Mobile learning bridging the gap in agricultural extension service delivery: Experiences from Sokoine University of Agriculture, Tanzania

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ABSTRACT

The ubiquitous nature of mobile phones offers a noble environment where farmers can learn informally anywhere, anytime and at any location. This is an innovative way to address some of the weakness of conventional agricultural extension service. Few empirical studies have reported on the development of mobile phone application to support blended learning for smallholder farming communities in developing countries. This study adopted a participatory action research method to develop innovative communication pathways in dissemination of agricultural information, agricultural knowledge and proven agricultural technologies from either extension agents or agricultural research centres or universities to farmers. The respondents who tested the system were selected random from 19 villages in Kilosa District, Tanzania. The developed systems support blended learning using mobile learning (m-learning) and electronic learning (e-learning). The findings from this study show that the systems can provide innovative mobile agricultural extension service to more than 380 smallholder farmers via web- and mobile-phone-based farmers' advisory information systems.

Keywords*: Blended Learning, Mobile Applications, Mobile Learning, Electronic Learning, Smallholder Farmers, Web, Mobile, Farmers' Advisory Information System*

1.   INTRODUCTION

The Sokoine University of Agriculture (SUA) is a Higher Education Institution (HEI) in Tanzania that serves local and international students (Sife *et al*., 2007). It uses traditional method of disseminating teaching and learning materials like other universities in developing countries (McHarazo and Olden, 2000). The printed course materials are delivered to students mainly through face-to-face teaching (Perraton, 2000; McHarazo and Olden, 2000). Also, SUA has a mandate for research, consultancy and to offer outreach extension services to farmers and general public. Outreach services are offered by the Institute for Continuing Education (ICE). ICE deals with the dissemination of research outputs, innovations and proven technologies from SUA to farmers and other stakeholders in the country. To do this, ICE has TV and Radio[1].

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[1] http://www.suanet.ac.tz/suatv/index.php/en/

These methods of disseminating agricultural advisory to farmers and other stakeholders have shortcomings such as low coverage as they cannot reach all regions and districts of Tanzania. According to Mvena *et al.* (2013), the uptake of research outputs, innovations and proven technologies from agricultural research institutes and universities to farmers has not been impressive in developing countries.

1.1 Statement of the Problem

The advancement of Information and Communication Technologies (ICTs) in education worldwide has resulted in many universities to implement e-learning to reach a large number of its stakeholders. Implementation of e-learning can be achieved if and only if, there are available resources and ICTs infrastructure. One of the key requirements is access to the Internet, which forms basis for e-learning implementation. In Tanzania, Internet coverage and usage is very low to rural communities (Gillwald *et al.*, 2005; Zanello and Maassen, 2009; TCRA, 2015). This low coverage of Internet is affecting farming communities residing in rural areas (Furuholt & Kristiansen, 2007). In spite of this, farmers' mobile phones ownership is about 65% (TCRA, 2015). Hence, mobile learning (m-learning) shows a promise (Gillwald *et al.*, 2005; TCRA, 2015), and their usage have a potential to bridge Africa's digital divide for communities in rural areas. Thus, the specific objective of this study was to build a prototype for m-learning to enhance informal teaching and learning among farmers, extension agents, researchers, and other actors in various agricultural value chains.

1.2 Research Questions

This study answered the question: What kind of an information system can be implemented to enhance access to informal learning among farmers, extension agents, researchers and other actors in rural setting in Tanzania?

1.3 Significance of the Study and Rationale

E-learning has brought a dramatic change in the education sector by providing learning management systems which support and facilitate learning and teaching. However, there is a digital divide between developed countries and developing countries in terms of the development and use of ICTs in education. The challenge is how the available mobile technologies can be used to enhance face to face learning, distance learning and e-learning. Learning and teaching activities in universities should embrace existing and new emerging technologies. Implementation of e-learning in Tanzanian universities faces some challenges, namely: lack of enough instructors, inadequate teaching and learning materials and lack of infrastructure. Also, there is a high percentage of illiteracy among farmers. The appropriate use of ICTs for learning can address some of the above mentioned problems.

