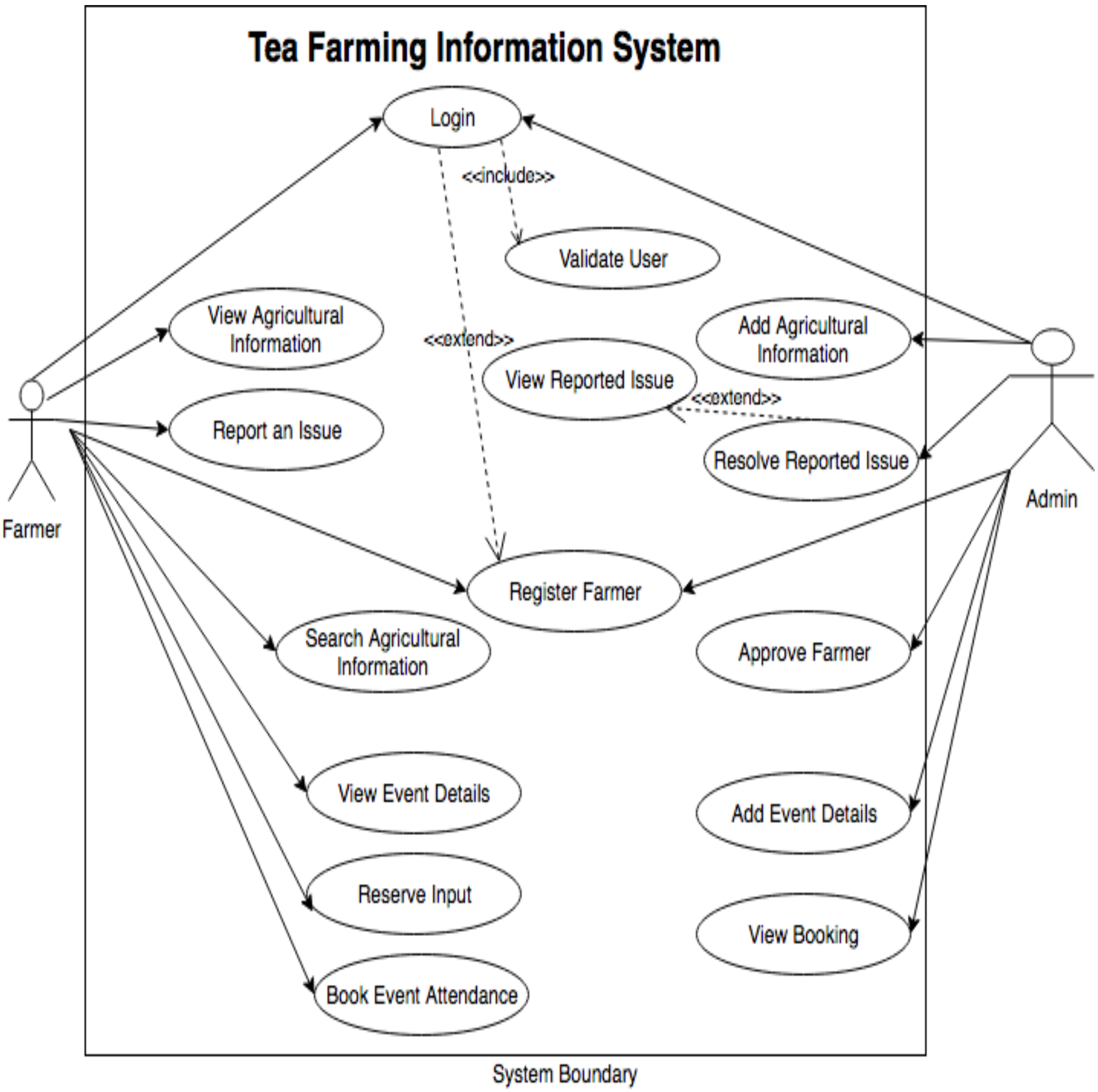


Figure 4.5 Tea Farming Information System Use Case Diagram

4.4.2 Use Case Description

The detailed description of the various use case scenario in the tea farming information system that the actors interact with were developed. Table 4.8 demonstrated the use case description for

Register a Farmer use case. More use case descriptions are provided in other sections of this study (see Appendix F).

Table 4.8 Use Case Description of Registration of Farmer

<table>
<tr><td colspan="3">Use Case Name: Register a Farmer</td><td>ID Number: UC_001</td></tr>
<tr><td colspan="4">Description: The user of the application enters own details such as names and user authentication details.</td></tr>
<tr><td colspan="4">Trigger: The user accesses the mobile application and is prompted to register if he/she is a new user of the system.</td></tr>
<tr><td colspan="4">Type: External</td></tr>
<tr><td colspan="2">Major Inputs</td><td colspan="2">Major Outputs</td></tr>
<tr><td>Description
Farmer details
Register request</td><td>Source
Farmer
Farmer</td><td>Description
User details
Registration confirmation</td><td>Destination
Database
User’s email and mobile phone</td></tr>
<tr><td colspan="2">Major Steps Performed:
i. Prompt the user to provide personal details if not yet registered.
ii. User provides registration details to be able to access the system.
iii. User submits the details and a confirmation is sent to the user via email and mobile app notification.</td><td colspan="2">Information for Steps:
User details
User details
Confirmation message</td></tr>
</table>

4.5 System Design

4.5.1 Data Flow Diagrams

Data Flow Diagrams showed an overview and detailed insight of how data flows through the processes of the tea farming information system.

Context Diagram

The context diagram demonstrated the overall system with the various processes that are involved in the provision of services to the farmer. Figure 4.6 shows the context diagram for the tea farming information system.

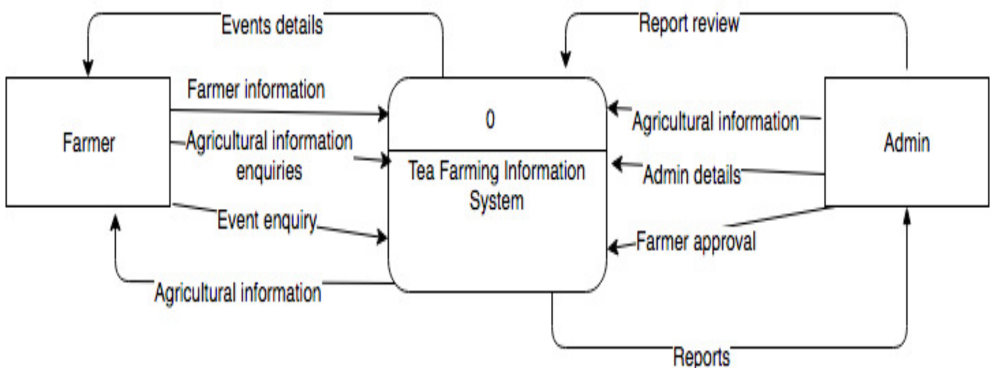


Figure 4.6 Context Diagram

Level Zero (0) Diagram

This diagram focused on the processes for registering a user, maintaining farmer records, updating information on technology and management of farm input. The extension staff and other factory employees are responsible for updating this information to make it available to the user. The system administrator can also update this information. The level zero diagram is shown in Figure 4.7.

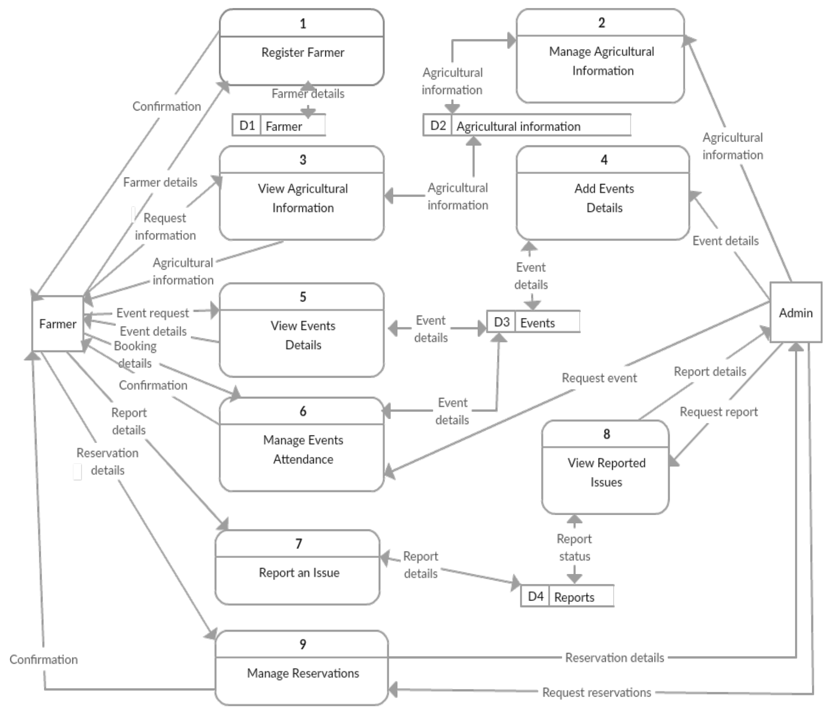


Figure 4.7 Level Zero Diagram

Level One (1) Diagram

This diagram focused on the process of managing the information on all the inputs required by the farmer. A level one diagram is demonstrated in Figure 4.8.

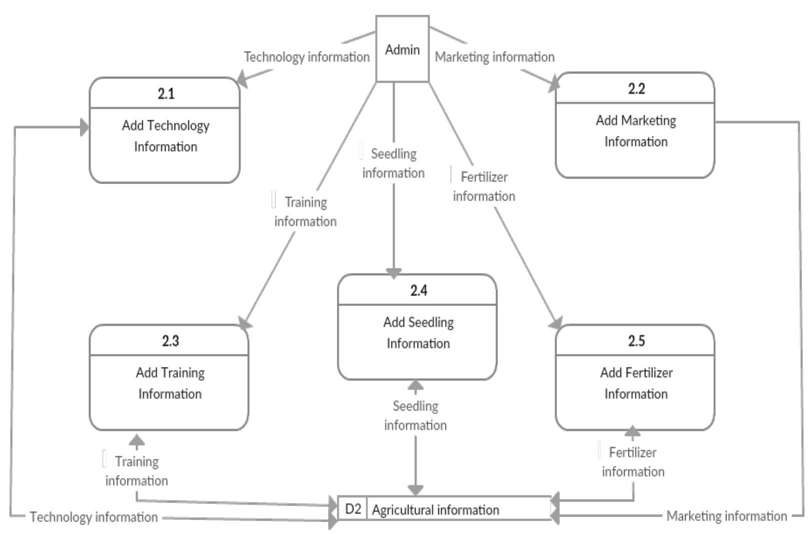


Figure 4.8 Level One Diagram

4.5.2 System Sequence Diagram

A system sequence diagram showed the external actors that interact directly with the system and the system events generated by the actor. Figure 4.9 shows a system sequence diagram for viewing agricultural information scenario.

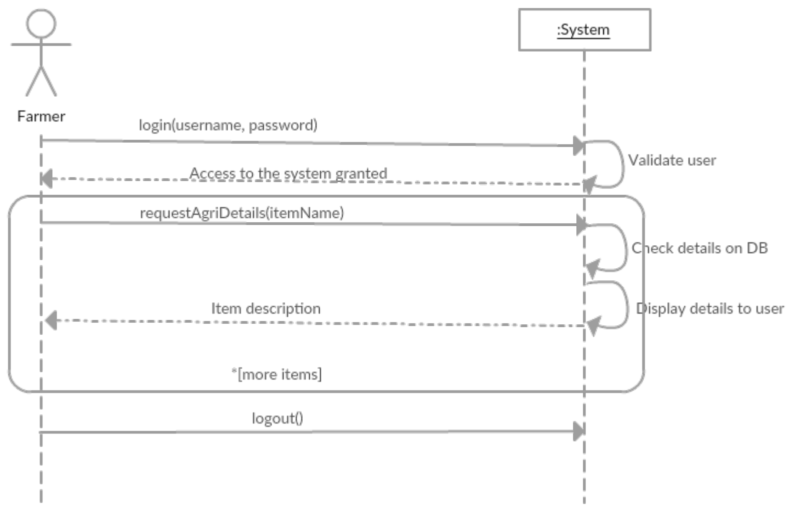


Figure 4.9 System Sequence Diagram for View Agricultural Information Scenario

4.5.3 Data model

A data model represents the data created by the system and takes into account the entities that capture this data and how they relate. It defines how data is processed and stored inside the system. A Database schema was illustrated by tables consisting fields, data types and descriptions that relate to the database entities of the system under construction. It defined how the data was organised as well as the relationships of the associations. An Entity Relationship Diagram (ERD) is used to represent the logical data model especially for a database by showing the relationships of entity sets stored in the database as shown in Figure 4.10.

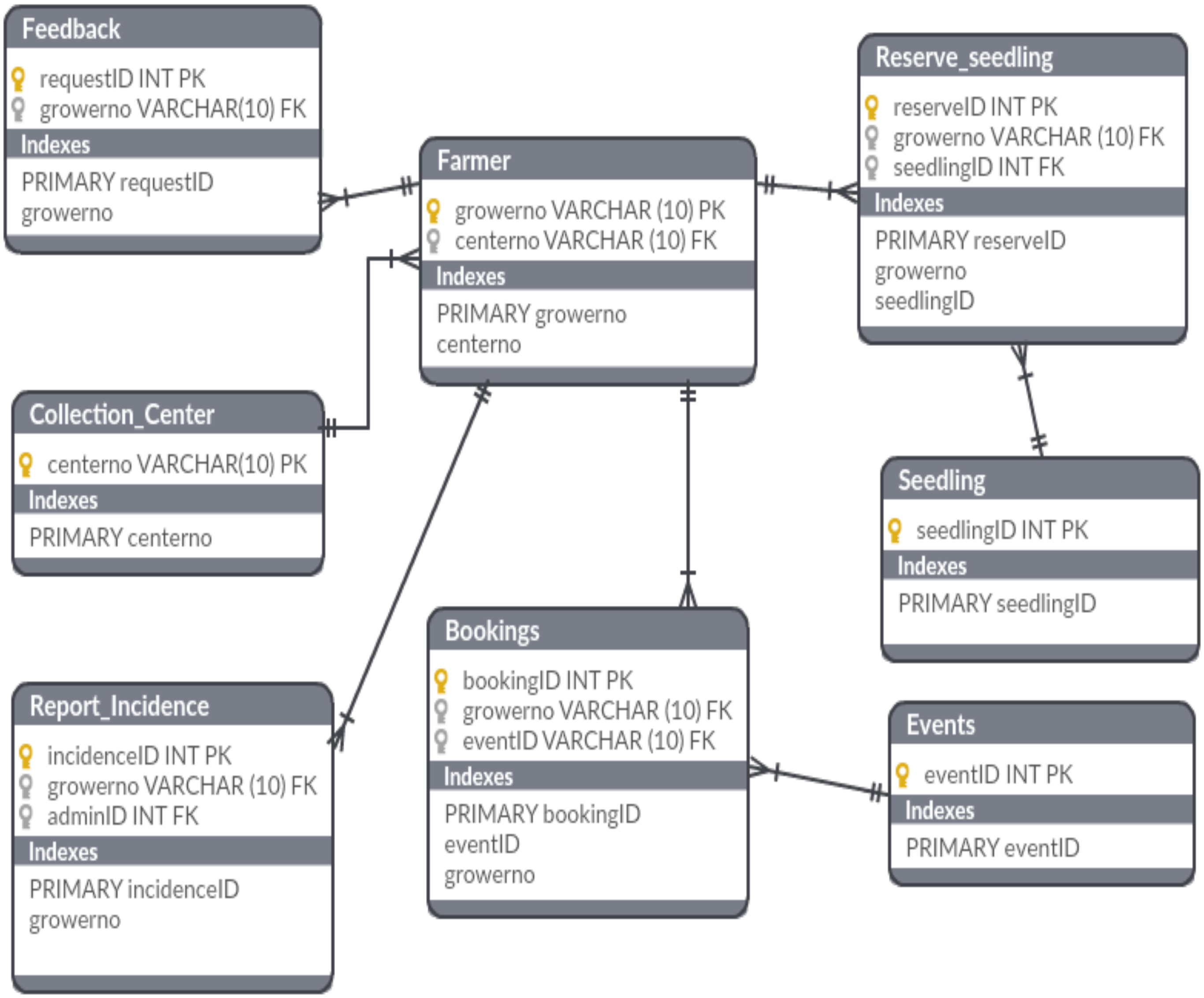


Figure 4.10 An Entity Relationship Diagram for the System

The following tables are tabular representations of the relations contained in the system database.

Farmer

This table holds details of the farmers registered in the system. The tabular representation is shown on Table 4.9

Table 4.9 Farmer Table

Columns			
Column	**Type**	**Default Value**	**Extra**
surname	Varchar(25)	None	
middlename	Varchar(25)	None	
lastname	Varchar(25)	None	
IDNo	Varchar(15)	None	
phone	Varchar(15)	None	
emailAddress	Varchar(100)	None	
password	Varchar(65)	None	
salt	Varchar(65)	None	
approved	Varchar(5)	No	
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	Varechar(10)	YES	growerno
Foreign keys			
Name	**Table**	**Column**	**Table Referenced**
centerno	farmer	centerno	Collection_Center

Feedback

This table contains all the information on the feedback given by the farmer. This is demonstrated on Table 4.2

Table 4.10 Feedback Table

Columns			
Column	**Type**	**Default Value**	**Extra**
subject	Varchar(50)	None	
request	Varchar(255)	None	
status	Varchar(15)	Unchecked	
response	Varchar(100)	None	
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	INT	YES	requestID
Foreign keys			
Name	**Table**	**Column**	**Table Referenced**
growerno	feedback	growerno	farmer

Report_Incidence

This table contains details of all the incidences that have been reported by the farmers. A tabular representation is shown on Table 4.11.

Table 4.11 Report_Incidence Table

Columns			
Column	**Type**	**Default Value**	**Extra**
description	Varchar(70)	None	
location	Varchar(25)	None	
status	Varchar(50)	Unchecked	

dateReported	date	None	
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	INT	YES	incidenceID
Foreign keys			
Name	**Table**	**Column**	**Table Referenced**
growerno	report_incidence	growerno	farmer

Bookings

This table references to the events that have been booked by farmers. A tabular representation is shown on Table 4.12.

