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Analysis and Design of a Tea Farming Information System

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Abstract - *The traditional practice in tea farming has been overly reliant on dissemination of information through extension officers, Farmer Field Schools, mass media or farmer's sharing own experience. Consequently, this vital information is either accessed too late or when obsolete and/or it is sometimes completely lacking. Limited access to information has led to an information gap hence farmers practice poor planning and farming resulting to environmental degradation and reduced revenues. Tapping into the existing information and communication technology can lead to development of information systems that promote sustainable farming through timely information access, particularly in tea farming. This paper focused on the analysis and design of a tea farming information system that meets 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. The contribution of this research concerns adoption of a tea farming information system to improve on productivity, service delivery, 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.*

***Keywords*: Information access, Tea farming, Information system, Mungania, KTDA, Tea farmers System**

1. INTRODUCTION

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 [1, 2]. 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.

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 [3,4]. 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. For example, in a research on fertiliser application, it was noted that some farmers use less than or more than recommended fertiliser rates [5]. 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.

Information-intensive enterprises including agricultural enterprises require provision of timely information. Mittal and Mehar [6] 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 [6, 7].

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 paper 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.

The study was limited to tea growers who sell their produce at Mungania Tea factory. 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 which is 20 kilometres from Embu County Headquarters and 152 kilometres from Nairobi, Kenya. The study was inspired by reduced yield for area under cultivation and environmental degradation which could be addressed by timely provision of quality agricultural information.

2. LITERATURE REVIEW

2.1 Information Needs of Tea Farmers

Ozowa [8] categorically grouped information needs into agricultural inputs, extension education, agricultural technology, marketing and agricultural credit. This is further

supported by Odini [9] 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 1. Agricultural inputs include the consumable and capital inputs required for organic farming for instance, seeds, fertilisers, agrochemicals, machineries and levelers.

Table -1: The Kind of Information Needs

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, in order for farmers 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.

2.2 Existing Information Systems in Use

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 [10], 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 [11] 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 [12]. 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 [13] 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 views these interventions as having immensely contributed to the development of agriculture therefore 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 [14-17]. This calls for a reliable and efficient information system that is not subject to the enumerated limitations.

2.2.1 Agricultural Information Dissemination Channels

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 [18-19]. Information is delivered to farmers through monthly magazine, agricultural radio programmes, films and posters by extension agents, web portal, social media, newspapers, notice boards, use of leaflets, exhibits, public campaigns, banners, visual aids, text (SMS) based service, self-support online community, interactive video conferencing service and mobile Internet based service [8, 13, 20-24].

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 [20, 25]. Whereas mass media is effective in creating awareness of an innovation it might have limited influence on their adoption.

Mitei [25] 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. 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 from a research conducted by Gakuru, Winters and Stepman [26].

Table -2: Technology Used to deliver Agricultural Information

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

2.2.2 Mobile Technologies in Agriculture

Mobile technology has made communication and information access convenient and timely to users. Applications like FarmGraze [27], M-Shamba [28] and Horse Ration App [29] 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 fertilizer. It mainly deals with dairy cows, beef cattle and sheep. Horse RATION 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. Dialog Tradenet [30] disseminates agricultural information through SMS, USSD and web. WeFarm [31] 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. Virtual City [32] 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.

M-PESA, which is a fast, secure and convenient way to transact on mobile, adoption for Factory Door Sales (FDS) has curbed loses related with cash transactions. It has further facilitated 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 [33]. 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.

2.2.3 Weaknesses in Existing Systems

The following existing gaps were identified:

Limited access by extension officers: Few officers and cultural inhibitions for interaction with women farmers limit their interaction with farmers [20, 34]. Zulberti [35] 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.

Lack of targeted information: Mass media like radio, television, film, video, magazines, leaflets, audiocassettes, newspapers, web portal, leaflets and posters may not address specific farmer needs since it is not tailored to the needs of rural populations [36]. 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.

High Cost: Khatam et al. [37] observed that Farmer Field Schools (FFS) suffered from being expensive to implement, time consuming and having a difficult weekly routine to attend school and requires extension officers or experts. 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 [24, 26].