ICT based Open and Distance Learning (ODL) can improve learning and teaching to different stakeholders (e.g. farmers), who cannot leave their work and join programmed instruction in residential universities, too.

In Tanzania, there is a big coverage and usage of mobile phones compared to other technologies like the Internet (TCRA, 2015), which provides an enabling environment for the implementation of m-learning. E-learning takes learning away from the campus or classroom while m-learning takes learning away from any fixed location. Thus, operationalization of m-learning at SUA can extend the benefits offered by the implementation of e-learning by:
a. provide access to learning materials to the farmers and other actors who are scattered all over the country.

b. allow easy communication between researchers and farmers especially for those residing in places with no Internet connectivity.
c. provide easy collaboration between farmers by enhancing independent learning (Kurhila *et al.*, 2004); and
d. provide affordable education to farmers. This is due to the fact that it is economical because farmers will not have to incur the extra costs of living on campus as well as giving up their jobs to attend any training (McHarazo and Olden, 2000).

2   LITERATURE REVIEW

Many researchers have explored how the emerging mobile technology can be used in provision of informal education to farmers (Petrova, 2009; Dissanayeke *et al.*, 2015a; Dissanayeke *et al.*, 2015b).. It is felt that e-learning and m-learning are technologies that can enhance teaching and learning in HEI of developing countries depending on availability of infrastructure and resources. Infrastructure for e-learning and m-learning comprise of Internet connectivity, means of telecommunications and electricity while resources comprise of availability of skilled instructors, learning and teaching materials, electronic devices (such as computers, laptops, printers) and different kind of software (e.g. learning management system, graphics software, publishing software). Developing countries can enhance teaching and learning in HEI using either Free and Open Source Software (FOSS) learning management system or commercial software. ICT solution aimed at solving a problem in developing countries must have low costs to ensure their sustainability.

2.1 Technologies for Learning in Higher learning institutions

Brown (2003) gave an overview of flexible learning. According to Brown (2003), flexible learning is divided into two namely: contact (or face to face or residential) learning and distance learning. Distance learning is further divided into paper based distance learning and e-learning. Online learning and m-learning are subsets of e-learning and e-learning is a subset of distance learning. The use of Free & Open Source Software (FOSS) Learning Management Systems holds great promise to enhance teaching and learning in Tanzania. It can increase the uptake of students from secondary schools, colleges and vocational technical training centers to universities; especially those who cannot afford full time tuition. It can also increase the enrollment from the marginalized communities; women with household responsibility; employees who don't want to leave their jobs and those who are living in remote areas. Yet, it can allow lifelong learning for the general public. For example, it can allow farmers to learn by doing while they are at home or farming (i.e. problem based learning). Apart from the above benefits, the use of a FOSS learning management system can:
   i.   Improve performance of students (due to the increased access to course materials and increased possibilities for remedial updating to the course materials online and offline) (Khvilon *et al.*, 2002),
   ii. improve efficiency in communication; and
   iii. simplify administrative support to learners (e.g. students, farmers).

The learners can access course materials at any time and from different locations as well as share ideas with other learners situated at different places. Karlsson (2005) argues that the enrolment of students to traditional universities is increasing drastically. Therefore, in order to expand the enrollment, universities need to look for paradigm shifts to accommodate the growing number of students and other stakeholders (such as farmers) who need outreach services from universities. Integration of e-learning and m-learning will allow teaching, learning and communication via the Internet and through other mobile devices.

Ragus (2006) argues that m-learning won't replace e-learning completely in traditional universities or in ODL universities but there is a need to incorporate it to complement other functions (i.e. mandates) of universities. The University of the South Africa (UNISA) is an example of an ODL institution which has implemented e-learning (Venter, van Rensburg & Davis, 2012). Mobile devices can be used for downloading course contents and for the communication between either learners and instructors or learners and learners or instructors and instructors. Mobile devices can also improve the following:

a. effectiveness and efficiency of communication between learners and instructors as well as with other stakeholders (e.g. policy makers) (Barker *et al*., 2005)
b. collaborative learning between learners and support between learners and instructors (Vila *et al*., 2003) and
c. increase learners' motivation and mobility due to the use of students' centred approach which has direct influence in learners satisfaction towards the course (Vila *et al*., 2003). Also learners will have fun as they interact with other learners and instructors via mobile devices (Jong *et al*., 2005).