Table 4.12 Bookings Table

Columns			
Column	**Type**	**Default value**	**Extra**
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	INT	YES	bookingID
Foreign keys			
Name	**Table**	**Column**	**Table Referenced**
growerno	bookings	growerno	Farmer
eventID	bookings	eventID	schedules

Reserve_Seedling

This table contains details of seedlings reservations made by all the farmers. A tabular representation is shown on Table 4.13.

Table 4.13 Reserve_Seedling Table

Columns			
Column	**Type**	**Default Value**	**Extra**
number	int	None	
approval	Varchar(12)	Pending	
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	INT	YES	reserveID
Foreign keys			
Name	**Table**	**Column**	**Table Referenced**
growerno	reserve_seedling	growerno	Farmer
seedlingID	reserve_seedling	seedlingID	Seedling

Events

This table contains details of the events that farmers could book to attend. A tabular representation is shown on Table 4.14.

Table 4.14 Schedules Table

Columns			
Column	**Type**	**Default Value**	**Extra**
name	Varchar(50)	None	
location	Varchar(50)	None	
theme	Varchar(100)	None	
event_date	date	None	

maxNo	int	None	
slots	int	None	
status	Varchar(10)	Open	
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	INT	YES	eventID

Seedling

This table contains details of seedlings that are available giving farmers a chance to reserve them. A tabular representation is shown on Table 4.15.

Table 4.15 Seedlings Table

Columns			
Column	**Type**	**Default Value**	**Extra**
image	Varchar(100)	None	
seedlingType	Varchar(25)	None	
location	Varchar(50)	None	
unitcost	Float	None	
availability	Varchar(10)	Yes	
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	INT	YES	seedlingID

Admin

This table contains details system administrators as shown on Table 4.16.

Table 4.16 Admin Table

Columns			
Column	**Type**	**Default Value**	**Extra**
name	Varchar(50)	None	
username	Varchar(50)	None	
password	Varchar(65)	None	
salt	Varchar(65)	None	
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	INT	YES	adminID

Notices

This table contains details of notices that are intended for the farmers as shown on Table 4.17.

Table 4.17 Notices Table

Columns			
Column	**Type**	**Default Value**	**Extra**
notice	Varchar(50)	None	
details	Varchar(100)	None	
date	date	None	
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	INT	YES	noticeID

Pruning

This table contains pruning information. A tabular representation is shown on Table 4.18.

Table 4.18 Pruning Table

Columns			
Column	**Type**	**Default Value**	**Extra**
method	Varchar(100)	None	
description	Varchar(100)	None	
Indexes			
Key	**Type**	**Unique**	**Column**
PRIMARY	INT	YES	pruningID

4.5.4 Wireframes

Mobile Application Wireframes

The mobile application has various functionalities that are demonstrated by the wireframe shown in Figure 4.12 portraying an open slide menu. Figure 4.13 further shows some of the functionalities in the system by showing the appearance of fertiliser and

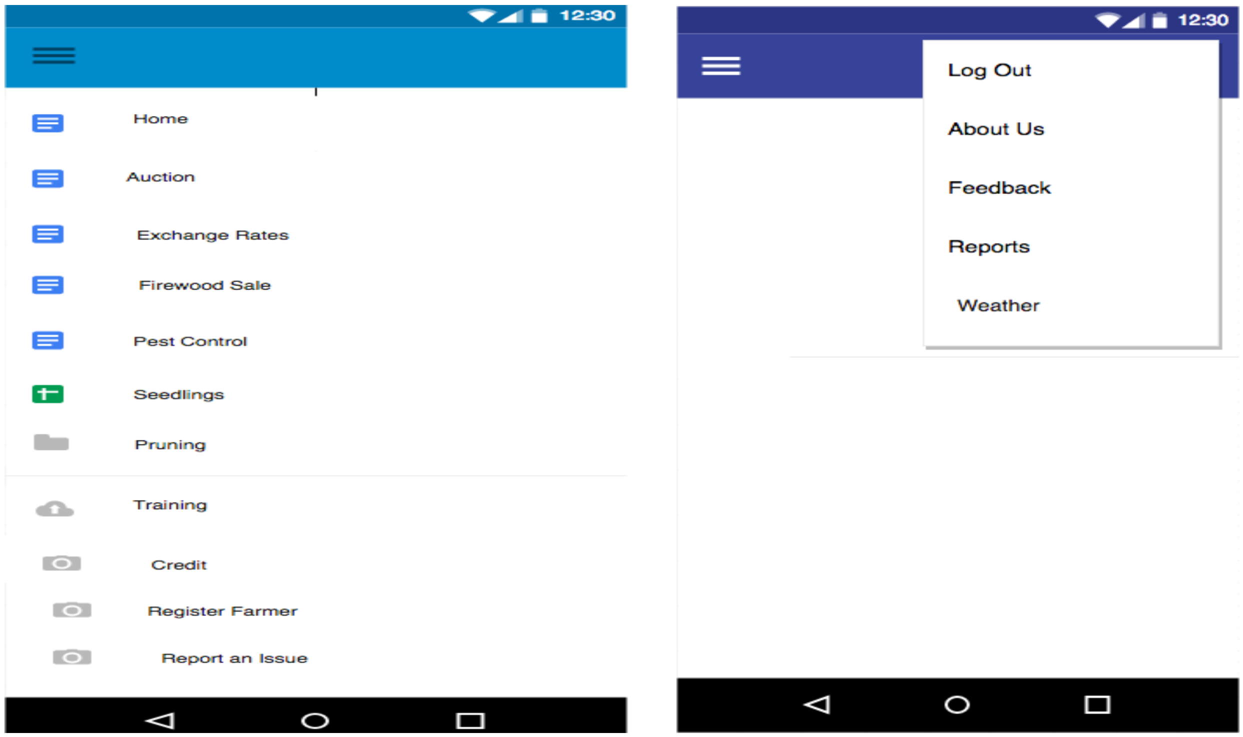


Figure 4.11 Wireframe Slide Menu Demonstrating Functionalities

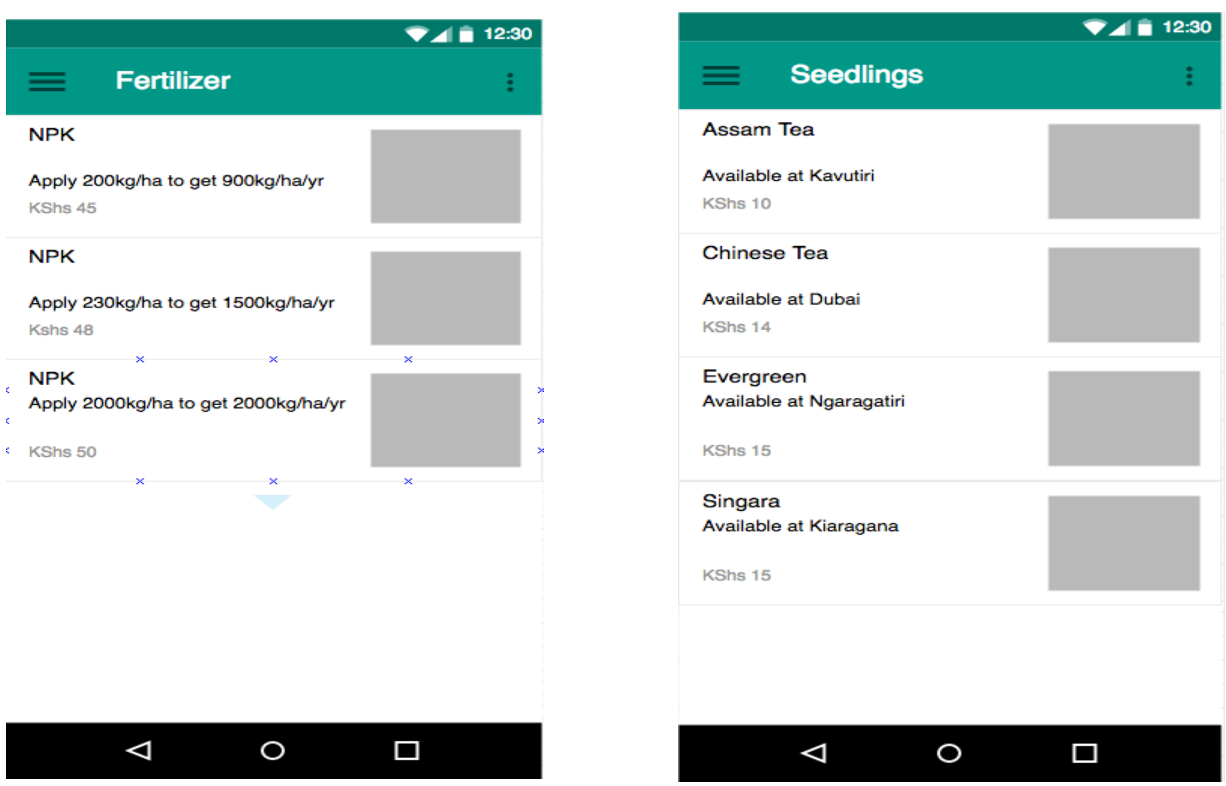


Figure 4.12 Wireframe Demonstrating Information for Fertiliser and Seedling

Website Wireframes

The main groups of contents, structure and administrator interaction with the interface for the administration backend were demonstrated through a wireframe. Figure 4.13 shows the administrator home page presented to the administrator after a successful login. It gives the menus for the various tasks that the administrator can undertake. Figure 4.14 shows how the administrator views the data whereas Figure 4.15 demonstrates how data is updated on the system. Figure 4.16 illustrates how information is added into the system.