Limited reach and capacity: Libraries are limited by their location in urban areas. 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, costly and less efficient.

Unreliability: Relying on social media for information access leads to identity misuse, privacy and security issues and invalid information dissemination causing misunderstanding [21].

3. METHODOLOGY

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 [1, 2]. 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.

This study sought to analyse and design an information system to meet information needs of tea farmers. The researcher employed Agile system development methodology with Scrum as they would offer flexibility and adaptable rapid delivery of software product through iterative feedback loop and time-boxed sprints [38-41]. The cycle of activities undertaken under Scrum involved Planning, Analysis and Design.

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 analysis, presentation and interpretation of the collected data using Microsoft Excel 2011 was done. 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. 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. Document reviews were carried out under literature review.

System Analysis 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 to identify and document the requirements. The study was carried out in Embu County at Mungania Tea Factory Company Limited. The researcher chose this location as they are well versed with the terrain of the area providing a higher probability of getting cooperative respondents.

The factory currently has 9,024 farmers some of whom are also its employees. They offered information on technologies, inputs, credit and marketing. The researcher focused on a sample size of 43 farmers obtained by selecting a confidence level of 95% and a confidence interval of 15 as shown next [42].

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

Where:
Z = Z value
P = Percentage picking a choice, expressed as decimal
C = Confidence Interval expressed as decimal

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

Approximated to 43 farmers.

Document review involved review books, journals, company's database and articles to collect secondary data. The review purposed to identify existing system weaknesses as well as identify some of the information needs of tea farmers. Qualitative interviews were used to provide in-depth findings through discussions with the respondents on the information needs of tea farmers. The interviews were conducted on the 43 farmers and the findings helped in designing of the system.

4. SYSTEM ANALYSIS AND DESIGN

4.1 Requirements Analysis

The requirements specifications of the tea farming information were identified through interviewing various stakeholders in the tea farming. The analysis in Table 3 and Table 4 gives the results of the findings from the interviews conducted.

Table -3: Requirements for a 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.

Table -4: Requirements for an Administrative Staff

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

4.1.1 Information Needs of Tea Farmers

The research question on the information needs of tea farmers was partially answered under literature review. The interview was used to gain a clear understanding on these needs from the farmers. Table 5 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 6 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 -5: 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	39	91

application		
Access to high yield clones	35	81
Pest and disease control	30	70
Farm mechanisation	5	12

Table -6: 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 7. 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 -7: 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

It was 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.

4.1.2 Weaknesses of Existing Systems

An interview was conducted 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 8. These results rated the current structures of information delivery as being average as can be shown on Table 9, 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 10.

Table -8: 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 -9: 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 -10: 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.

4.1.3 Need for a Mobile Information System

As part of the interview, there was seeking 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 Fig 1. The remaining 12% were a bit sceptical on relevance of a mobile application in tea farming citing costs as the main concern.

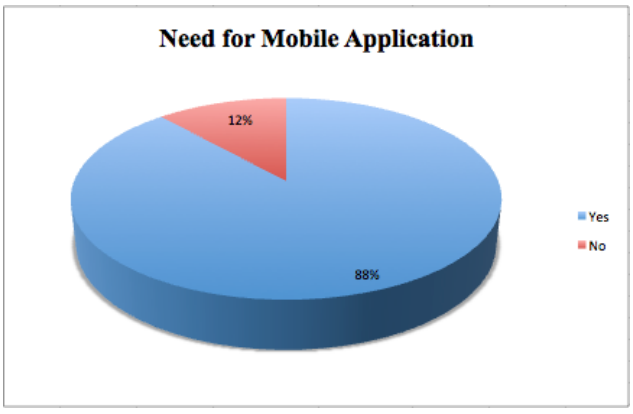

Fig -1: Support for the Need of a Mobile Application

Some of the features that were identified as being important to farmers are shown in Table 11. It was also discovered that the highest number of the respondents used Android OS as shown in Fig 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 -11: 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