On the other hand, mobile devices cannot deliver content per se, due to the small size of the screen (Matsuura, 2005). Lehner and Nosekabel (2002) argue that researchers must keep on looking into ways of solving the limitation that arise due to the use of mobile devices in teaching and learning. There is thus a need for the development of systems which will improve the provision of education in developing countries using mobile technology (Petrova, 2009; Louise & Venter, 2011; Ganesan *et al*., 2013; Dissanayeke *et al*., 2015a; Dissanayeke *et al*., 2015b).

2.1.1 Electronic learning (E-learning)
In Sub Saharan Africa (SSA), the demand for higher education is increasing significantly. Traditional universities cannot accommodate the influx of students and other stakeholders who want to join the university because of limited infrastructure and resources. Brakel and Chisenga *et al.* (2004) and Maritim (2009) suggest that SSA countries can reach the required increase in number of students that enroll for tertiary programmes only by using ICT based Open and Distance Learning (ODL). In Africa, the use of e-learning for ODL has not been growing very fast because of the low coverage of Internet and its usage[2] (LaRocque & Latham, 2003; Maritim, 2009). Examples of universities that have implemented e-learning in Tanzania are the University of Dar es Salaam, Sokoine University of Agriculture, Mzumbe University and Open University of Tanzania (Sife *et al*., 2007). The lesson learnt from their implementations is that deployment of e-learning using FOSS learning management system has an impact for HEI in developing countries. Hence, there is a need to look into how new emerging ICTs (i.e. mobile phones) can be used to improve learning and teaching, especially of farmers and other actors in agriculture (Dahms & Stentoft, 2008; Dahms & Zakaria, 2015).

2.1.2 Mobile learning (m-learning)
Mobile technology has been growing fast in developing countries; compared to technologies like the Internet (Kamssu, 2005; Motlik, 2008; Avila, 2009, TCRA, 2015). In Tanzania, there is big percentage gap between mobile subscribers compared to percent of Internet users (Gillwald *et al*., 2005; Zanello and Maassen, 2009, TCRA, 2015). The rise in usage of mobile devices (like mobile phones, pocket PC's, notebooks, PDA's) has led to the development of systems to facilitate learning and teaching for instructors, learners and other educational actors or stakeholders (e.g. farmers) who are nomadic/mobile (Lehner & Nosekabel, 2002; Stanton, 2014). Such systems will complement the benefits offered by e-learning both at campus based and ODL universities (Venter, van Rensburg & Davis, 2012). Mobile technology has shifted the teaching and learning paradigm to a new learning method called mobile learning (m-Learning) which enables communication and

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[2] http://www.internetworldstats.com/stats1.htm

access to contents at any place and at time (Georgiev *et al*., 2006; Lehner & Nosekabel, 2002; Motlik, 2008; Stanton, 2014). In Africa, the phenomenon that the ratio of people who have access to mobile devices to those that have access to the Internet is high; indicates that there is great potential for the implementation of m-learning (Barker *et al*., 2005; Brakel & Chisenga, 2004; Gray, 2006; Hudson, 2004; Motlik, 2008; ITU, 2009; Pearce & Rice, 2013). In line with this argument, Tanzania has more mobile subscribers compared to Internet users (Saad and Sparviero, 2003; Gillwald *et al*., 2005; Zanello and Maassen, 2009; Stork *et al*., 2013; TCRA, 2015). The low Internet coverage in Africa has the effect that there is low measurable uptake of e-learning programmes (LaRocque & Latham, 2003; Brown, 2005; Pearce & Rice, 2013).

M-learning allows a student to access course materials 'anytime and anywhere' that is: it creates a flexible learning environment for residential university students, lifelong learning students as well as distance learning students (Brown, 2005). Furthermore, it allows farmers and other stakeholders in agriculture to communicate research outputs, proven technologies and innovations. Currently, the ODL that suits best for SUA and other universities in developing countries is the learning that integrates e-learning and paper based learning (Brown, 2003).