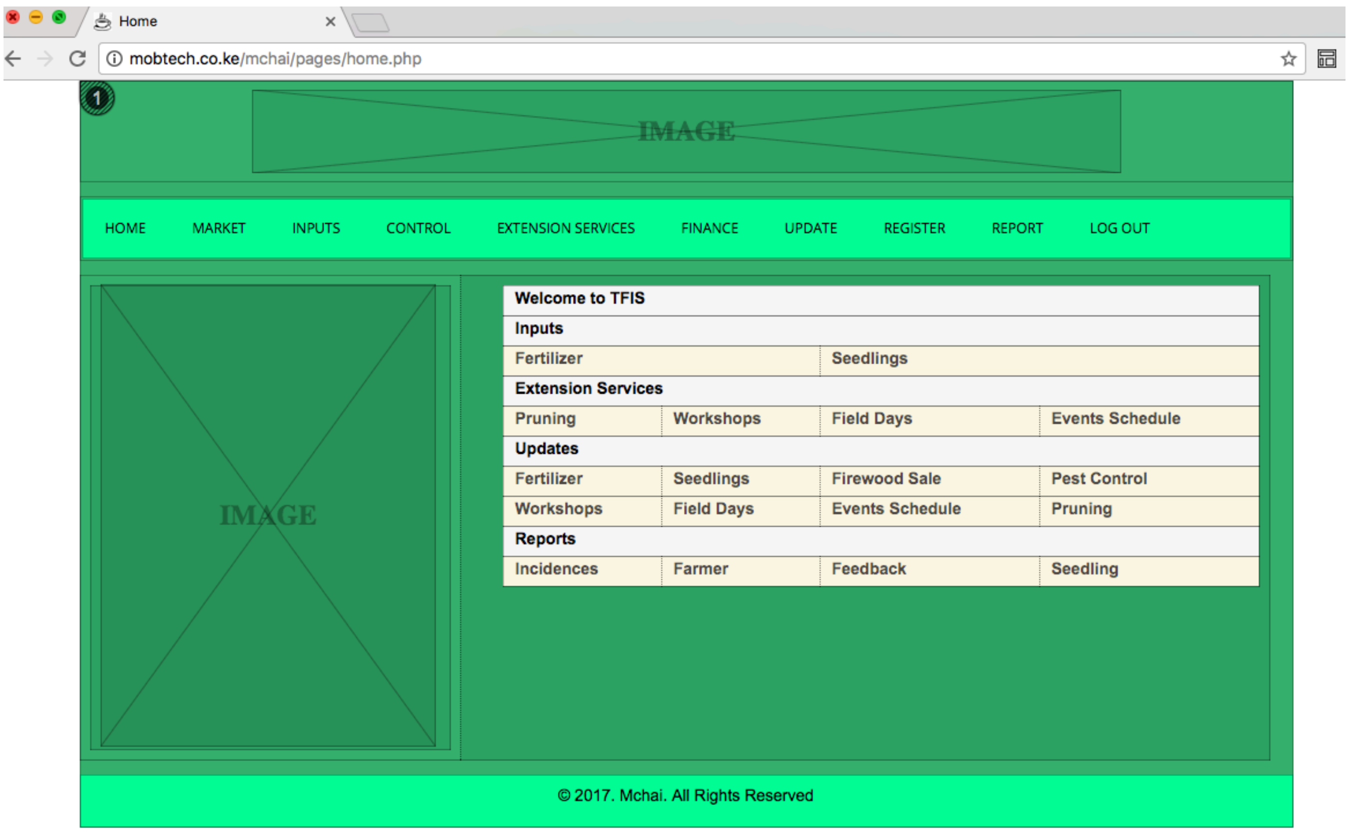


Figure 4.13 Home Page and Viewing Data Wireframe

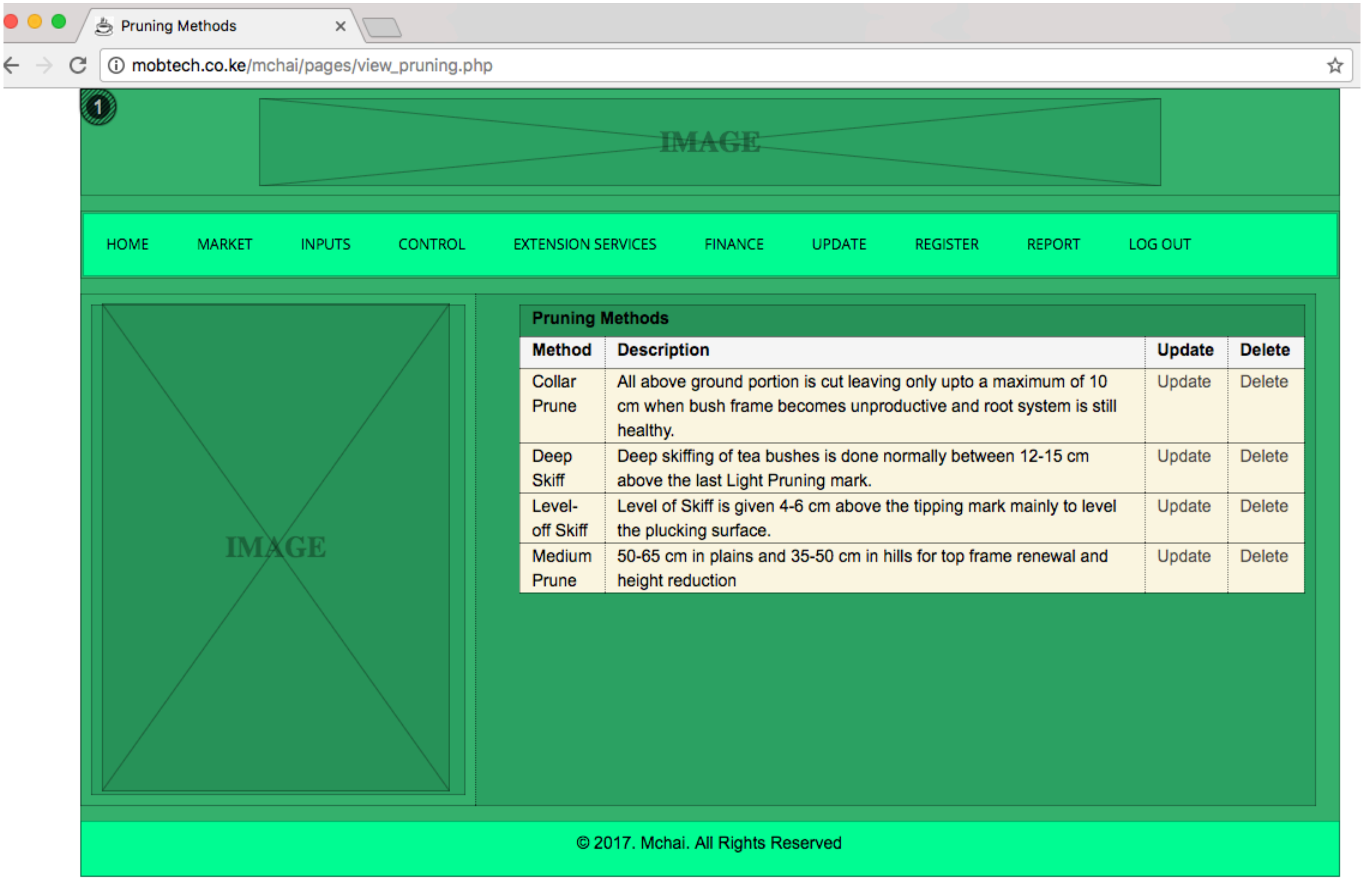


Figure 4.14 Viewing Pruning Details Wireframe

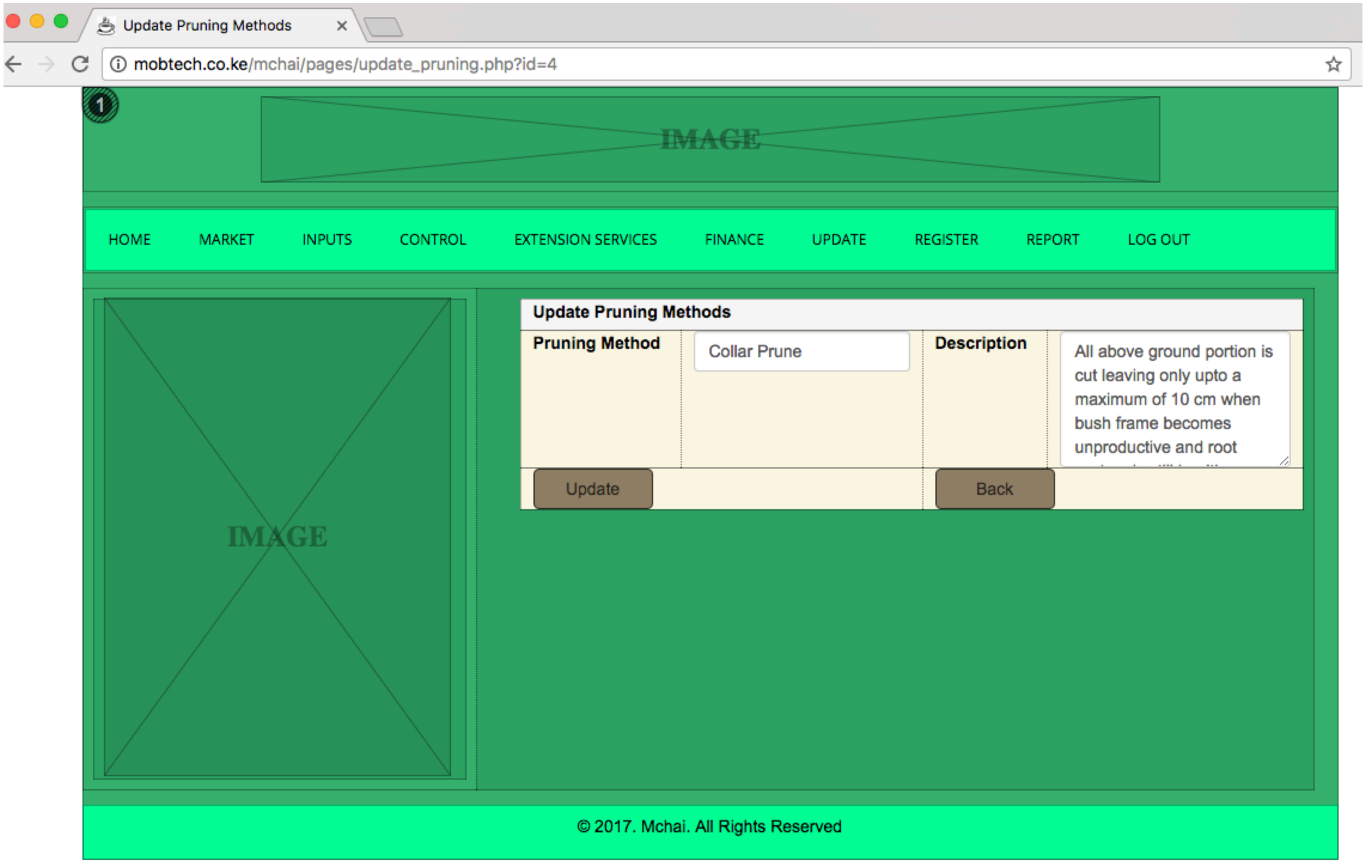


Figure 4.15 Updating Pruning Details Wireframe

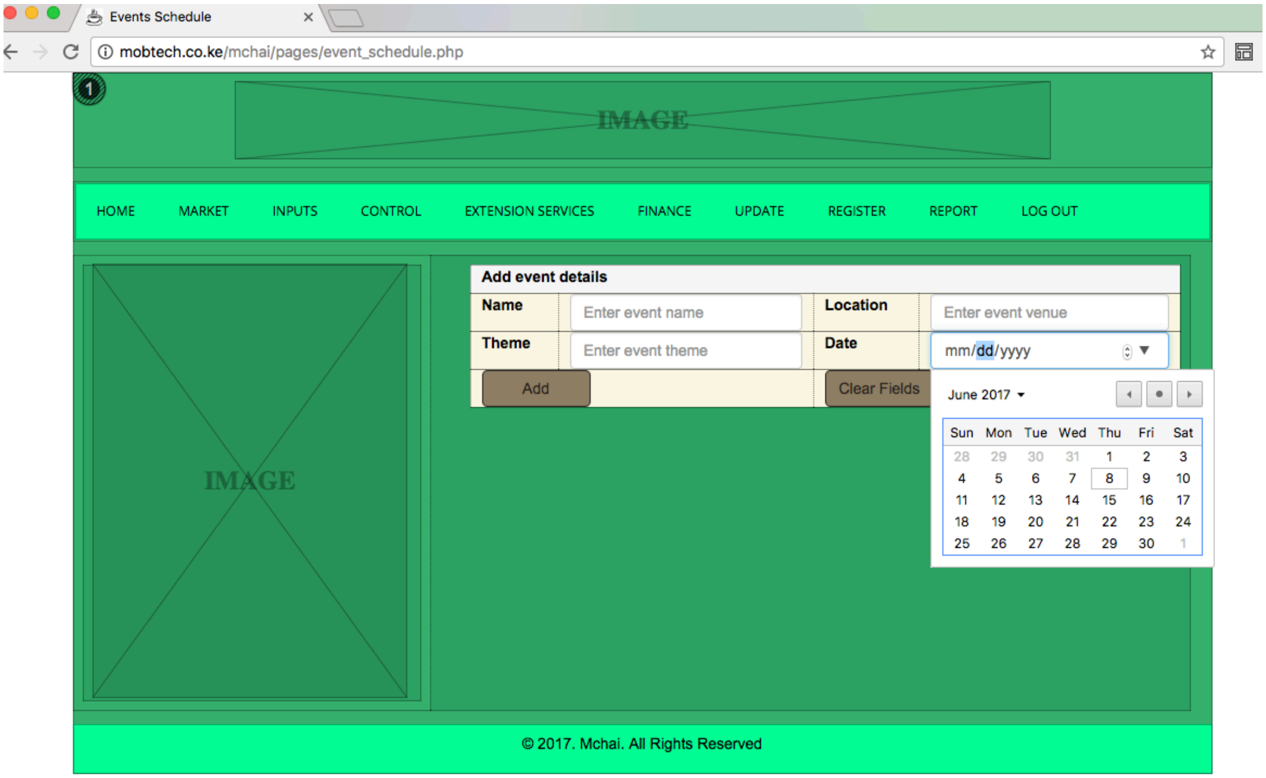


Figure 4.16 Adding Event Wireframe

USSD Wireframes

The USSD was solely aimed at providing limited services for those farmers who did not have a smartphone to access the Android application. Figure 4.17 shows a USSD interaction for farmer seeking information on fertiliser application.

Figure 4.17 USSD Wireframe

4.6 Conclusions

This chapter concentrated on the analysis and design of the system. A use case diagram was used to describe the set of actions that the system will perform in collaboration with the users of the system. Moreover, data flow diagrams were used to show what data will come into the system, how it will advance through the system, its storage and processing as well as the output from the system. A system sequence diagram was also used to demonstrate when and how tasks are completed in the system. The researcher also employed data model to describe the relationships of entity sets stored in the system database. The next chapter will further outline how the system was implemented, tested and validated to certify its applicability addressing the problem of relaying timely information to the farmers.

Chapter 5: System Implementation and Testing

5.1 Introduction

The implementation of the tea farming information system involved developing of native application, a USSD application and website for the backend administration. The native application was implemented on Android version 4.2 and above. The web technologies used were PHP, Bootstrap and JSON. The USSD module that provides data to users without a smart phone was built on PHP for server side scripting to enable the mobile application to communicate with the external database hosted on a server. MySQL was chosen as the database management system for the system. The PHP script fetch data from the database and send it to the application in the JSON format that can be interpreted by an Android platform. The overall structure is a three-tier architecture as shown in Figure 5.1.

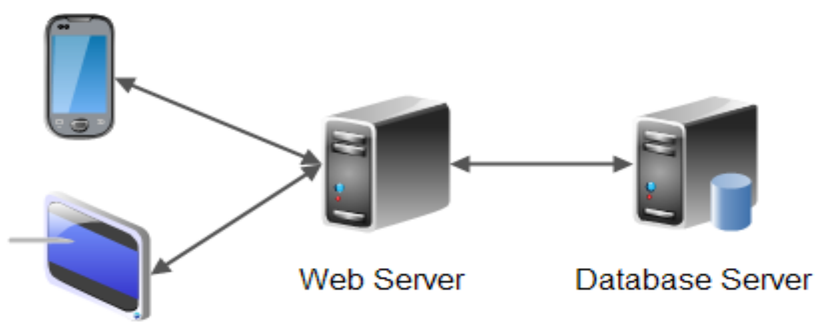


Figure 5.1 Three-Tier Architecture (Adapted from Jenkov, 2014)

5.2 Native Application Modules

The native application implemented on Android had several functionalities presented next through use of screenshots.

Notices

After a successful login, the system presents the user with a list of all available notices order by date as shown in Figure 5.2. The user can also search through the list for a specific notice.

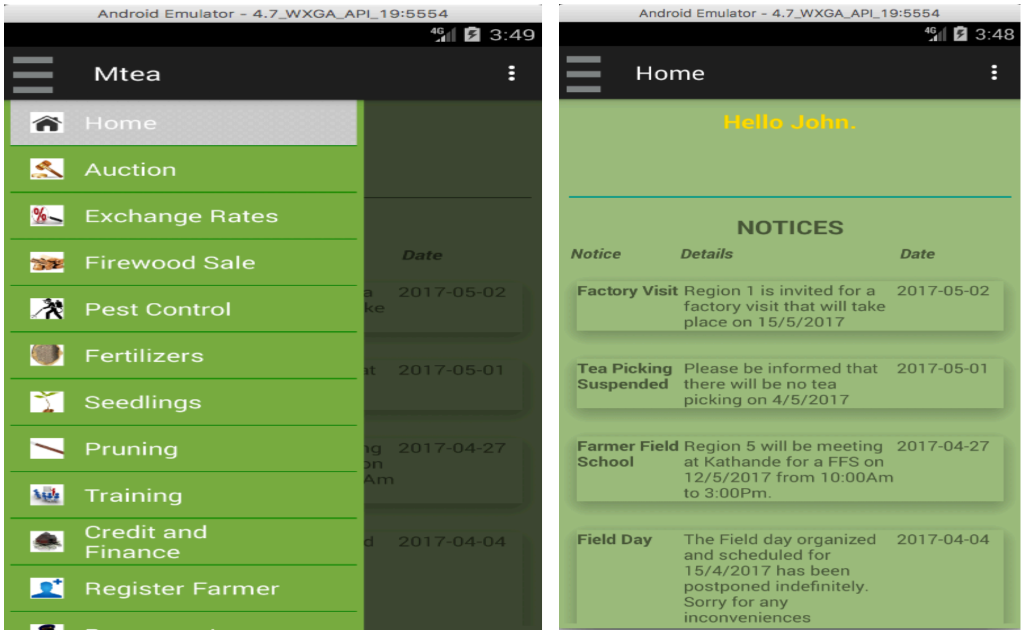


Figure 5.2 Screenshots Showing Notices to the User

Registration Module

This module allows a farmer to register other farmers into the system pending approval by the administrator. The administrator will approve or register more farmers on the backend of the system. Figure 5.3 shows the registration module.

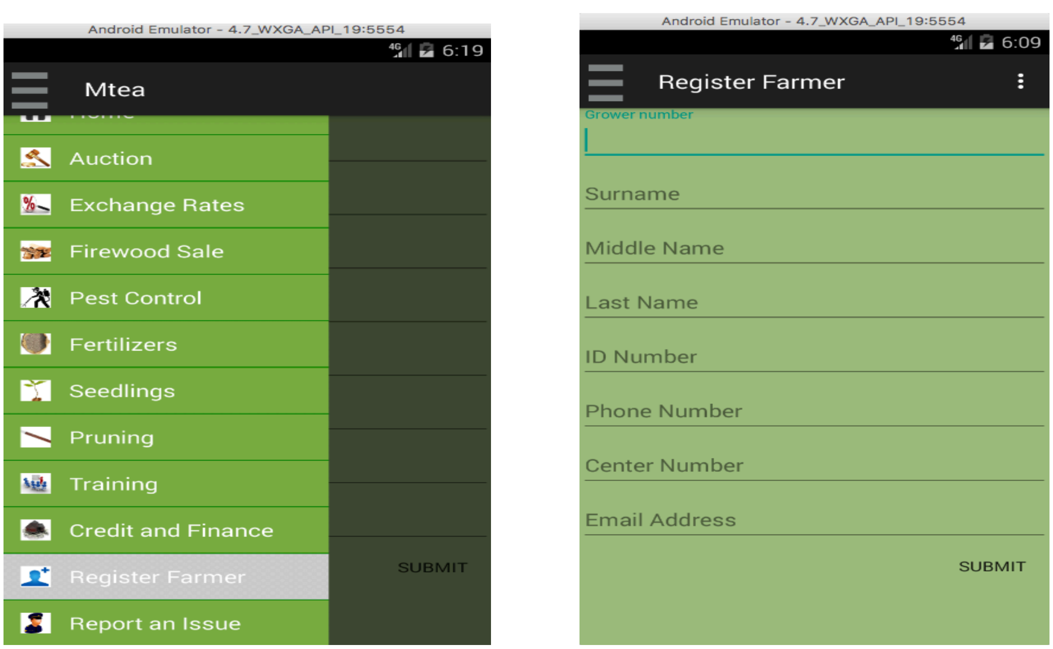


Figure 5.3 Screenshots of Registration Module

Training Module

This module provides the farmers with details of all workshops, field days and event schedules that the farmer can book and attend to learn more on tea farming as shown in Figure 5.4. The farmer can also search through the list to get a specific event they want to access.

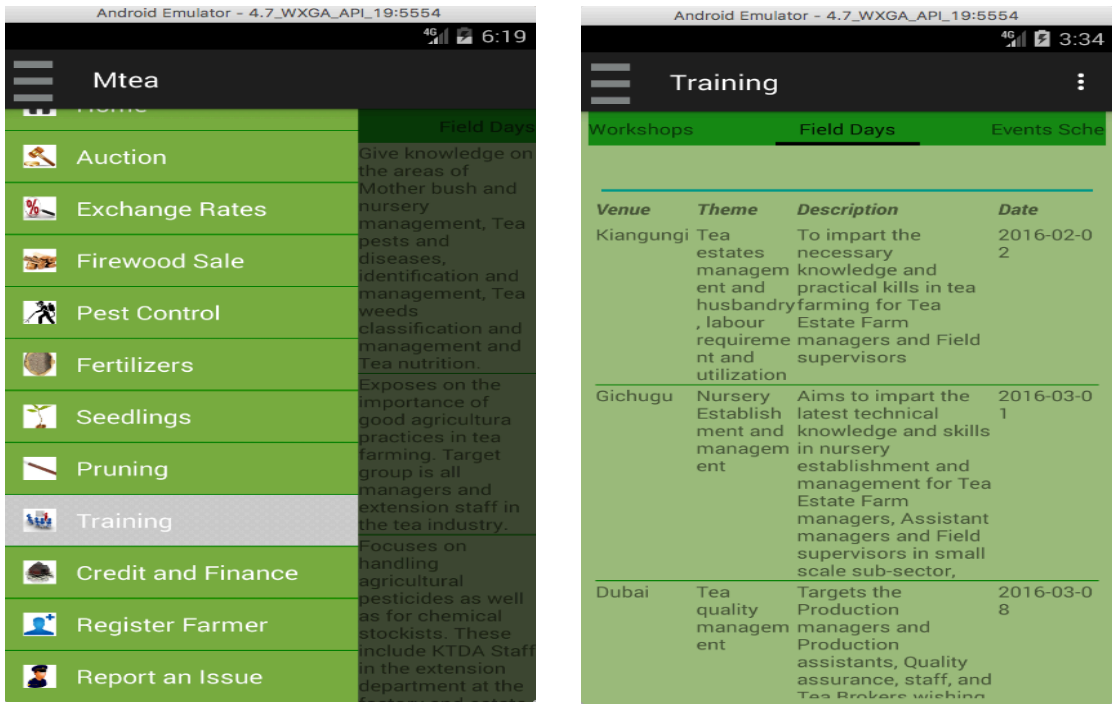


Figure 5.4 Screenshots of Training Module

Event booking

After a farmer accesses the list of the event available, they are provided with an option to book an event that they can attend as shown in Figure 5.5. A search facility is provided to get a specific event. Once the farmer presses the book button, the system processes booking by determining that the farmer had not previous booked or that there is available space for that event.

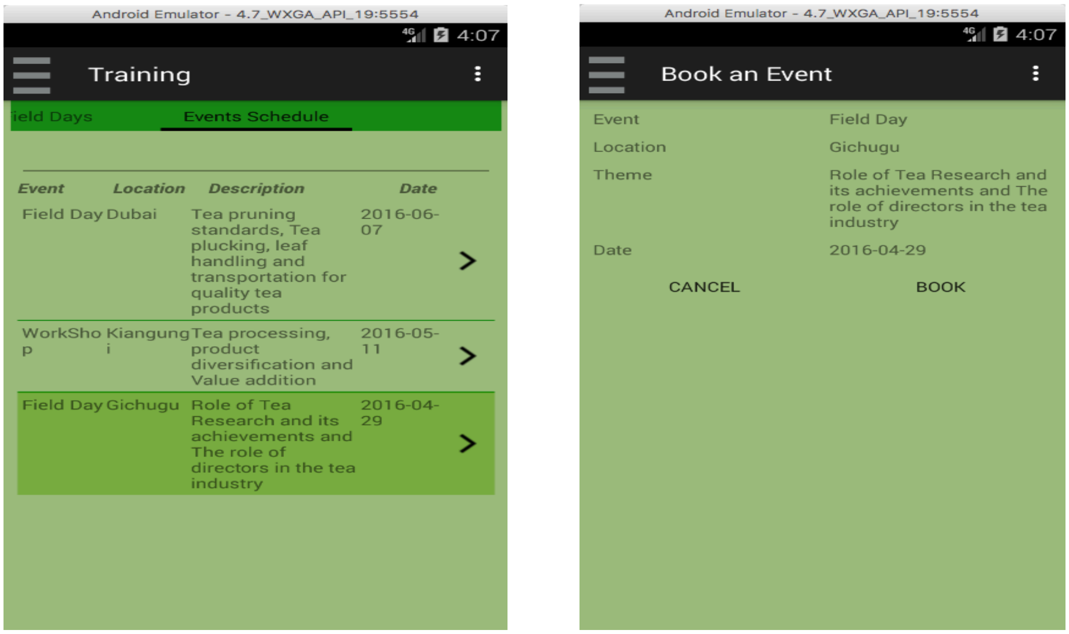


Figure 5.5 Screenshot Showing How a Farmer Books for an Event

Pest Control

This module provides information on pest control. Details are provided on the various pests that affect tea farming and the methods that are used to control these pests as shown in Figure 5.6. A search facility is also provided to help the farmer get specific information on a given pest.