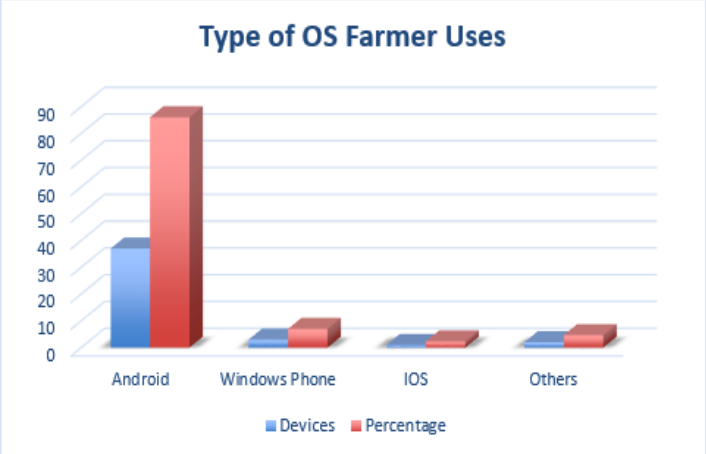

Fig -2: Type of Operating System a Farmer Uses on their Smartphone

4.1.4 Use Case

Kinyua and Shibwabo [43] noted that system requirements and analysis phase helps one to better comprehend a problem they are solving. Mutua, Shibwabo and Kaiburu [44] 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 Fig 3.

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.

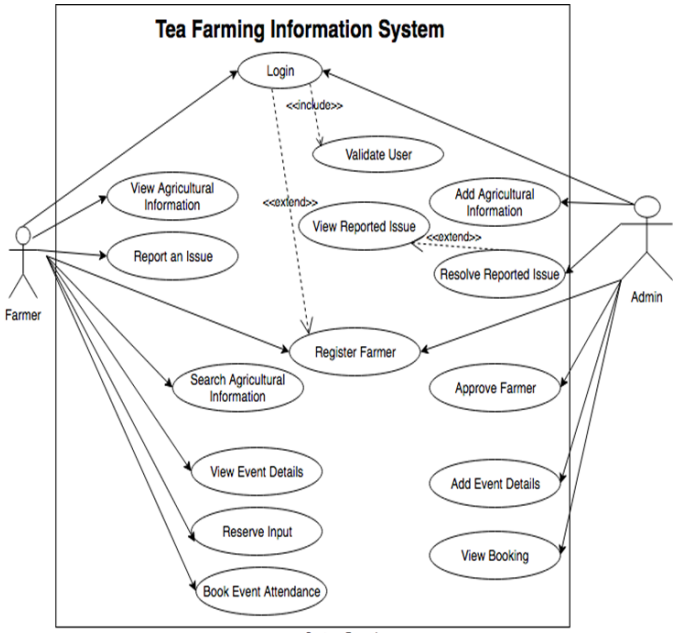

Fig -3: Tea Farming Information System Use Case Diagram

4.1.5 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. Fig 4 shows a system sequence diagram for viewing agricultural information scenario.

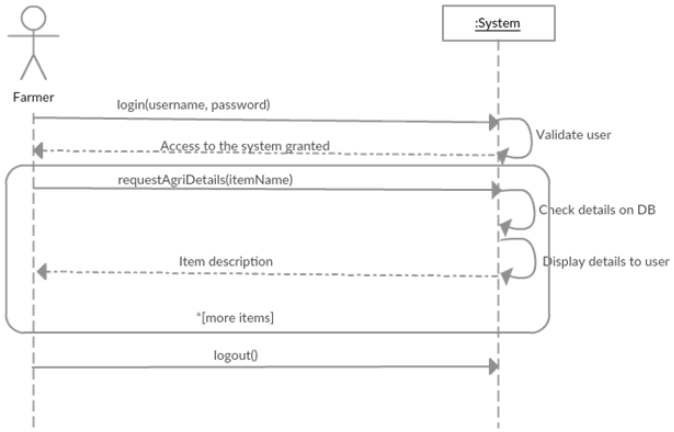

Fig -4: System Sequence Diagram for View Agricultural Information Scenario

4.2 System Design

4.2.1 Context Diagram

The context diagram demonstrated the overall system with the various processes that are involved in the provision of services to the farmer. Fig 5 shows the context diagram for the tea farming information system.