Approaches for m-learning implementation are similar to those for e-learning which comprises of communication and content approaches (Brown, 2003; Brown, 2005; Motlik, 2008). These approaches can be implemented in stand-alone or net-worked computers as well as mobile phones and other portable devices. The diagram by (Brown, 2003; Brown, 2005) can be used as an aid for systematic implementation of ICT to enhance education in HEI for different stakeholder (actors). Brown (2003) argues that the strength of m-learning lies into communication approach rather than delivery of content. Communication is the key attribute in facilitating collaborative learning among learners, instructors or any other stakeholders at SUA (e.g. farmers). Research by Sanga *et al*. (2016) has shown that implementation of communication functions for m-learning can enhance collaborative learning between agricultural extension agents/officers, farmers and researchers in Kilosa District, Tanzania by:

- allowing agricultural extension agents/officers and researchers to answer farmers' queries anytime;
- allowing agricultural extension agents/officers and researchers to deliver answers to the farmers anytime; and
- enable farmers to receive advisories easily from agricultural extension agents/officers and researchers timely.

2.2 Technical requirements for the implementation of m-learning

Technology selection is one of the important aspects to consider when implementing m-learning (Attewell, 2005). According to Attewell (2005), selection of technology is dependent on option available for the delivery, media options, platforms options, available transport and development languages. Furthermore, Attewell (2005) technology selection depends on items listed below:

a. Transport options: This includes GPRS, 3G, Infra Red, Bluetooth and PC download.
b. Development languages: This includes Flash, C, HTML, VoiceXML, XHTML and WML.
c. Platform options: This includes Pocket PC, Windows CE, Symbian, Palm OS, J2ME, Android and Pogo.
d. Delivery options: This includes WAP, e-mail, SMS, MMS and HTTP.
e. Media options: This includes Video, Audio files, phone calls, teleconferencing, video recognition and TV broadcasts.

Moreover Attewell (2005) mentioned criteria used in technology selection to include: ease of use, likely longevity, popularity, standardization, features, cost, availability, reliability and robustness.

According to Singh (2003), criteria which guide the selection of mobile device are: cost, battery life, display size, data input, form factor, processing power, storage capacity, communication options,

security, application development tools and support. It is also crucial to take into consideration the limitation of mobile devices, which are pedagogical issues, safety and security concerns, training and support issues and cost (for mobile devices and equipment which support wireless communication) (Barker *et al*., 2005; Georgiev *et al*., 2006; Tekkedal *et al*., 2005). Connectivity, low-cost devices, appropriate user interfaces and power are the key requirements for the proper implementation of any ICT for development (ICT4D) research (Brewer *et al.,* 2005) in developing countries.

The criteria for selecting mobile device and technology to be used in any research study are very important in order to find a solution which would be possible to implement in a specific context. In this study, the existing mobile infrastructure in Tanzania was used. Some of the mobile phones have the following features for networking: GPRS, Modem, EDGE, 3G, 4G, WCDMA, USB, Bluetooth, Browser, WAP 2.0/xHTML and Infrared. Also, they are Java enabled with capability of sending and receiving SMS and MMS. These features are important for mobile learning computing[3].

Other requirement when developing m-learning is the mobile learning framework, which should consists of: mobile learning applications (level 1), mobile user infrastructure (browser, handheld devices – level 2), mobile protocol (adoption of content with WAP – level 3) and mobile network infrastructure (cellular systems, satellites, etc. – level 4). Leung and Chan (2003) argue that the mobile learning application should be developed on top of functionalities provided by other aspects of mobile computing (level 2, 3, and 4). The open source software can provide development kit for mobile devices, and gateways between mobile devices and web servers[4].

Leung and Chan (2003) proposed mobile learning framework to simplify functional design and development of mobile learning application so that different developers, vendors and providers can easily deal with the individual level of tasks without compromising interoperability.

The interoperability is between tools from different levels:
- Level 1: this includes mobile learning activity management and learning management.
- Level 2: this level consists of mobile devices and wireless networks that provide texts, video on demand, and information services.
- Level 3: this level deals with connection with different applications, tools, networks, and technologies in order to provide a common user interface.
- Level 4: Mobile learning applications should depend on networking support which deals with transmission rate and coverage.