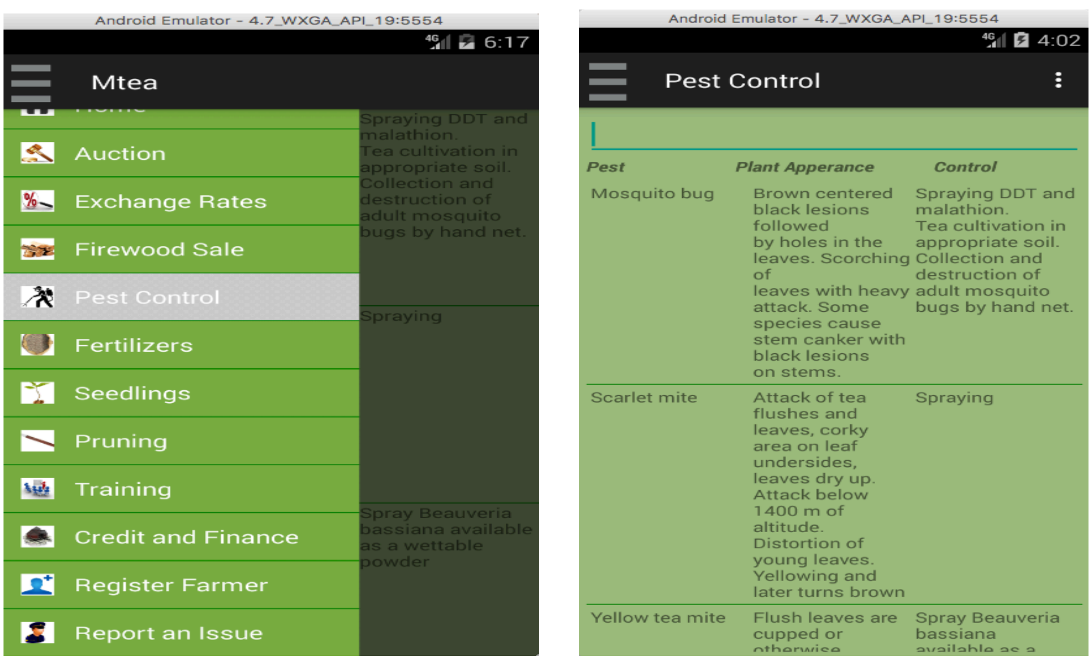


Figure 5.6 Screenshots of Pest Control

Pruning

This module gives information to the farmers on the best practices for carrying out pruning activities as demonstrated in Figure 5.7. This is inclusive of a search facility to check for a specific pruning method.

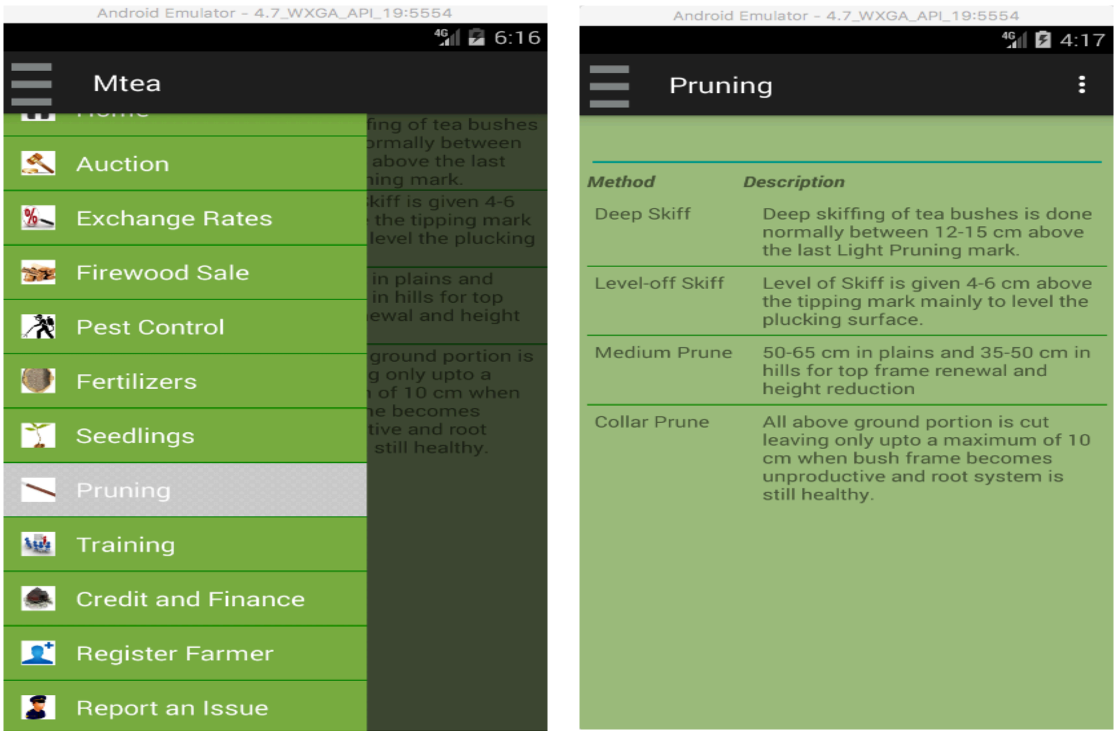


Figure 5.7 Screenshots of Pruning

Fertiliser

A farmer can access information on available fertiliser together with the cost implication as shown in Figure 5.8. A search facility is also provided to search for a specific type of fertiliser.

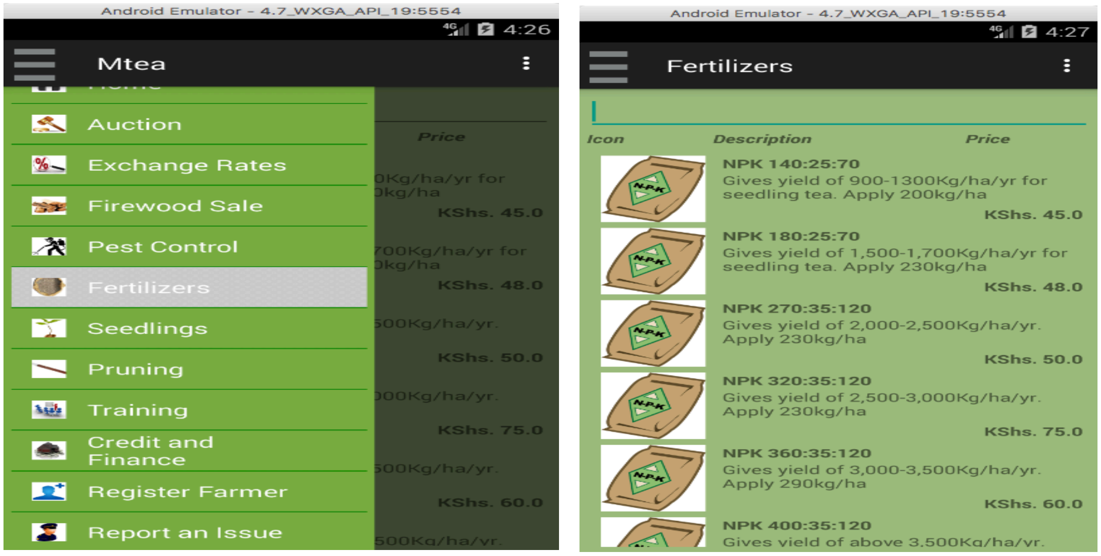


Figure 5.8 Screenshots Showing Information on Fertiliser

Seedlings

A farmer is provided with information on where they can find the seed and their costs as well as the type of the seed as shown in Figure 5.9.

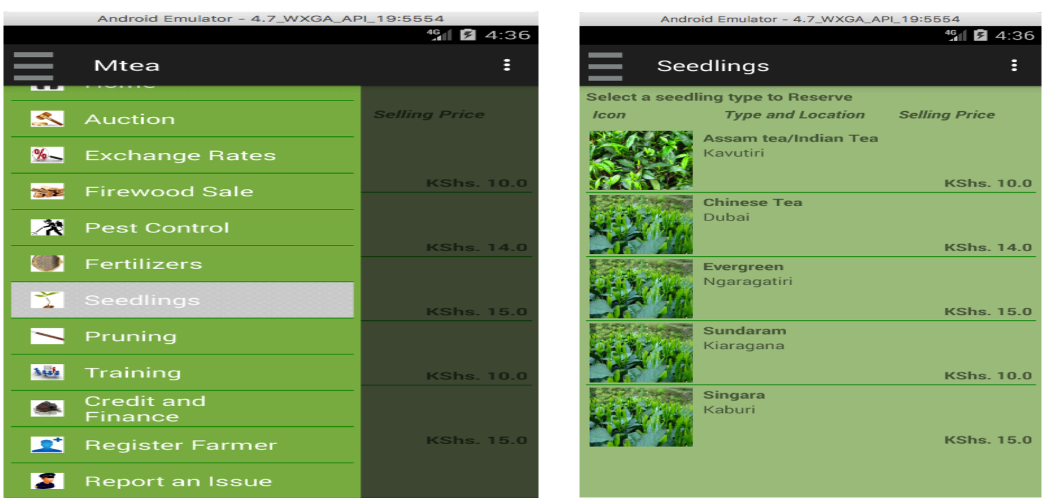


Figure 5.9 Screenshots showing Seedlings Information

Reserve Seedlings

Once a farmer has identified the type of the seedlings they want to have, they are allowed to reserve the seeds as shown in Figure 5.10. The farmer is expected to indicate the number of seedlings to reserve. Once they reserve the seedlings, they await approvals from the administrator.

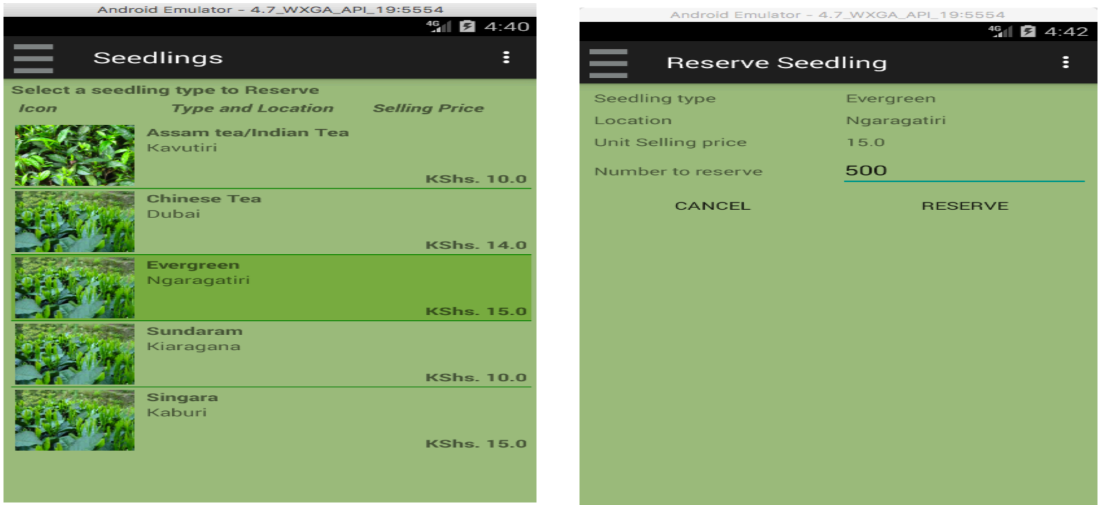


Figure 5.10 Screenshots Showing How a Farmer Reserves Seedlings

Feedback

The system allows the farmer to give a feedback based on the services they have received from the system as shown in Figure 5.11. This will help to give customised responses to the farmer needs.

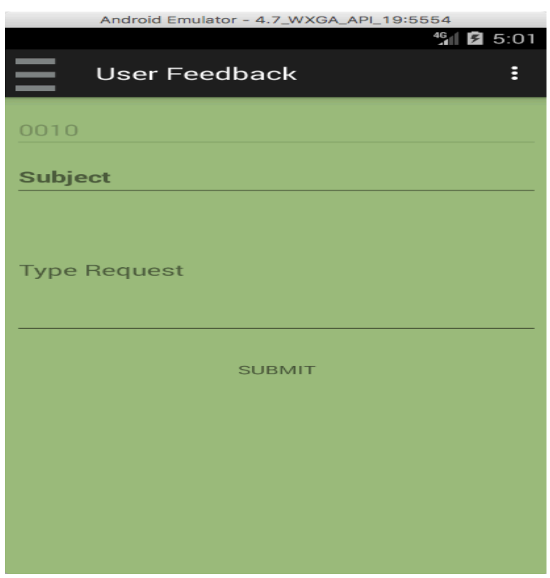


Figure 5.11 Screenshot for Farmer Feedback

Reports

A farmer can access various reports from the system showing the status that has already been undertaken. The system generates report on farmer feedback, event booking, reported incidences and seedling reservation as shown in Figure 5.12.

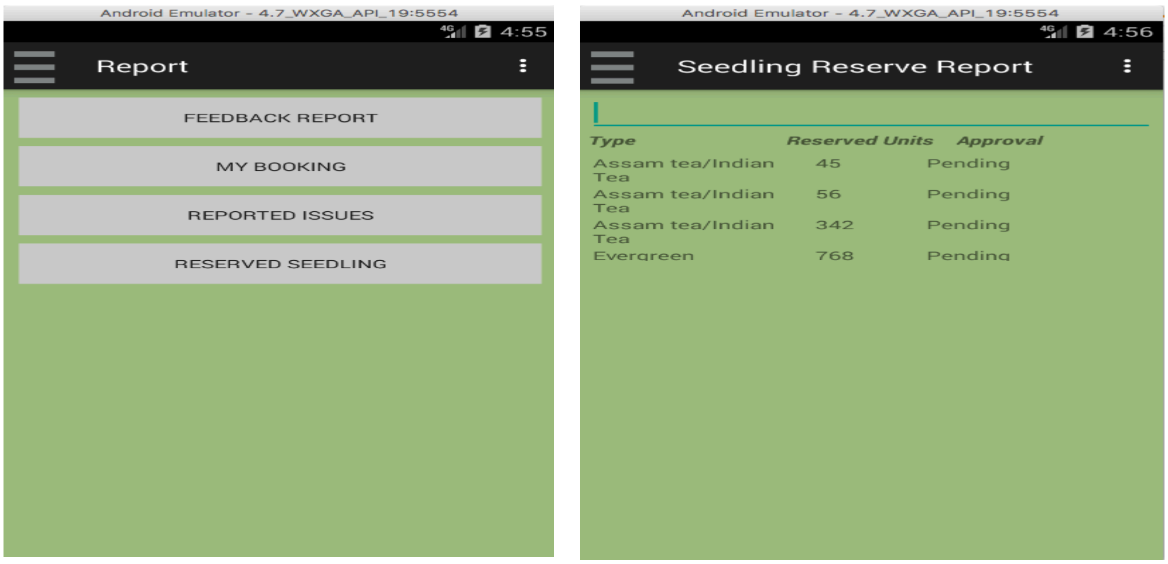


Figure 5.12 Screenshots Demonstrating Reports Generated by the System

Weather

This module gives the weather information for the day to the farmer so that they can plan accordingly as shown in Figure 5.13.

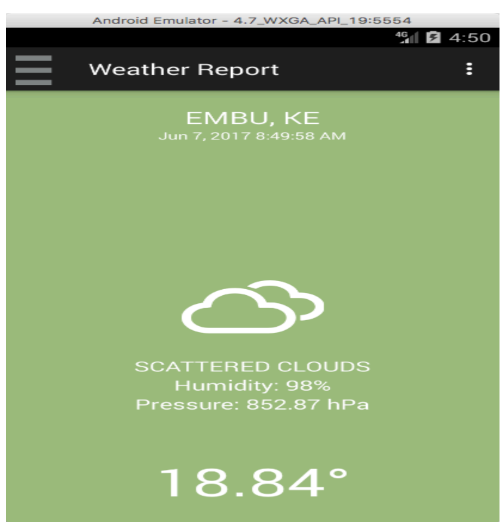


Figure 5.13 Screenshot Showing Weather Information

Search

Various modules in the system have an integrated search facility to help a farmer easily get specific information. This can is demonstrated through a search facility on pest control as shown in Figure 5.14.

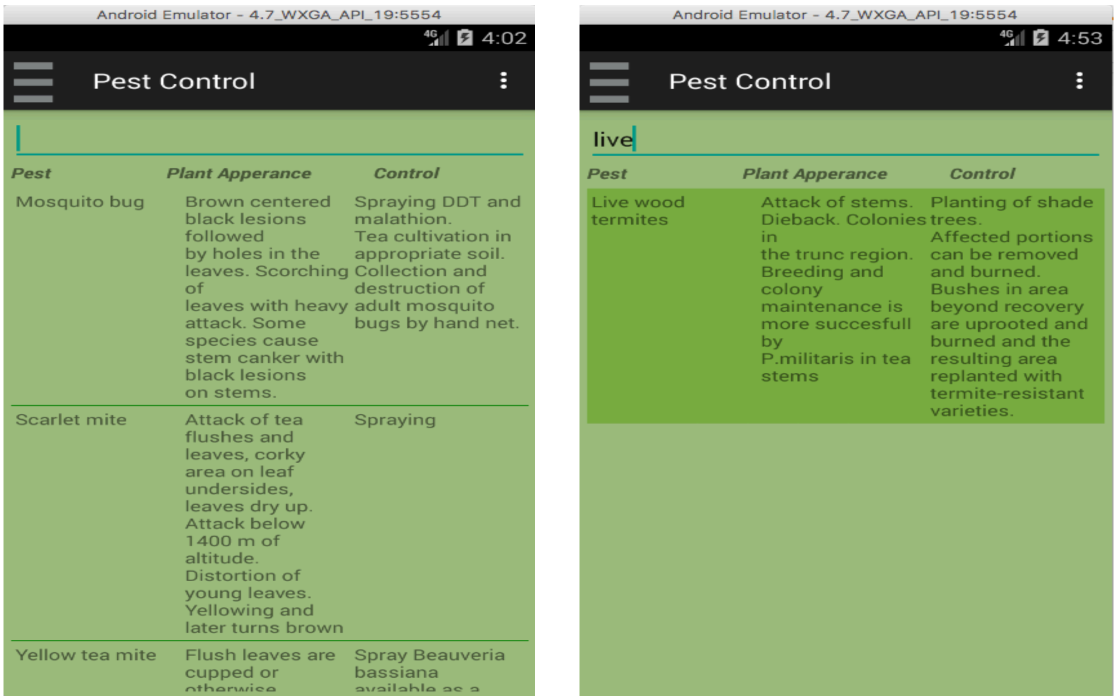


Figure 5.14 Screenshots Demonstrating Searching

5.3 USSD

This module is intended to allow those who do not currently have a smartphone to get some limited services from the tea farming information system. Figure 5.15 shows the main menu of the services provided on the USSD. The services are mainly categorised as input, extension service, market, finance and Technology.