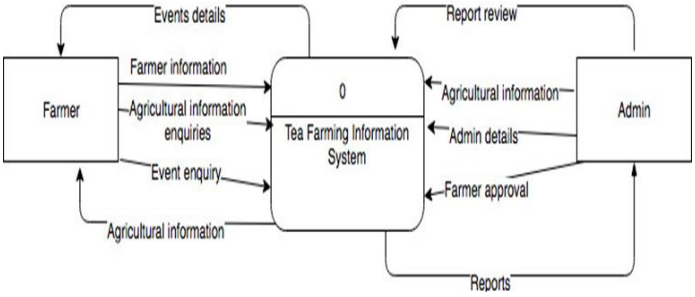

Fig -5: Tea Farming Information System Use Case Diagram

4.2.2 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 Fig 6.

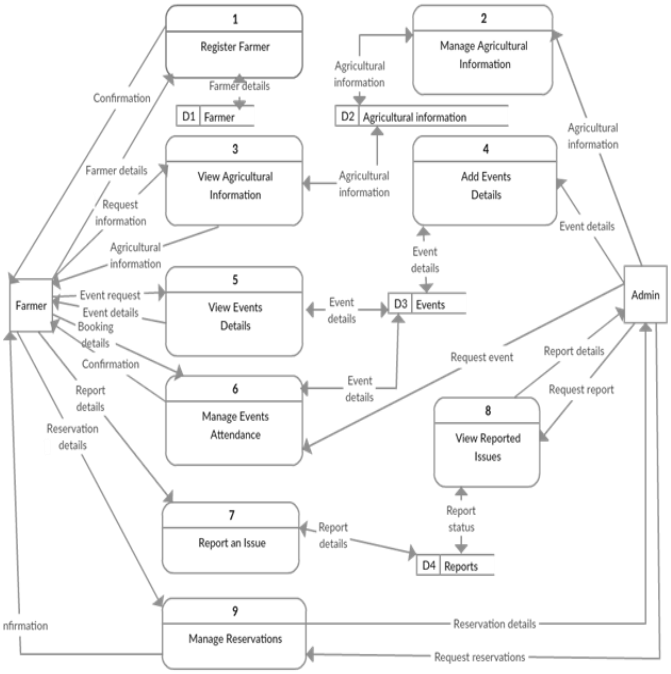

Fig -6: Level Zero (0) Data Flow Diagram

4.2.3 Level One 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 Fig 7.

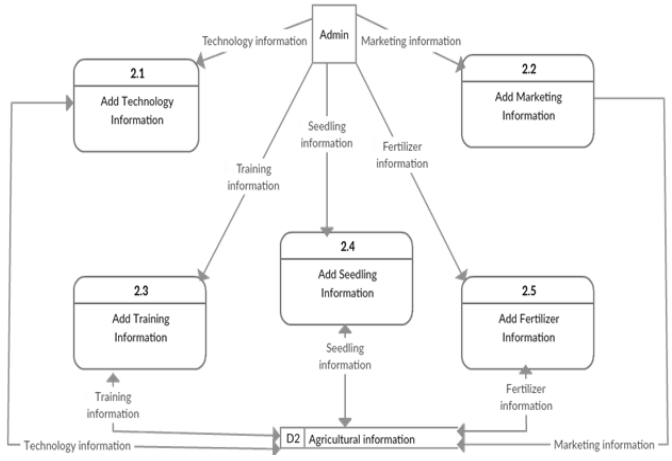

Fig -7: Level Zero (0) Data Flow Diagram

4.2.4 General Architecture

The general architecture of the proposed solution 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 should is shown in Fig 8. Users should be able to 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 should be able to access information on inputs, marketing, extension education, agricultural technology and credit and report on an identified issue.