2.3 Prototype Implementation

Prototype was developed in accordance with the principles of Client and Server architecture using FOSS tools. Requirement analysis was done using questionnaires and interviews in Kilosa District before the prototype was implemented. In this research study, the implementation of the prototype was done using SMS and WAP (Wireless Application Protocol). WAP uses WML (Wireless Markup Language) which works well with all cellular standards using any operating system like PalmOS, EPOC, Windows CE, OS/9 and JavaOS[5]. Another technology with which the prototype could be

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[3] http://mobile.softpedia.com/phones/Nokia/Nokia-N80.shtml

[4] http://www.handhelds.org/geeklog/index.php,   http://www.developershome.com/sms/freeLibForSMS.asp, http://java.sun.com/developer/earlyAccess/j2meconwizard/, http://www.kannel.org/overview.shtml

[5] (http://www.wapforum.org/)

implemented is Java 2 Platform Mobile Edition (J2ME), but it is not widely used in mobile devices (Lawton, 2002). Ninety nine percent of mobile phones on the market support WAP[6].

2.4 Framework for Integration

Attewell (2005) researched how delivery of learning materials via hand-held mobile devices could stimulate students' interest in learning and to assist with improvement of literacy, numeracy and life skills. Attewell (2005) found that a mixture of e-learning and m-learning, using materials previously downloaded onto hand-held devices, helps to reduce costs and the inconvenience of poor connectivity or poor signal in some remote rural areas, while traveling. Ally *et al*. (2005) researched delivering course materials via mobile devices and came to the conclusion that new courses have to be developed or existing courses have to be revised for delivery on mobile devices. Sun's Wireless Toolkit (WTK) and PalmOS Emulator were used in the testing of a mobile application developed by Ally *et al*. (2005). Testing was done before the application was deployed in real environment. This was done with the purpose of saving time.

Luckin *et al*. (2005) in a research titled "using mobile technologies to create flexible learning contexts" found that technology can be used to provide continuity across different locations. While most previous studies have focused on designing a framework and a system of supporting development of learning content in mobile technology (Juang *et al*., 2004). But in this research, a framework by which mobile learning could be delivered to farmers, agricultural extension officers and researchers was designed, developed at SUA and tested in Kilosa District (Sanga *et al*., 2016). The focus was in aspects that enhances communications between farmers, agricultural extension officers and researchers.

Studies developing countries have taken place on mobile learning covering aspects of m-learning, theory, designing, developing, testing, integration and implementation of mobile learning systems (Attewell, 2005; Ally *et al*., 2005; Jong *et al*., 2005; Vila *et al*.,2003; Lehner & Nosekabel, 2002; Georgiev *et al*., 2006; Sharples *et al*., 2005). However, few studies have been done in developing countries (Barker *et al*., 2005; Duveskog *et al*., 2004; Petrova, 2009; Louise & Venter, 2011; Ganesan *et al*., 2013; Dissanayeke *et al*., 2015a; Dissanayeke *et al*., 2015b; Sanga *et al*., 2016). Specifically, no study has been done in Tanzania with regard to m-learning that connect universities, research institutes, agricultural extension officers and farmers (Sanga *et al*., 2016). Hence, this was a gap that this study sought to fill.

3   RESEARCH METHODOLOGY

The study adopted a Soft Systems Methodology (SSM), which is suited for dealing with ill structured complex problem situation which has human activity component (Checkland & Scholes, 1990; Shaw, 1996). SSM was compounded with participatory action research method. SSM differs from other methodologies which try to solve hard problems which are technologically oriented (Couprie *et al*., 1997). Soft problems are complex while hard problems are easy to define in such a way that, the HOW and WHAT can be defined before obtaining a solution (Couprie *et al*., 1997) (see Figure 1).