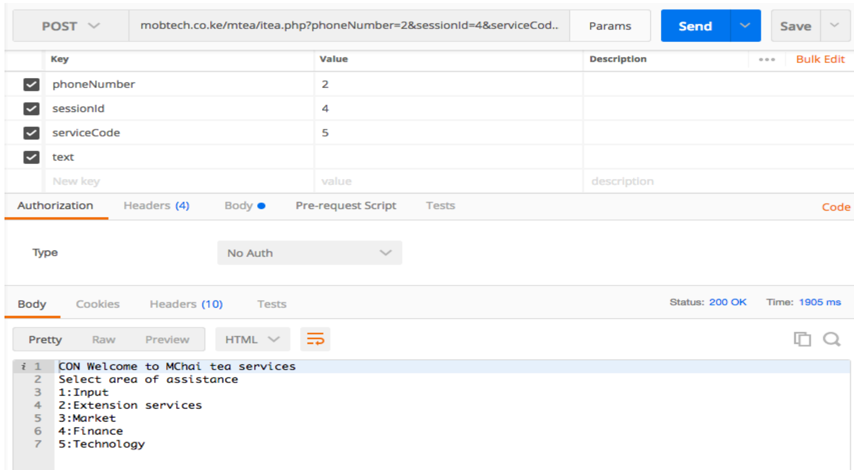


Figure 5.15 Screenshot Showing USSD Main Menu

Inputs

This module allows a farmer to get information on fertiliser, seeds and protective gear as shown in Figure 5.16. When a farmer selects seeds they are taken to another screen that prompts them to decide whether they want to purchase or get the recommended seedlings. Figure 5.17 shows recommendations for seedlings to a farmer.

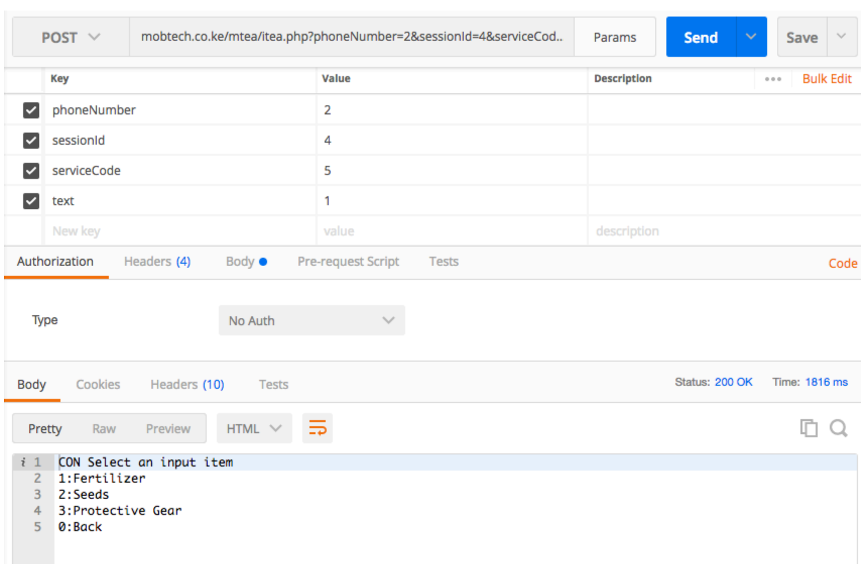


Figure 5.16 Screenshot Showing Input Services

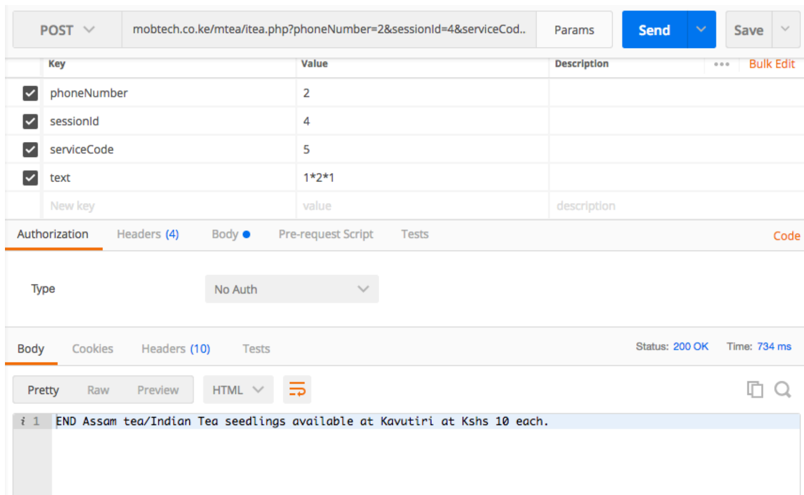


Figure 5.17 Screenshot Showing Recommended Seedlings

Extension Services

This module gives a farmer access to information on pruning and trainings as shown in Figure 5.18. The system provides details on pruning based on use of machine, pruning period or how to prune. Figure 5.19 shows information on how to prune provided to the farmer.

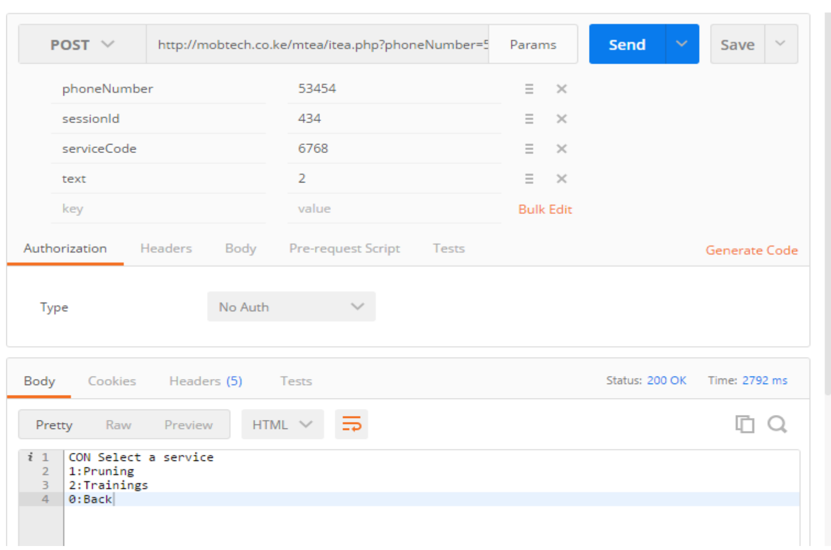


Figure 5.18 Screenshot Showing Extension Services

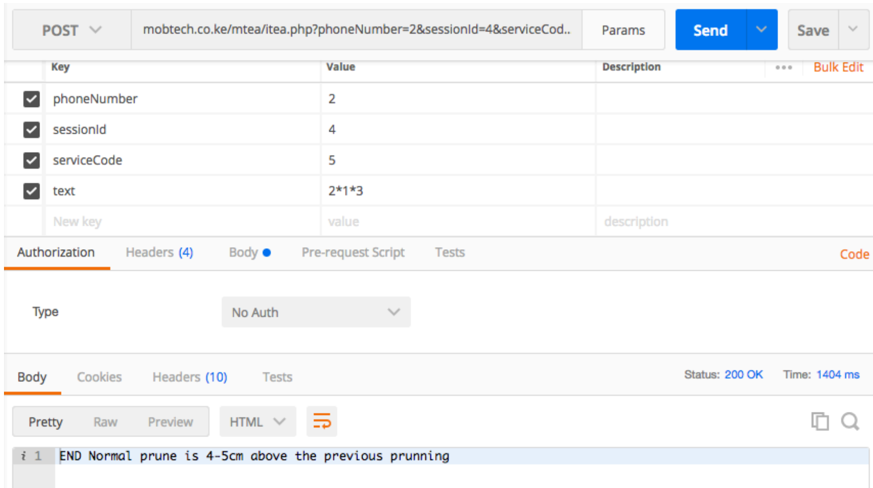


Figure 5.19 Screenshot Directing a Farmer on How to Prune

Market Information

This module gives information on the auction rates that have been achieved at Mombasa or Nairobi auction Centre. Figure 5.20 shows the auction prices per kilogram of made tea at Mombasa.

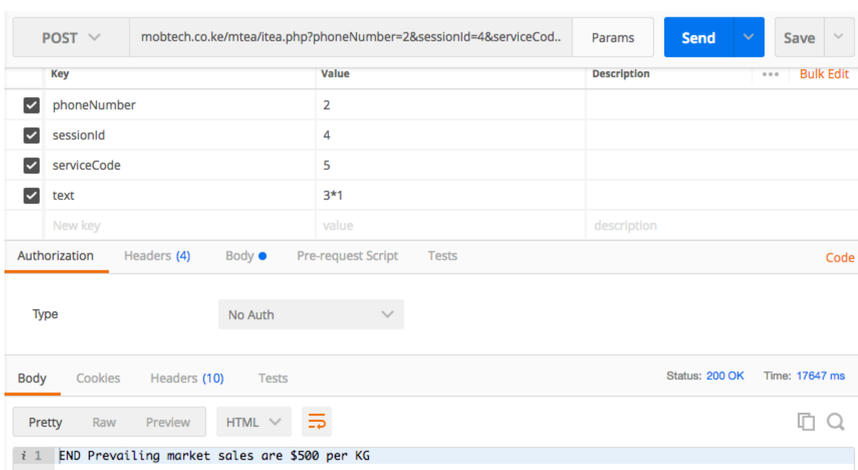


Figure 5.20 Screenshot Showing Auction Prices at Mombasa

Technology

This module gives the farmer information on the available harvesting and pruning technologies that they can adopt. Figure 5.21 shows a recommended use of a tea harvester for harvesting.

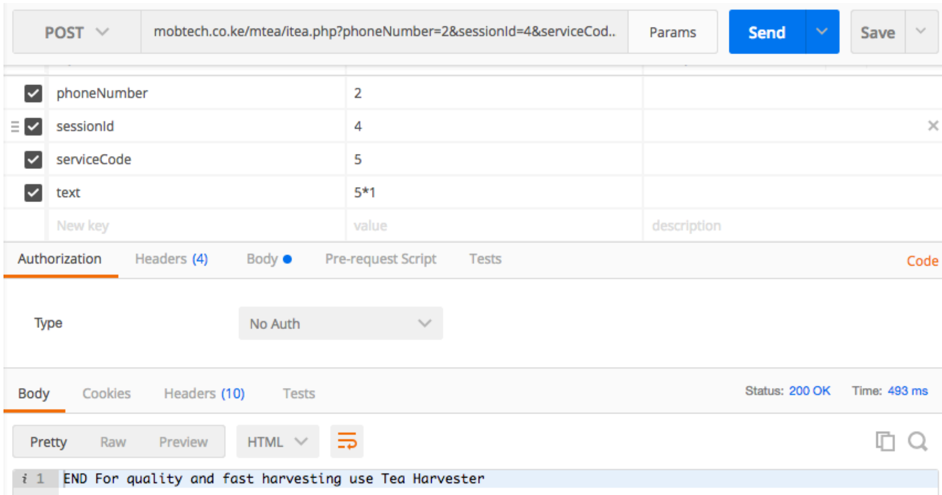


Figure 5.21 Screenshot Showing Recommendation for a Tea Harvester

5.4 Backend

This module provided the administrator with an interface to add, delete and modify various data sets on the database of the system. The various items that the administrator can undertake include modifying marketing, inputs, finance information and extension services information.

Add

The administrator has the mandate of adding content into the system. Figure 5.22 and Figure 5.23 demonstrates the add events for the system.

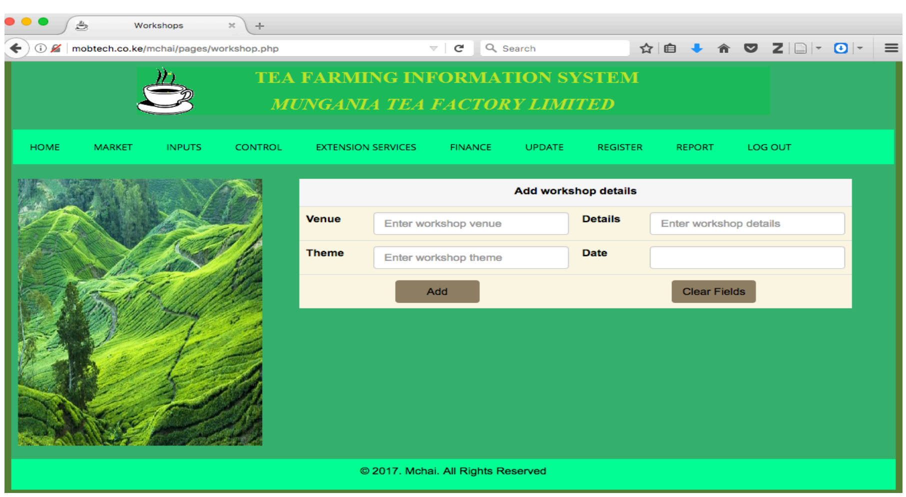


Figure 5.22 Screenshot Showing Adding Workshop Details

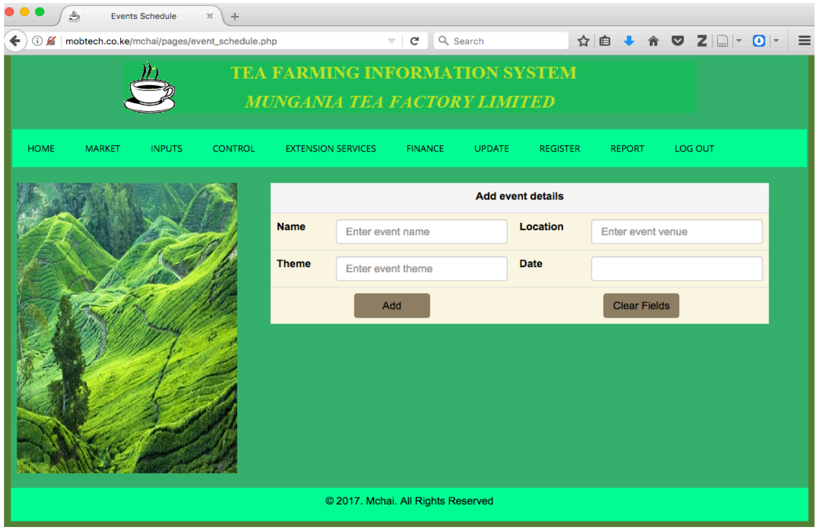


Figure 5.23 Screenshot Showing Adding Event Details

Update

Once the content has been added in the system, the administrator can view and edit it accordingly. This is demonstrated in Figure 5.24 showing a view of pruning methods details and Figure 5.25 showing update for field days information.

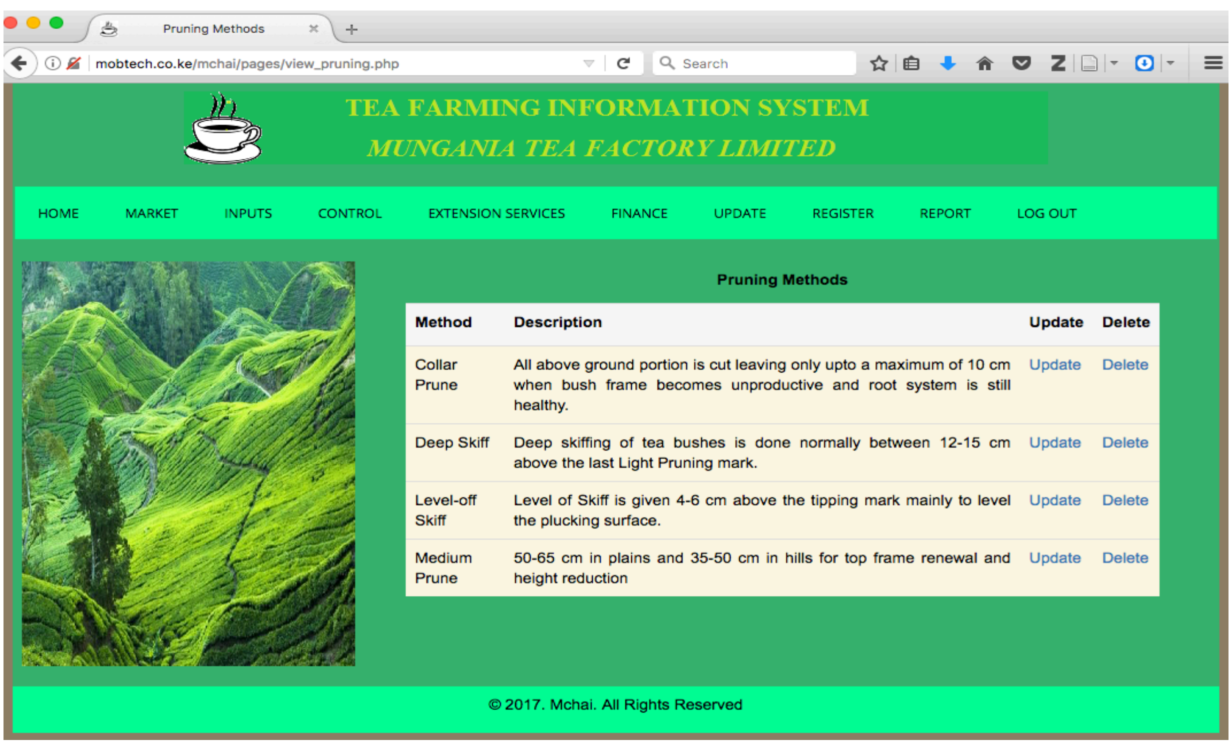


Figure 5.24 Screenshot Displaying Pruning Methods Details

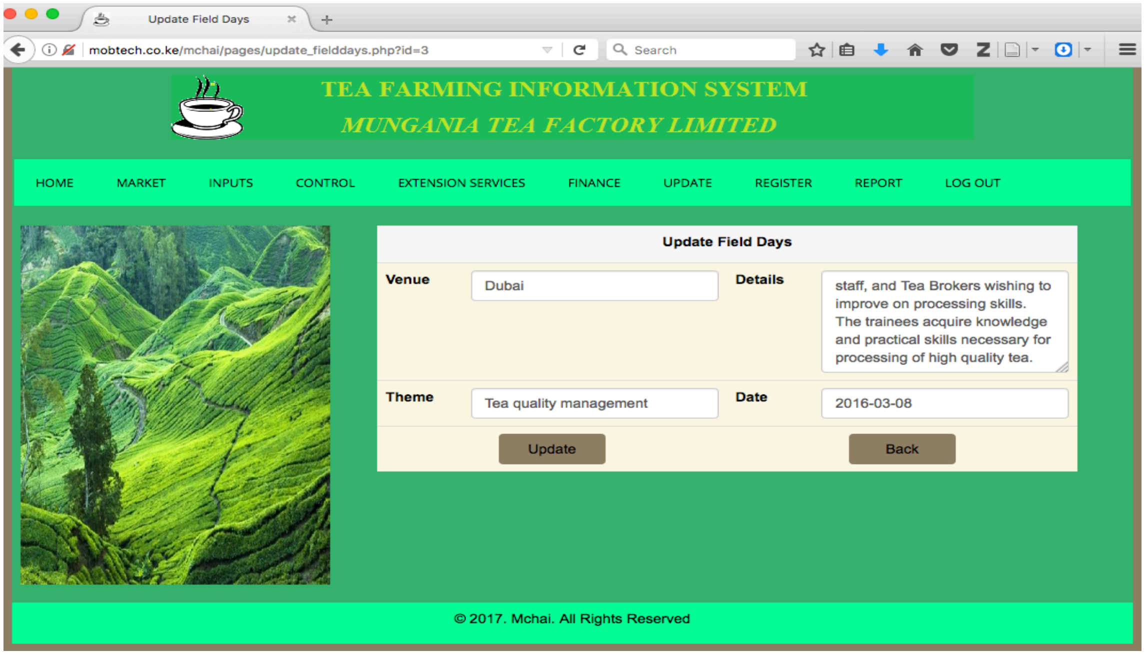


Figure 5.25 Screenshot Showing an Update for Field Days Information

Resolve

This allows the administrator to approve the requests made by the farmer from the Android application. Figure 5.26 shows a view of seedling reservations whereas Figure 5.27 demonstrates the process of approving the reserved seedlings. The system also provides the administrator a platform to register new users or approve registration requests. More screenshots for the Android App, USSD and backend are provided for within the document (see Appendix E).