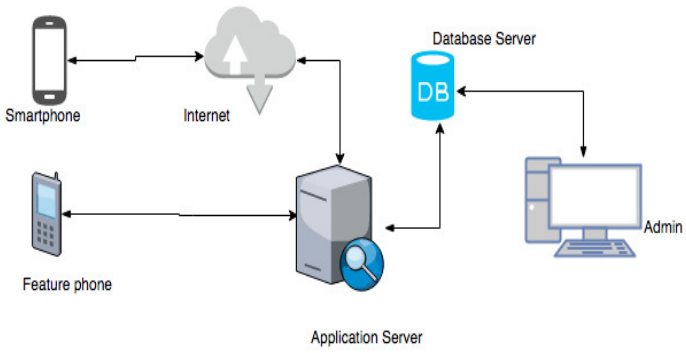

Fig -8: Tea Farming Information System Architecture

4.2.5 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 [46]. Fig 9 shows a USSD architecture of the proposed solution. The proposed USSD flow fit into the tea farming information system as has been demonstrated in Fig 8 earlier. The service may reside as an independent application server that is connected through a USSD Gateway using SMPP.

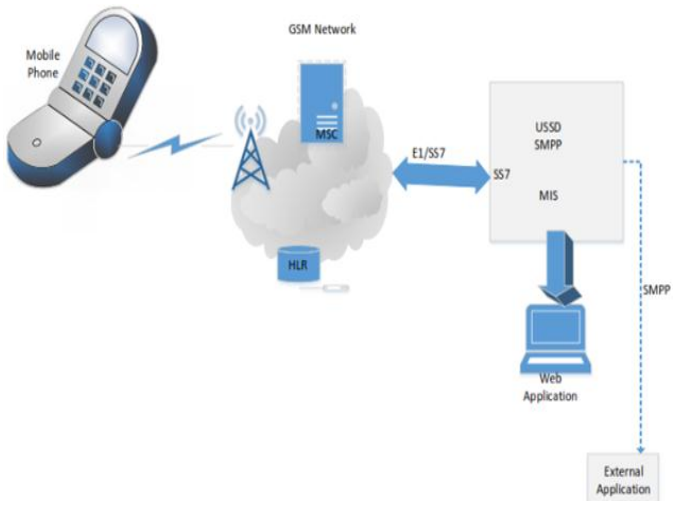

Fig -9: Architecture of USSD Implementation (Adapted from [46])

4.2.6 Database Design

The following tables are tabular representations of the relations for a system database based on the requirements. The Farmer table holds details of the farmers registered in the system. The tabular representation is shown on Table 12.

Table -12: 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

The Feedback table contains all the information on the feedback given by the farmer. This is demonstrated on Table 13.

Table -13: 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

The Report_Incidence table contains details of all the incidences that have been reported by the farmers. A tabular representation is shown on Table 14.

Table -14: 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

The Bookings table references to the events that have been booked by farmers. A tabular representation is shown on Table 15.

Table -15: 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

The Reserve_Seedling table contains details of seedlings reservations made by all the farmers. A tabular representation is shown on Table 16.

Table -16: Reserve_Seedling Table

Columns			
Column	**Type**	**Default value**	**Extra**
type	Varchar(25)	None	
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

The Schedules table contains details of the events that farmers could book to attend. A tabular representation is shown on Table 17.

Table -17: 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

The Seedlings table contains details of seedlings that are available giving farmers a chance to reserve them. A tabular representation is shown on Table 18.

Table -18: 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

The Admin table contains details system administrators as shown on Table 19.

Table -19: 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

The Notices table contains details of notices that are intended for the farmers as shown on Table 20.

Table -20: Notice 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

The Pruning table contains pruning information. A tabular representation is shown on Table 21.

Table -21: 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

4.2.7 Wireframes

The mobile application could have various functionalities that are demonstrated by the wireframe shown in Fig 10 portraying an open slide menu. Fig 11 and Fig 12 further shows some of the functionalities in the system.