Figure 1 depicts the basic shape of SSM. First the problem situation which exists in a real world must be identified by the researcher. Then relevant systems of purposeful activities are selected

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[6] (http://www.wapforum.org/new/M-CommerceWorld.ppt),
   http://openuss.sourceforge.net/openuss/marketing/papers/erlina-wap-openuss.pdf).

with the purpose of improving the situation of concern. The purposeful activities involve any system/action which is implemented to improve the problem situation. The models from the relevant systems are then compared with the perceived real world and again purposeful action is taken to improve the problem situation. This mostly initializes another cycle of problem solving; thus the process is a cyclical process. In a real world problem, a number of relevant systems can be identified depending on the researchers' understanding of the problem situation. Each relevant system needs a purposeful action which can rectify the problem situation. This also depends on the world view of the researchers' and participants. These act as stakeholders who initialize the debate about the actions for changes of a real world problem according to their interests. In order to have a clear purposeful action of a relevant system a root definition must be formulated (Venter *et al.*, 2001), (Checkland & Scholes, 1990).
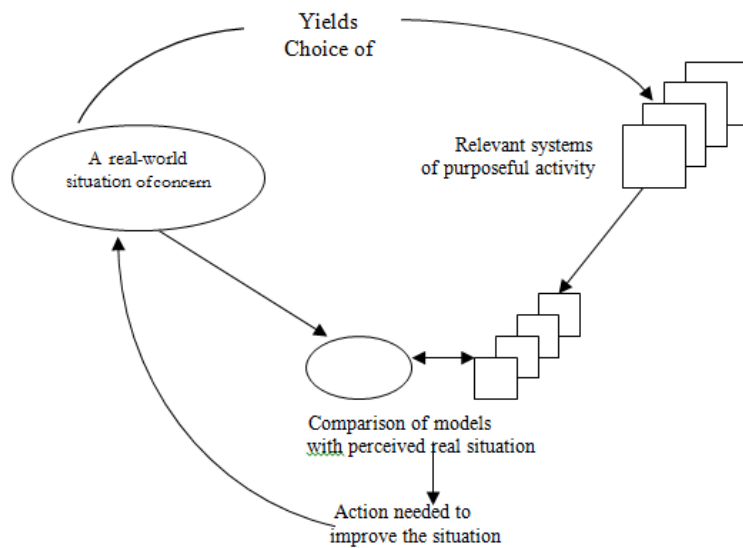
Figure 1: *Basic Shape of SSM (Checkland & Scholes, 1990, p.7)*

In a process of formulating a root definition, the elements of CATWOE (i.e. Customers, Actors, Transformation process, World view, Owners, Environmental constraints) were considered (Table 1). The following are the elements of CATWOE which was done in process of F1 (see Figure 2).

Table 1: *CATWOE mnemonic (Checkland & Scholes, 1990)*

Customers	the victims or beneficiaries of transformation
Actors	those who would do the transformation
Transformation Process	the conversion of input to output
World view	the worldview which makes this transformation meaningful in context
Owners	those who could stop transformation
Environmental Constraints	elements outside the system which it takes as given