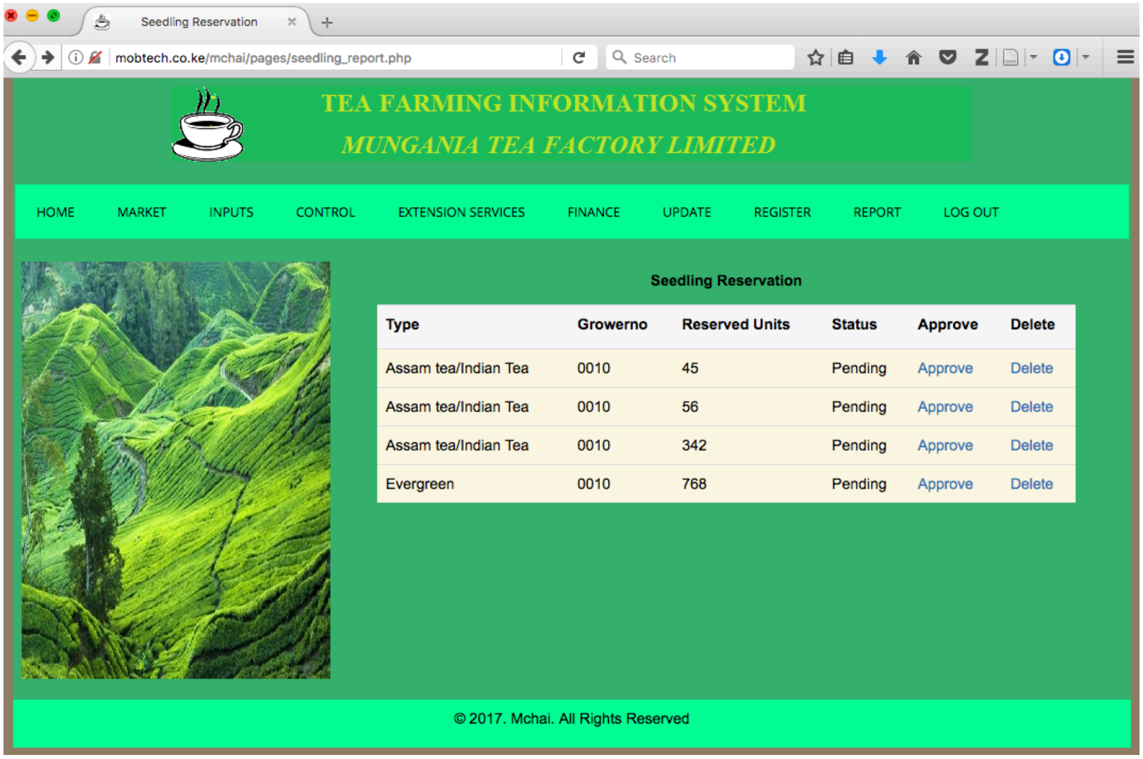


Figure 5.26 Screenshot Showing a View of Seedling Reservations

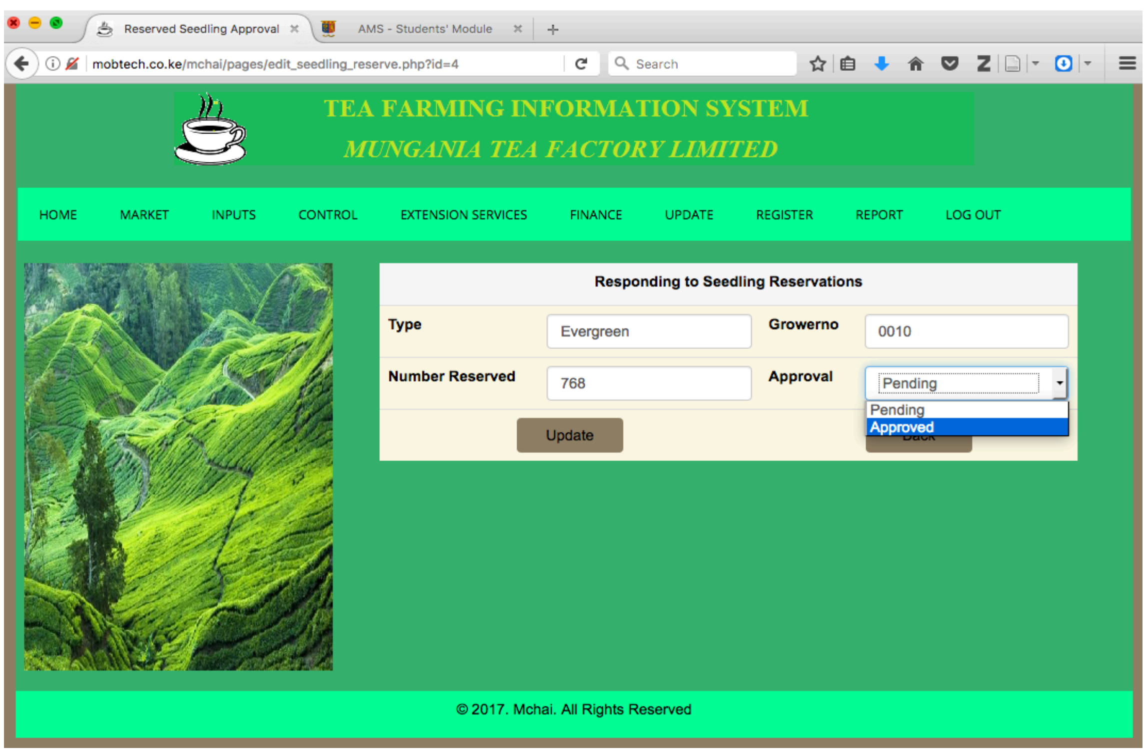


Figure 5.27 Screenshot Demonstrating How to Handle Seedling Reservation

5.5 System Testing and Results

The researcher undertook various tests to ensure that the system designed met the user expectations. A questionnaire (see Appendix C) was administered to thirty (30) respondents and the results of the testing are highlighted in the sections below. The quantitative questionnaire required the respondents to state their opinion or preference for a particular question. These results were quantifiable and measurable and were analysed accordingly through Microsoft Excel 2013. The questionnaire took both closed and open-ended responses and was disseminated by hand to the respondents. It emerged that the participants were within 21 to 45 years of age and had a primary level to bachelor's degree with majority having a high school level of education. They could therefore articulate issues consistently to ensure meaningful data was collected.

5.5.1 Functional Testing

Functional testing of the system was carried out to ascertain that the functions provided by the application were working as expected and ensure stability of the system. It was discovered that all the tests carried out on all functions worked as expected and did not produce any errors as shown on Table 5.1. The importance of this testing was to guarantee reliability of the system and data integrity. All these functions combined together delivered the desired information needs of tea farmers enhancing their decision-making.

Table 5.1 Functional Testing Results

Function Tested	Test Carried Out	Expected Results	Observation	Error
Farmer registration	Registering a new farmer	Successful registration	Performed as expected	None
Login	Successfully login a registered user	Successful login	Performed as expected	None
Add events (Fertiliser, Pruning, Event, Firewood, Pest control, Seedling, Workshop, Notices)	Administrator can agricultural information and details on events	Successful addition of information	Performed as expected	None

View events (Pruning, Auction, Firewood, Pest control, Seedlings, Finance, Reports, Fertiliser, Workshops, Field days, Incidences, Notices, Weather)	Farmers and administrator can view information available on the system	List of available data displayed to the farmer and administrator	Performed as expected	None
Search events (Pruning, Firewood, Pest control, Seedlings, Fertiliser, Workshops, Field days, Incidences, Notices)	Logged in farmers can search information on the system	List of data according to user search criteria	Performed as expected	None
Report incidence	Report a farmer breaking laid down regulations	Successful reporting of incidences on the system	Performed as expected	None
Update events (Fertiliser, Pruning, Event, Firewood, Pest control, Seedling, Workshop, Notices)	Administrator updates information on the system	Information successfully modified	Performed as expected	None
Resolve events	Administrator resolves the requests of the farmer	System allowed administrator to successfully resolve farmer requests	Performed as expected	None
Book event	Farmer books for a Field day or workshop they	Field day or workshop successfully booked without	Performed as expected	None

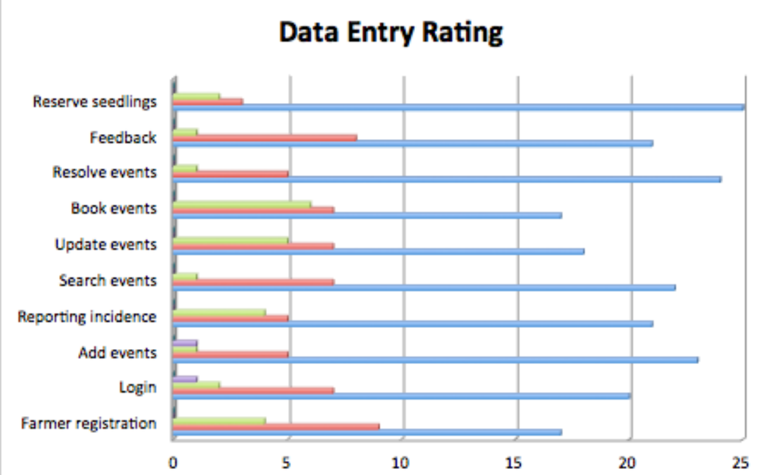
	intend to attend	double booking		
Feedback	Farmer gives a feedback regarding the system	Feedback successfully recorded	Performed as expected	None
Reserve event	Farmer reserves seedlings	Successful reservation of seedlings	Performed as expected	None
Reports (Feedback, Bookings, Incidences, Reservations)	System provides the farmer with various relevant reports	Successful generation and viewing of reports	Performed as expected	None

5.5.2 Usability Testing

Usability testing was carried out to verify the ease of use of the system, overall acceptance and how user friendly the system was. This ensured that the users were satisfied with the system leading to acceptance. The results analysed below rated the ease of data entry and ease of navigation as excellent, the appearance of the application as very good and the feedback of the application as good.

Ease of Data Entry

Majority of the respondents rated the ease of data entry as excellent. The functionalities tested included farmer registration, login, fertiliser, pruning, firewood, pest control, seedling, workshop, notices, reporting incidence, field days, book event, resolve event, feedback and reserve seedlings. This can be shown in Figure 5.16 for the various modules that were tested. The respondents found out that it was easy to use the application to enter data into the system. The high rating for ease of data entry was an endorsement of the data entry modules.

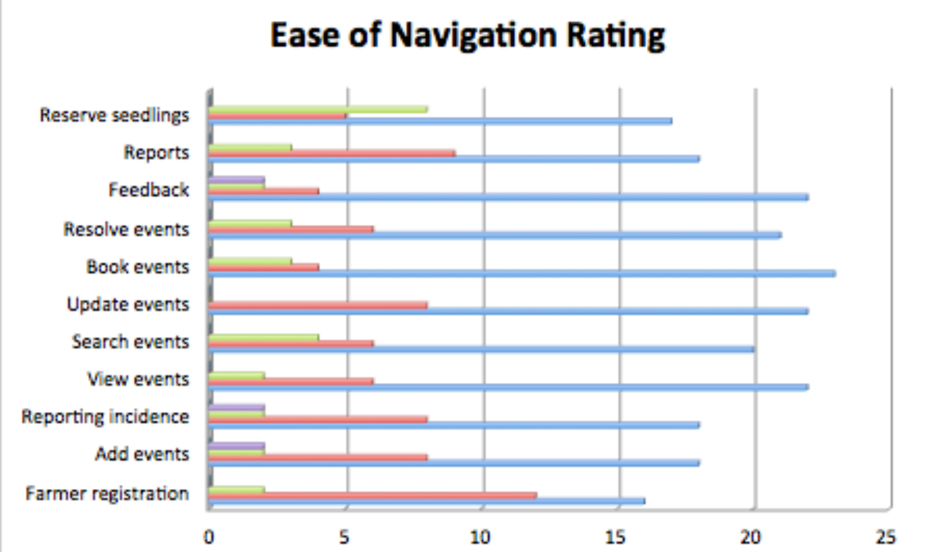


	Farmer registration	Login	Add events	Reporting incidence	Search events	Update events	Book events	Resolve events	Feedback	Reserve seedlings
Bad	0	0	0	0	0	0	0	0	0	0
Fair	0	1	1	0	0	0	0	0	0	0
Good	4	2	1	4	1	5	6	1	1	2
Very good	9	7	5	5	7	7	7	5	8	3
Excellent	17	20	23	21	22	18	17	24	21	25

Figure 5.28 Data Entry Rating Test Results

Ease of Navigation

Majority of the respondents rated the ease of navigation for the various modules as excellent as can be shown in Figure 5.17. The functionalities tested included farmer registration, login, fertiliser, pruning, firewood, pest control, seedling, workshop, auction, finance, weather, notices, reporting incidence, field days, book event, resolve event, feedback and reserve seedlings. The users managed to easily browse through the application from the home screen to a page that contained the information they required. This was confirmed by the excellent ratings that were given by the users on ease of navigation for the various modules. This was due to categorisation, working search feature, clickable navigation links and consistency of the application.



	Farmer registration	Add events	Reporting incidence	View events	Search events	Update events	Book events	Resolve events	Feedback	Reports	Reserve seedlings
Bad	0	0	0	0	0	0	0	0	0	0	0
Fair	0	2	2	0	0	0	0	0	2	0	0
Good	2	2	2	2	4	0	3	3	2	3	8
Very good	12	8	8	6	6	8	4	6	4	9	5
Excellent	16	18	18	22	20	22	23	21	22	18	17

Figure 5.29 Ease of Navigation Rating Test Results

Application Appearance

Majority of the respondents rated the application very good in terms of appearance with 27% rating it as excellent. The results are shown in Figure 5.18. The user interface is key in maximising the usability and user experience. It is everything that a user can see and interact with. The application provides an operational, usable and adaptable interface to the changing needs of users. The respondents rated the application as having a very good appearance implying that the application had a good look and feel.

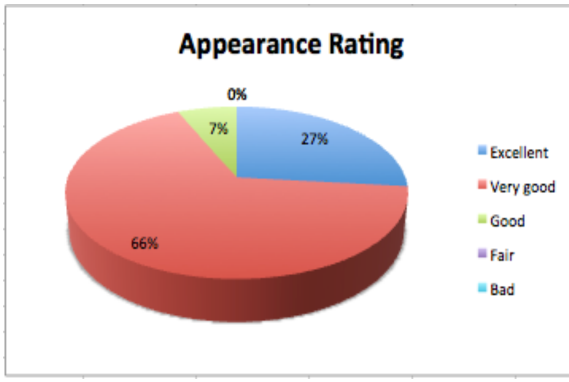


Figure 5.30 Appearance Rating Test Results

Feedback of the System

The respondents also rated the feedback to warnings and dialogs as good to the user whereas a 20% viewed it as being very good. This is as shown in Figure 5.19. The reaction a user receives from engaging with the application is important since it leads to learning, improved performance and informed response to warnings. A rating of good by the majority of the respondents meant that users accepted the feedback they received from the application.

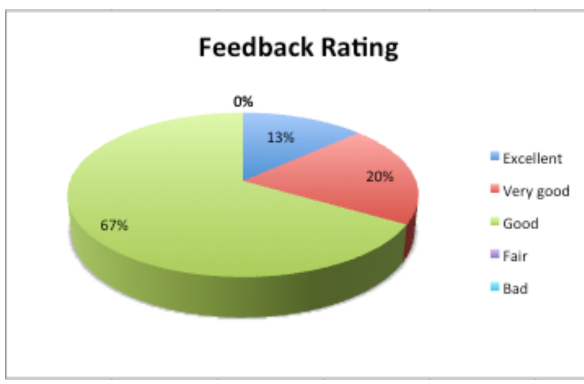


Figure 5.31 Feedback Rating Test Results

5.5.3 Compatibility Testing

The application was tested with various versions of Android and different models of smartphones and the results thereof tabulated. It was established that the application works well with different Android versions and smartphone models as shown in table 5.2.