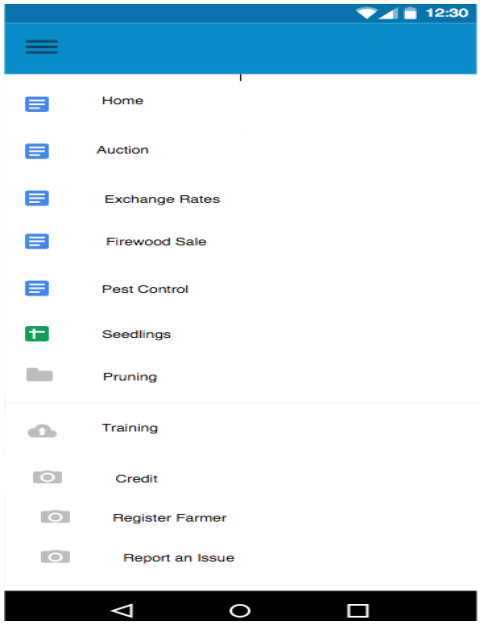

Fig -10: Wireframe Slide Menu Demonstrating Functionalities

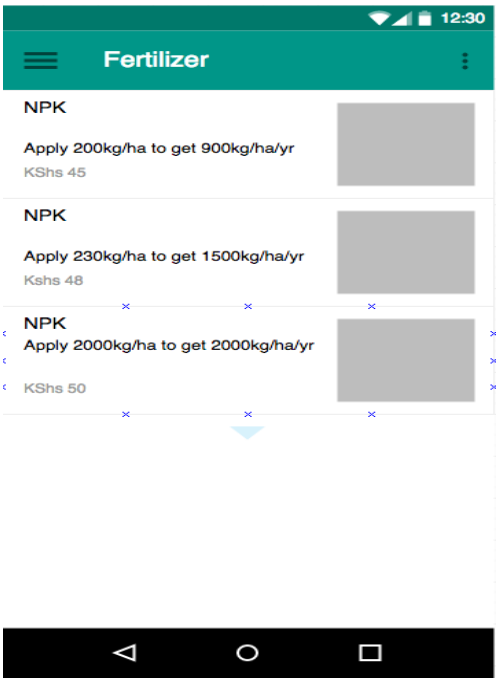

Fig -11: Wireframe Slide Menu Demonstrating Functionalities

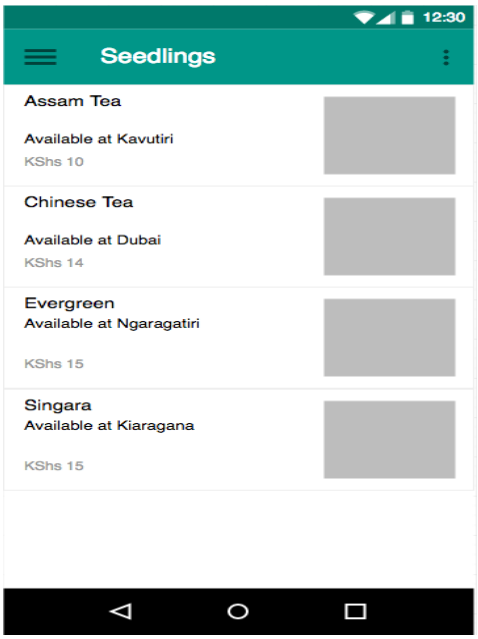

Fig -12: Wireframe Slide Menu Demonstrating Functionalities

The USSD side is solely aimed at providing limited services for those farmers who do not have a smartphone to access the Android application. Fig 13 shows a USSD interaction for farmer seeking information on fertiliser application.

Fig -13: USSD Wireframe

5. CONCLUSIONS

This paper concentrated on the analysis and design of a tea farming information system. The existing challenges that farmers face while seeking agricultural information include lack of awareness, low literacy level and uncoordinated research and dissemination of information. It was found that lack of information or inadequate information is a major contributor to information gap and lack of adoption to available technologies. Further work could be done in coming up with the implementation of the proposed designs using any preferred programming environments.

REFERENCES

[1] Dutta, S., Geiger, T., and Lanvin, B. 2015. The global information technology report 2015. In World Economic Forum (Vol. 1, No. 1, pp. P80-85).

[2] Pilat, D., and Lee, F. C. (2001). Productivity Growth in ICT-producing and ICT-using Industries.