Table 5.2 Compatibility Testing Results

Type of Smartphone	Compatible	Incompatible
Tecno Phantom 6 – Android Version 6.0	Yes	
Samsung Galaxy A5 (2016) – Android Version 5.1.1	Yes	
Tecno C8 – Android Version 5.0.2	Yes	
HTC 820 Desire - Android Version 4.4.2	Yes	
Tecno H6 – Android Version 4.4.2	Yes	

5.6 Validation

The researcher undertook system validation by determining and documenting system requirements, system testing, issuing a survey and providing an installation protocol. All the requirements specifications (see Appendix A) identified were included in the final system that was successfully tested to ascertain that the system solved the problem identified. Testing was conducted through questionnaire (see Appendix C) administered to thirty (30) respondents to help test the functionality, usability and compatibility of the system and the lessons learned documented. The system testing process was discussed in the previous section of this study. The native Android application was downloaded and installed from Google Play Store.

In addition, a survey was issued via email to thirty (30) respondents to help the researcher assess whether the system met its intended purpose (see Appendix D). Analysis of the survey results gave the application an excellent overall rating. From the analysis of the results, the respondents rated the application as excellent in terms of meeting the information needs of tea farmers as shown in Figure 5.20. The respondents further rated the relevance of information in the application as appropriate with a 22% viewing it as absolutely appropriate as demonstrated in Figure 5.21. The application was also rated as influencing above 75% of decisions made by farmer whereas 11% were of the view that it influenced about 100% of their decisions as shown in Figure 5.22. The application had an excellent overall rating as can be shown on Figure 5.23.

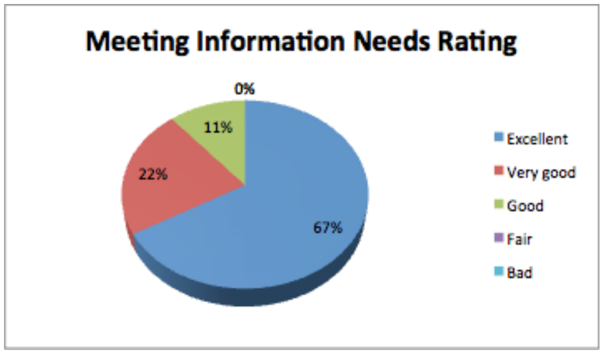


Figure 5.32 System Rating on Meeting Information Needs of Farmers

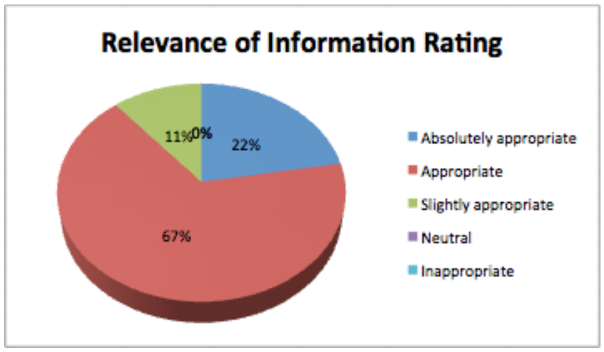


Figure 5.33: System Rating on the Relevance of Information Available

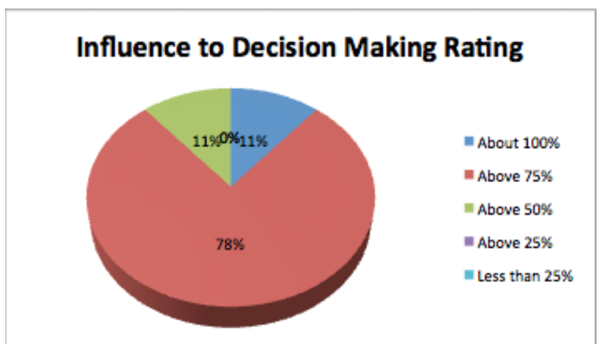


Figure 5.34 System Rating on its Influence to Decision Making by Farmers

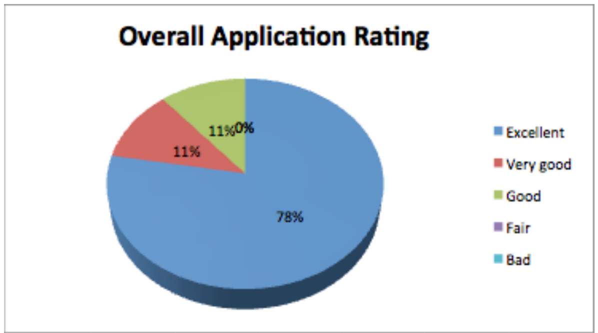


Figure 5.35 Overall Rating of the Application

5.7 Conclusions

The researcher discussed the various modules that were developed for the tea farming information system. These included a native Android application and a USSD for accessing information and a web based backend for modifying information on the system. The researcher also carried out various successful tests on the system. Finally the system was validated to ensure that it could respond to the intended purpose. The next chapter will discuss in details the results of testing and the research findings from the data that was collected.

Chapter 6: Discussions

6.1 Introduction

This chapter covered the lessons that the researcher derived from the testing results and data collected during the study. It presented an in-depth view of the system through a discussion on the revelations derived from the user data. The benefits of using the mobile information system were highlighted together with some recommended improvements.

6.2 Summary Research Findings

The underlying objective of this dissertation was to develop a tea farming information system for relaying information to tea farmers in a timely manner through a USSD and a native Android mobile application. This would help farmers make quick and informed decisions leading to improved revenue both to the farmers and the government. Information providers ought to be proactive and provide information to the farmers effectively and timely. CPDA (2008) discovered that information flow and sharing was poor and in some cases completely missing with the farmer being the major loser. This was achieved by addressing the four main objectives highlighted in chapter one of this study.

The first objective was analysing the information needs of tea farmers. This was partially addressed by review of related literature under chapter two. The literature review gave insights into the need for an interview (see Appendix B) with the farmers that was developed and administered as elaborated in chapter three and the results thereof discussed in chapter four. The second objective was investigating the weaknesses on existing information systems in tea farming. The researcher focused on this through literature review as discussed in chapter two. As part of understanding weaknesses on existing systems, interview questions were developed and conducted as featured in chapter three and the results thereof reviewed in chapter four.

The third objective was to design, develop and test an information system that would address the information needs of the farmers. Based on the identified weaknesses on existing information systems and the information needs of tea farmers, the researcher carried out an analysis and design for the new information system as discussed under chapter four. A detailed description of the implementation and testing of the designed system is provided in chapter five. The researcher discussed how the last objective on validating the information system developed in chapter three.

As part of validation process, a survey (see Appendix D) was designed and administered as detailed in chapter three and the results thereof discussed in chapter five.

Firstly, the information needs of tea farmers were broadly classified into agricultural inputs, marketing information, technology information, credit information and extension education. Ensuring easy and timely access to information, knowledge and experts via mobile technologies will lead to improved production and revenue, reduced digital gap, better practices and increased awareness of government policies and support. Secondly, the existing challenges that farmers face while seeking agricultural information include lack of awareness, low literacy level and uncoordinated research and dissemination of information. Thirdly, it was deduced that lack of information or inadequate information is a major contributor to information gap and lack of adoption to available technologies.

Consequently the smallholder farming systems are less productive and profitable, less value addition and increased cost of production. The results of this study therefore sought to address these issues by providing a way that farmers could access information on the go. The system was put to test and the respondents voiced their satisfaction that the functionalities worked out as expected. The system was also validated to ensure that it meets the intended purpose. However, the farmers highlighted some areas of improvements that were pointed out to form the basis for future research and development

6.3 Findings of System Testing

The researcher undertook to verify that the system would perform optimally and meet the user expectations. This was done through functional, usability and compatibility testing as discussed in chapter 5. All the modules of the system performed as expected without errors showing that the system could be relied upon to information needs of tea farmers hence enhancing their decision-making. The system proved usable by the farmers who rated the ease of data entry and ease of navigation as excellent, the appearance of the application as very good and the feedback of the application as good. The application was tested and worked excellently on various smartphone models and different versions of Android.

Coupled with functional testing, usability testing and compatibility testing the tea farming information system managed to influence decision-making among tea farmers. In addition, a survey was issued to verify if the system actually solves the problem identified. The results showed satisfaction by giving the system an excellent rating on meeting their information needs and the overall experience.

6.4 Merits of the Mobile Application

Below are some benefits that users of the system will reap.

i. The factory will incur reduced costs of disseminating information.
ii. Increased farmer independence due to availability of expert information.
iii. Improved efficiency that reduces spoilage and heightens quick decision-making.
iv. Enhanced availability of information on the go to the farmers.
v. Increased production that will boost revenue for farmers and the Government of Kenya.

6.5 Conclusions

This chapter discussed the deduction that the researcher derived from the study. The merits of the developed system were also highlighted and recommendations for its improvement provided. The developed tea farming information system changed the way information is relayed to the farmers as well as ensure that up to date relevant materials were available to farmers on the go. The next chapter will cover suggestions, recommendations and conclusions for future work in this area of study.

Chapter 7: Conclusions, Recommendations and Future Work

7.1 Introduction

This chapter focused on the conclusions derived by the researcher as well as the recommendations following the completion of the research work. It summarised lessons learned and suggestions for future work in this area of study. With the provision of a mobile application, it was noted that the farmers could easily get information on the go as anticipated from the inception of the project.

7.2 Conclusions

A review on the existing literature pointed to an existing gap in providing agricultural information to tea farmers. Many existing systems mainly gave marketing information or tracked produce delivery but failed to give information on improving production. In addition, lack of targeted and customised information, high cost of services like voice based and online communities and limited access to extension officers' services needed to be addressed. Further requirements specifications (see Appendix A) were discovered from the interviews that were undertaken with the stakeholders. Firstly, the information needs of tea farmers were broadly classified into agricultural inputs, marketing information, technology information, credit information and extension education.

Ensuring easy and timely access to information, knowledge and experts via mobile technologies will lead to improved production and revenue, reduced digital gap, better practices and increased awareness of government policies and support. Secondly, the existing challenges that farmers face while seeking agricultural information include lack of awareness, low literacy level and uncoordinated research and dissemination of information. Thirdly, it was deduced that lack of information or inadequate information is a major contributor to information gap and lack of adoption to available technologies. Consequently the smallholder farming systems are less productive and profitable, less value addition and increased cost of production.

This study therefore sought to address these issues by providing a way that farmers could access information on the go by developing a mobile based tea information system. The system was put to test and the respondents voiced their satisfaction that the functionalities worked out as expected. The system was also validated to ensure that it meets the intended purpose. However, the farmers highlighted some areas of improvements that were pointed out to form the basis for future research and development

7.3 Recommendations

The research carried out successfully demonstrated that a tea farming information system would immensely contribute to improving the overall production of in tea farming. This is by availing information on the go hence leading to quick and informed decisions by the farmers. The overall effect would be increased revenue for both farmers and the government. The researcher therefore recommends the adoption of the system by the Mungania Tea Factory Limited. This will help the factory cut down on information dissemination costs, curb poor and delayed communication, and provide targeted and customised feedback to farmers.

7.4 Future Work

Further development in this area can be conducted to improve the overall user experience. Some of the areas to be considered include the following.

i. Integration with other systems: Integrating with Mungania Tea Factory Company Limited systems and KTDA systems so that a farmer can have more information availed to them and allow for ordering and payments.
ii. Global Positioning System: This will achieve precision or site-specific farming to increase profits and help protect the environment.
iii. The respondents suggested that in future releases the application should include other mobile platforms like Windows Phone and IOS. The respondents further suggested that the system be provided in Kiswahili language so as reach more farmers.
iv. Impact assessment: Further study ought to be carried out to assess the significance brought about by the use of the tea farming information system.

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Appendices

Appendix A: Requirements Specifications

The system has two types of users interacting with the system: Farmer and Administrator. Each has a set of requirements shown below.

Farmer

Functionality	**Description**
User login	Registered and approved farmers should be able to login through the mobile application
Check notices	Checking all the notices given from the factory
Check auction details	Farmer accesses auction details
Currency conversion	Based on the auction details farmer can perform currency conversion
Check firewood sale	Farmer accesses information on the site for firewood sale
Check fertiliser details	Farmer checks information on fertiliser available and costs
Check seedling details	Farmer accesses seedling cost, type and location
Reserve seedlings	Farmer successfully reserves some seedlings
Retrieve seedling reservation report	Farmer gets a report on the status of the seedlings reservation
Check pruning details	Farmer accesses information on how pruning is done
Check workshop and Field day details	Information on workshops and field days is availed to the farmer.
Check events details	Farmer checks venue, date and the type of the event organised by the factory
Book an event	Farmer successfully books an event they would like to attend

Retrieve event bookings report	Farmer gets a report on the status of the events they booked to attend
Check credit and finance details	Information on Banks and SACCOs that the farmers can access credit facility is availed
Report an incidence	Farmer is able to report an illegal incidence they have observed
Retrieve reported incidences	Farmer can access all the incidences that have been reported as well as get a report on the status of the incidences they have reported
Enter feedback	Farmer is able to enter and submit feedback
Retrieve feedback report	Farmer gets a report on the status of all the feedback they have given
Check weather information	Farmer accesses the daily weather report so as to plan accordingly
Searching	Application should allow for searching for specific information.

Administrator

Functionality	**Description**
User login	Administrator can log into the system successfully
Add agricultural information (Fertiliser, Seedlings, Pruning, Workshops, Field days, Events schedule, Firewood sale, Pest control, Finance)	System provides the administrator with a platform to add agricultural information on fertiliser, seedlings, pruning, workshops, field days, events schedule, firewood sale, pest control and finance
View agricultural information	System allows the administrator to view all the agricultural information they have uploaded into the system
Update agricultural information	System allows the administrator to update all the agricultural information they have uploaded into the system

Resolve farmer feedback	Administrator is able to view the feedback given by the farmers and respond to it accordingly
Approve bookings and seed reservations	Administrator views the bookings and reservations made by the farmer and approves them accordingly
Register farmer	Administrator and register and approve new farmers
Add user	Administrator can add other administrators to manage the system

Appendix B: Interview Questions

TEA FARMING INFORMATION SYSTEM INTERVIEW QUESTIONS

Section A: Information Needs

1. What type of information do you seek in farming?
2. Who is your primary source of farming information?
3. How often do you receive updates on farming information?
4. Through what modes do you receive farming information?

Section B: Existing System Weaknesses

1. What challenges do you face while seeking farming information?
2. How would you rate the current model of delivering farming information? (1--Inefficient, 10-Very efficient)
3. Which method of accessing information would you prefer and why?

Section C: Mobile System for Relaying Farming Information

1. Would you consider use of a mobile application to provide farming information?
2. What features do you think are crucial for a mobile platform used to relay farming information?
3. What type of operating system are you using?

Appendix C: User's Questionnaire

TEA FARMING INFORMATION SYSTEM USER TESTING QUESTIONNAIRE

Dear Respondent,

I am a Masters student in the Faculty of Information Technology at Strathmore University conducting a research on dissemination of agricultural information to tea farmers. I kindly request you complete this questionnaire intended to assess the user experience and test that the application eases access and dissemination of agricultural information to the farmers to promote informed decision-making.

Section A: Demographics

1. Age group
    1) 21-25 ☐
    2) 26-30 ☐
    3) 31-35 ☐
    4) 36-40 ☐
    5) 41-45 ☐
2. What is your level of education?
    1) Primary school ☐
    2) High school ☐
    3) Diploma ☐
    4) Bachelor's degree ☐
    5) Post-graduate ☐

Section B: Application Testing

1. How would you rate the appearance of the application?

1) Excellent ☐

2) Very good ☐

3) Good ☐

4) Fair ☐

5) Bad ☐

2. How would you rate the application in terms of ease of navigation for the modules below?

Excellent-5 Very good-4 Good-3 Fair-2 Bad-1

Module	**1**	**2**	**3**	**4**	**5**
Farmer registration					
Add events					
Reporting incidence					
View events					
Search events					

3. How would you rate the ease of data entry for the following modules?

Excellent-5 Very good-4 Good-3 Fair-2 Bad-1

Module	**1**	**2**	**3**	**4**	**5**
Farmer registration					
Login					
Add events					
Reporting incidence					
Search events					

4. How would you rate the application's performance in completing a task in the following modules?

Excellent-5 Very good-4 Good-3 Fair-2 Bad-1

Task	**Worked as expected**	**Did not work as expected**
Farmer registration		
Login		
Add events		
Reporting incidence		
View events		

5. How would you rate the application's feedback for example on dialogs or warnings on input?

    1) Excellent ☐
    2) Very good ☐
    3) Good ☐
    4) Fair ☐
    5) Bad ☐

6. Is there any other improvement you would recommend for this application? Please indicate it

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Appendix D: Validation Survey Questions

TEA FARMING INFORMATION SYSTEM VALIDATION SURVEY

Dear Respondent,

I am a Masters student in the Faculty of Information Technology at Strathmore University conducting a research on dissemination of agricultural information to tea farmers. I kindly request you complete this survey intended to assess the relevance and satisfaction derived from the application.