[3] Okello, J. J., Okello, R. M., and Ofwona-Adera, E. 2009. Awareness and the use of mobile phones for market linkage by smallholder farmers in Kenya. E-agriculture and e-government for global policy development, 1-18.

[4] Winter, S. 2012. A growing lifeline: Mobile technologies in agricultural development. Retrieved August 23, 2016, from http://www.technoserve.org/blog/a-growing-lifeline-mobile-technologies-in-agricultural-development.

[5] Mwaura, F., & Muku, O. (2007). Tea farming enterprise contribution to smallholders' well being in kenya.

[6] Mittal, S., and Mehar, M. 2012. How mobile phones contribute to growth of small farmers? Evidence from India. Quarterly Journal of International Agriculture, 51(3), 227.

[7] Fischer, R. A., Byerlee, D., and Edmeades, G. O. 2009. Can technology deliver on the yield challenge to 2050. In Expert Meeting on How to feed the World in (Vol. 2050, pp. 1-48).

[8] Ozowa, V. N. 1995. Information Needs of Small Scale Farmers in Africa: The Nigerian Experience. Consultative Group on International Agricultural Research (CGIAR) Newsletter, 4(3), 10-12.

[9] Odini, S. 2014. Access to and use of agricultural information by small scale women farmers in support of efforts to attain food security in Vihiga County, Kenya. Journal of Emerging Trends in Economics and Management Sciences, 5(2), 100.

[10] Katungi, E., Edmeades, S., and Smale, M. 2008. Gender, social capital and information exchange in rural Uganda. Journal of international development, 20(1), 35-52.

[11] Hite, D., Hudson, D., and Intarapapong, W. 2002. Willingness to pay for water quality improvements: The case of precision application technology. Journal of Agricultural and Resource Economics, 433-449.

[12] Haddad, L., and Maluccio, J. A. 2003. Trust, membership in groups, and household welfare: Evidence from KwaZulu-Natal, South Africa. Economic Development and Cultural Change, 51(3), 573-601.

[13] Manda, P. A. 2002. Information and agricultural development in Tanzania: a critique. Information Development, 18(3), 181-190.

[14] Arumapperuma, S. 2008. The role of information technology in disseminating innovations in agribusiness: a comparative study of Australia and Sri Lanka (Doctoral dissertation, Victoria University).

[15] Barrios, E. B., Ryan, J. G., and Daquis, J. C. P. 2011. Impact assessment of the e-AGRIKultura project: Philippines. Praise for this book, 89.

[16] Baumüller, H. 2012. Facilitating agricultural technology adoption among the poor: The role of service delivery through mobile phones.

[17] Ogutu, S. O., Okello, J. J., and Otieno, D. J. 2014. Impact of information and communication technology-based market information services on smallholder farm input use and productivity: The case of Kenya. World Development, 64, 311-321.

[18] Barbara, G. and White, D. 2001. Developing an effective dissemination plan. United States of America. Retrieved September 27, 2016, from http://bir.ou.edu/files/bir/docs/Dissemination_plan.pdf.

[19] Monu, E. D. 1982. "Improving Agricultural Practices among African Smallholders"-The Contribution of Adoption and Diffusion of Innovation Research to Agricultural Development in Africa. African Studies Review, 25(4), 117-126.

[20] Asenso-Okyere, K., and Mekonnen, D. A. 2012. The importance of ICTs in the provision of information for improving agricultural productivity and rural incomes in Africa. African Human Development Report. UNDP Sponsored Research Series.

[21] Bertot, J. 2012. The impact of polices on government social media usage. Retrieved from Science Direct: http://www.sciencedirect.com/.

[22] Oxford University. 2003. Shortcomings of health information on the Internet. Oxford Journal.

[23] Vance, K. 2009. Social Internet Sites as a Source of Public Health Information. Retrieved from Science Direct: http://www.sciencedirect.com.

[24] Zhang, Y., Wang, L., and Duan, Y. 2016. Agricultural information dissemination using ICTs: A review and analysis of information dissemination models in China. Information Processing in Agriculture, 3(1), 17-29. http://dx.doi.org/10.1016/j.inpa.2015.11.002.