1. How would you rate the application in terms of meeting the information need you sought?

    1) Excellent ☐
    2) Very good ☐
    3) Good ☐
    4) Fair ☐
    5) Bad ☐

2. How would you rate the relevance of the information provided on the application?

    1) Absolutely appropriate ☐
    2) Appropriate ☐
    3) Slightly appropriate ☐
    4) Neutral ☐
    5) Inappropriate ☐

3. How would you rate the influence of the information provided on your decision-making?

    1) About 100% ☐
    2) Above 75% ☐
    3) Above 50% ☐
    ☐

4) Above 25% ☐

5) Less than 25%

4. What is your overall rating of the application?

1) Excellent ☐

2) Very good ☐

3) Good ☐

4) Fair ☐

5) Bad ☐

Appendix E: Sample Screenshots

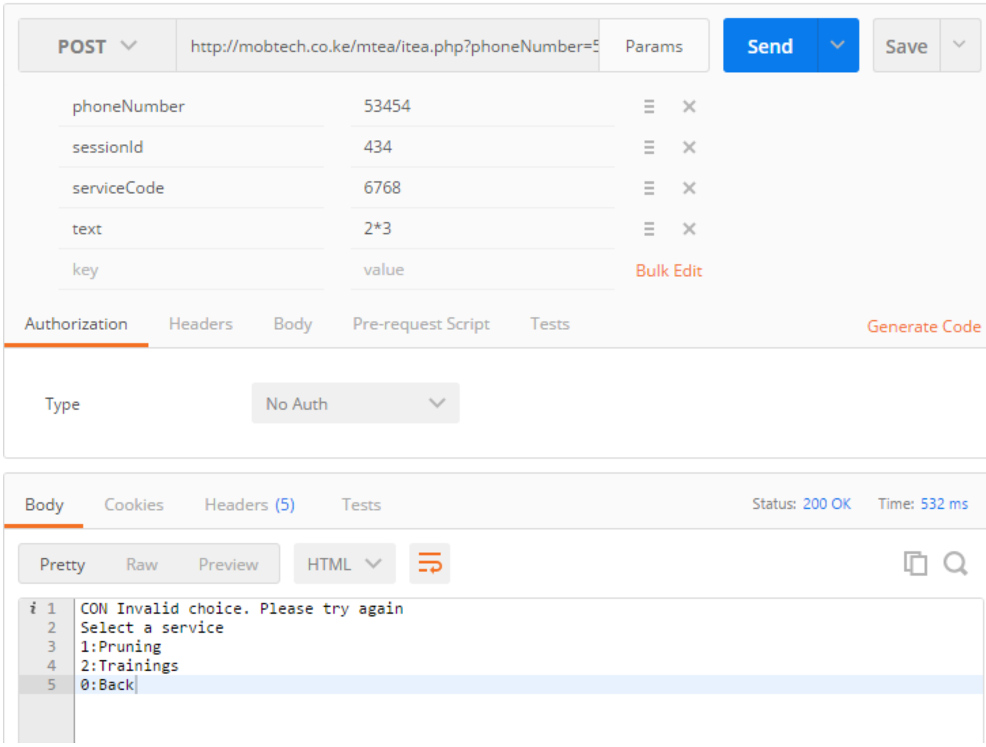

Figure E-1 Screenshot Showing USSD Invalid Menu Choice

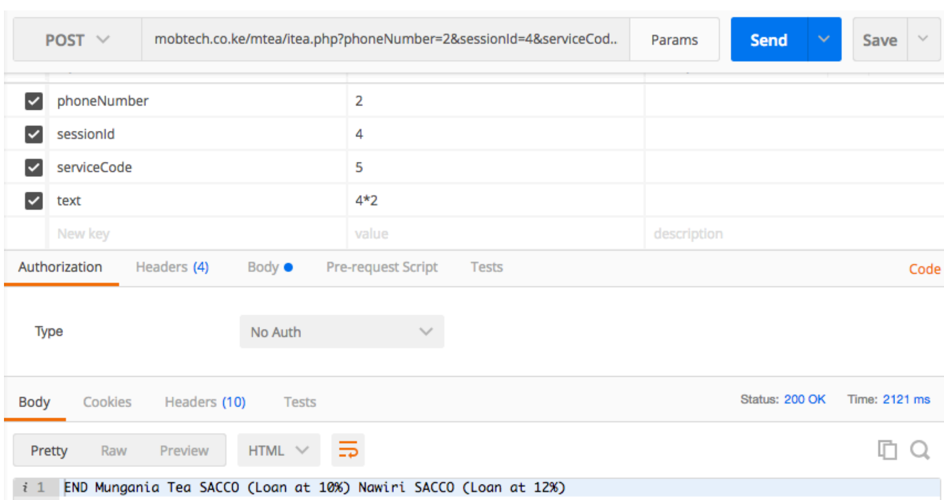

Figure E-2 Screenshot Showing Recommended SACCOs

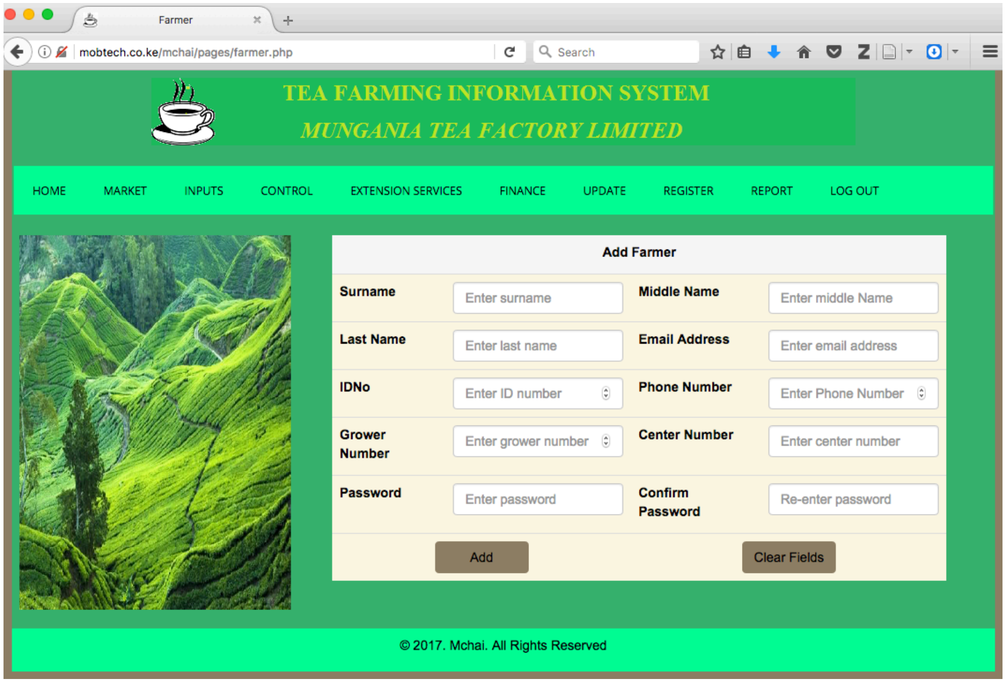

Figure E-3 Screenshot for Adding a Farmer

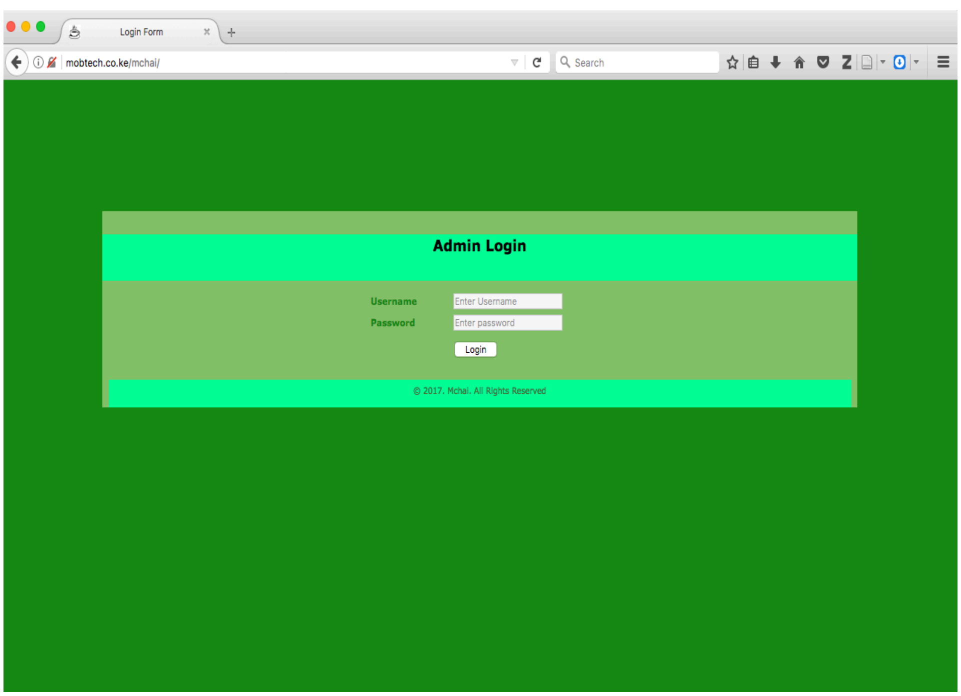

Figure E-4 Screenshot for Administrator Login Screen

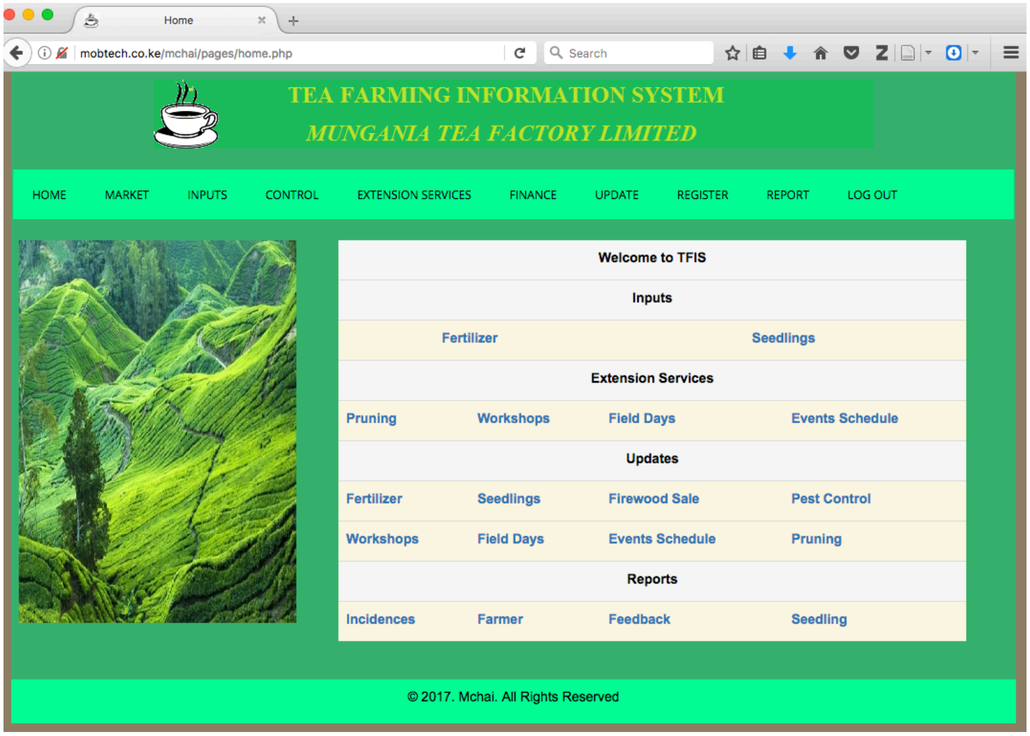

Figure E-5 Screenshot for Administrator Home Screen

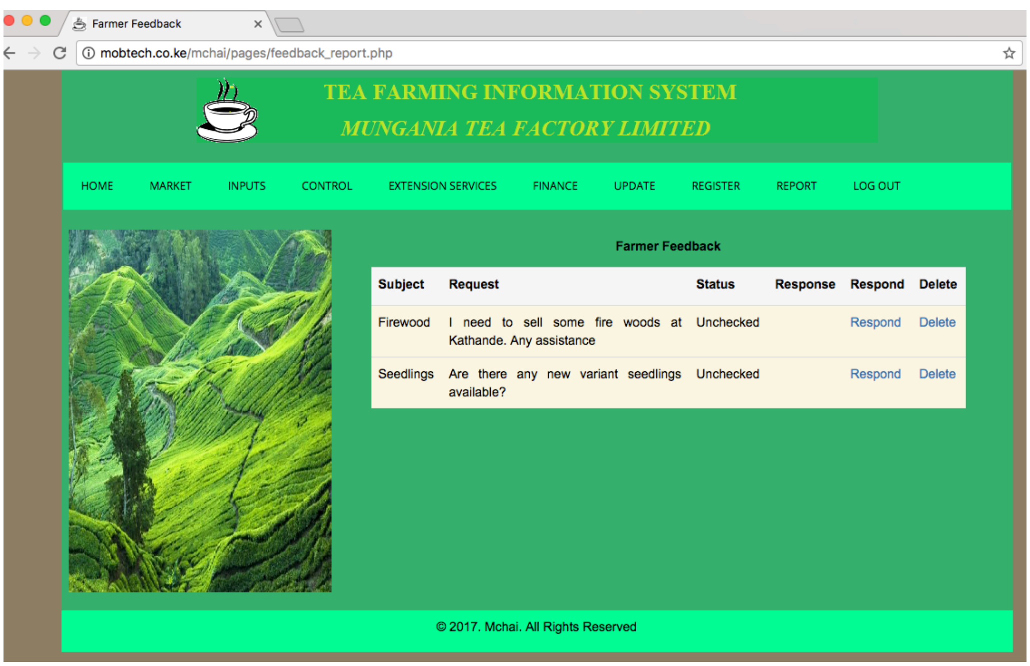

Figure E-6 Screenshot Listing Farmer Feedback

Appendix F: Use Case Description

Table F-1 Login Use Case Description

Use Case Name: Login			**ID Number: UC_002**
Description: The user of the application seeks to access information on the system.			
Trigger: The user accesses the mobile application and is prompted to login into the system.			
Type: External			
Major Inputs		**Major Outputs**	
Description User credentials Submit details	**Source** Farmer Farmer	**Description** Request access Authenticate	**Destination** Database System
Major Steps Performed: i. Prompt the user to provide login credentials. ii. System checks and authenticates that the user is a valid system user. iii. User successfully logged into the system.		**Information for Steps:** Username and Password Stored Username and Password Access granted	

Table F-2 Add Agricultural Information Use Case Description

Use Case Name: Add Agricultural Information	**ID Number: UC_003**
Description: The administrator logs into the backend of the system and updates the system with agricultural information on market, inputs, technology, credit and extension education.	
Trigger: The administrator requests access to update agricultural information.	

Type: External			
Major Inputs		**Major Outputs**	
Description	**Source**	**Description**	**Destination**
Administrator credentials	Administrator	Request access	Database
Agricultural information	Administrator	Information on market, inputs, technology, credit and extension education	Database
Major Steps Performed:		**Information for Steps:**	
i. Prompt the administrator to provide login credentials.		Username and Password	
ii. Authenticate the administrator request		Stored Username and Password	
iii. Find the agricultural information to update		Market, inputs, technology, credit and extension education	
iv. Provide information on the update required		Market, inputs, technology, credit and extension education	
v. Update the information accordingly		Agricultural information	

Appendix G: Turnitin Report

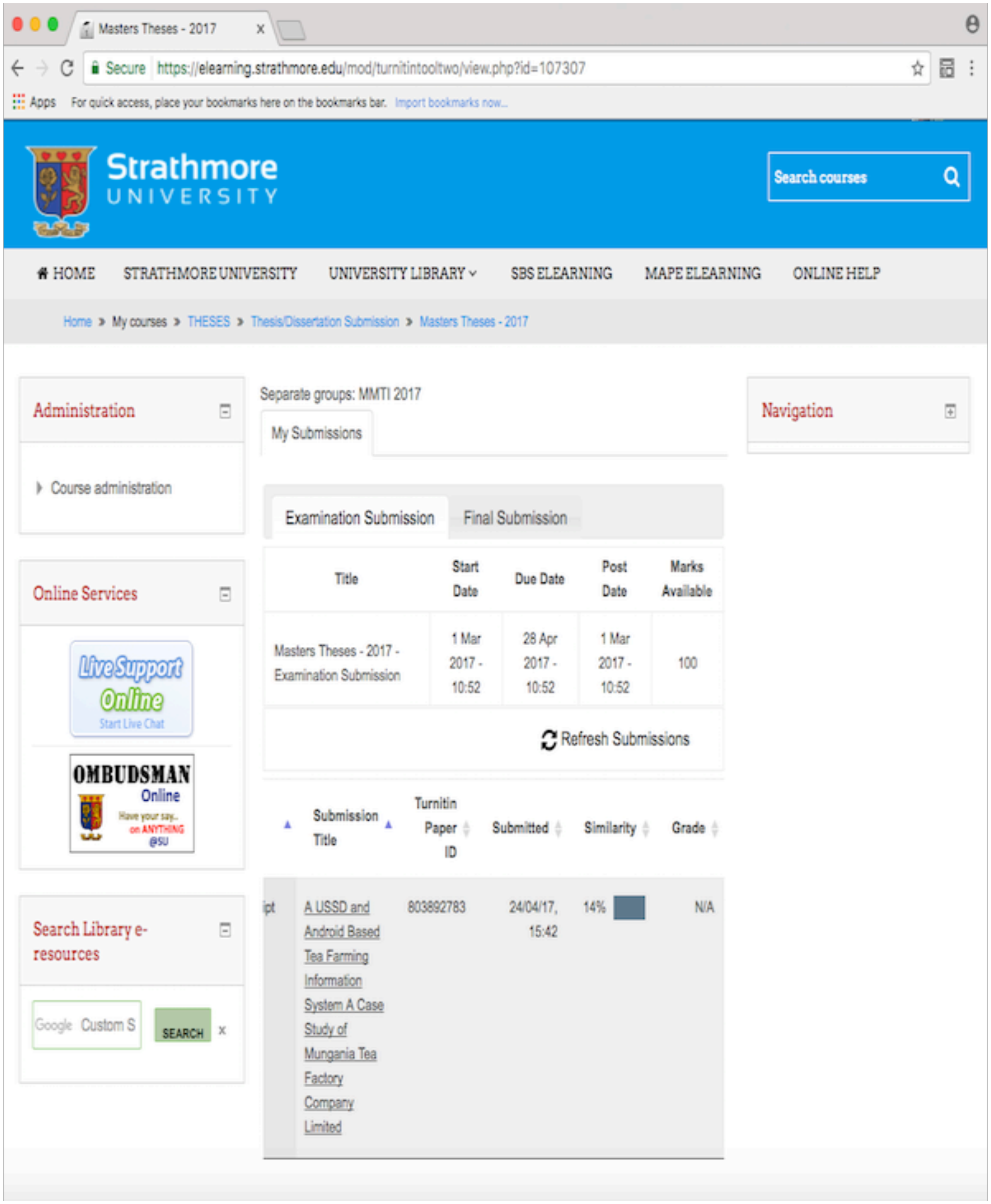

Figure G-1: Turnitin Report