[25] Mitei, Z. 2011. Growing sustainable tea on Kenyan smallholder farms. International Journal of Agricultural Sustainability, 9(1), 59-66.

[26] Gakuru, M., Winters, K., and Stepman, F. 2009. Innovative farmer advisory services using ICT. documento presentado en el taller de W3C "Africa perspective on the role of movile technologies in fostering social development", Maputo, 1.

[27] Chase, J. "Farmgraze is a mobile application made by farming experts at Aberystwyth University, UK" Retrieved September 17, 2017, from http://www.mobilefarmapps.com/farm-graze.html.

[28] Vutagwa, C. "Meet Calvince Okello, founder of M-Shamba" Retrieved September 17, 2017, from http://techmoran.com/meet-calvince-okello-founder-of-m-shamba/#sthash.2WOdEYrB.dpbs.

[29] Farrell, C. "HorseRATION is a mobile application made by Equine experts at Aberystwyth University, UK" Retrieved September 17, 2016, from http://www.mobilefarmapps.com/horse-app.html.

[30] Dialog. 2009. Dialog Tradenet – GGS Partnership Set to Revolutionise Agri Market Access. Retrieved from https://www.dialog.lk/news/dialog-tradenet-ggs-partnership-set-to-revolutionise-agri-market-access/.

[31] Barthorpe, A. (2016). WeFarm: Data's role in sustainable tea production. Retrieved from http://wefarm.org/datas-role-in-sustainable-tea-production/.

[32] Thuo, H. 2016. GSMA: Creating impact for stallholder farmers through mobile technology in East Africa. Retrieved from https://www.gsma.com/mobilefordevelopment/tag/virtual-city.

[33] KTDA. KTDA MPESA Launch. Retrieved from http://www.ktdateas.com/index.php/blogs/item/18-ktda-mpesa-launch/18-ktda-mpesa-launch.html.

[34] Sibanda, L. M. 2012. Women farmers: Voiceless pillars of African agriculture.

[35] Zulberti, E. (n.d.). Agricultural Extension and Training Needs of Farmers in the Small Island Countries: A Case Study from Samoa. Retrieved from http://www.fao.org/docrep/008/y8345e/y8345e04.htm#TopOfPage.

[36] Oakley, P., and Garforth, C. 1985. Guide to extension training (No. 11). Food and Agriculture Org.

[37] Khatam, A., Muhammad, S., Chaudhry, K. M., Mann, A. H., Haq, I., Khan, Z. U.,.. and Amin, H. (2010). Strengths and weaknesses of Farmers' Field Schools approach as perceived by farmers. Sarhad J. Agric, 26(26), 685-688.

[38] Abrahamsson, P., Salo, O., Ronkainen, J., & Warsta, J. 2002. Agile software development methods: Review and analysis.

[39] Highsmith, J. 2001. History: The agile manifesto. Sitio: http://www. agilemanifesto. org/history. html.

[40] Takeuchi, H. and Nonaka, I. (1986). The New Product Development Game. Harvard Business Review January Issue. Retrieved March 20, 2017, from https://hbr.org/1986/01/the-new-new-product-development-game.

[41] Schwaber, K. 1997. Scrum development process. In Business Object Design and Implementation (pp. 117-134). Springer London.

[42] Naing, L., Winn, T., and Rusli, B. N. 2006. Practical issues in calculating the sample size for prevalence studies. Archives of orofacial Sciences, 1(1), 9-14.

[43] Kinyua K. & Shibwabo, B. 2017. A Universal Mobile Money Transfer Platform. International Journal of Computer Applications 175(6):40-47, October 2017. DOI: 10.5120/ijca2017915595

[44] Mutua S. M., Shibwabo, B. & Kaiburu M. R. 2017. An Automatic Number Plate Recognition System for Car Park Management. International Journal of Computer Applications 175(7):36-42, October 2017. DOI: 10.5120/ijca2017915608

[45] Sanganagouda, J. (2011). USSD: A communication Technology to Potentially ouster SMS Dependency.