3.1 Description of the problem in relation to basic shape of SSM

From Figure 2, "A" represents a real world of concern, "E1 and E2" represent chosen systems for 2013&2014 (case study I) and 2015 & 2016 (case study II) respectively, similarly "F1 and F2" represent relevant systems for purposeful activity, "C1 and C2" represent comparison of the models with perceived real situation, "D1 and D2" represent action needed to improve the situation and W represent monitoring and taking controlled action according to the established performance measurement (Sanga *et al.*, 2013a; Sanga *et al.*, 2013b; Sanga *et al.*, 2014a; Sanga *et al.*, 2014b). The following description identifies some of the issues "in the real-world" (see "A" in Figure 2) which researcher considered to be problematic. Agriculture is the backbone of most African countries. In Tanzania, the sector is known for employing more than 70% of the total population. However, the sector is characterized by low productivity; under-utilization of the available land, water and human resources; lack of agricultural support services; weak research-extension-farmer linkages, among many others. This study tried to improve the linkages among SUA researchers, agricultural extension officers and farmers located in Kilosa District. The purposeful activity to improve the problem was done using ICT (see "E1" in Figure 2).
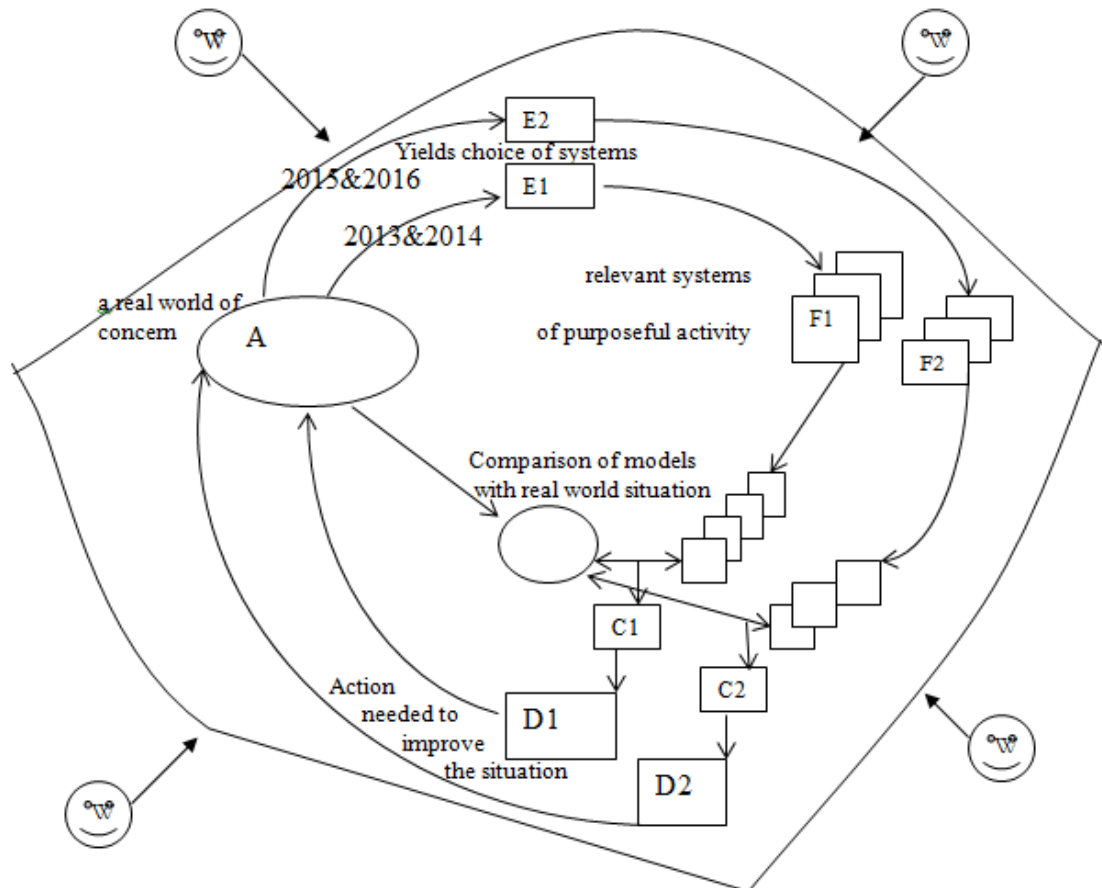

Figure 2: How this study used SSM

The proposed relevant system is an integration of e-learning and m-learning (see "F1" in Figure 2). This integrated system was implemented and some of the stakeholders participated in testing thereafter. Interviews and questionnaires were used to collect quantitative data. Qualitative and quantitative data were used to analyse data (see "C1" in Figure 2). The output of data analysis was to determine the kind of action(s) which needed to improve the problem situation (see "D1" in Figure 2).

The actions were applied in order to modify the "real world problem situation" and this starts another cycle (see "E1" in Figure 2). In 2015, the real problem situation was different due to the actions that were taken in 2013 & 2014 (Fue *et al*., 2015). Monitoring and controlling was done throughout the process, according to defined measures of performance (i.e. efficacy, efficiency, effectiveness) (as shown by "W" in Figure 2) to measure impact of the intervention. The whole processes were repeated in 2016 (Sanga *et al*., 2016) (see Figure 2).

4   PRELIMINARY FINDINGS

SSM Re-visited
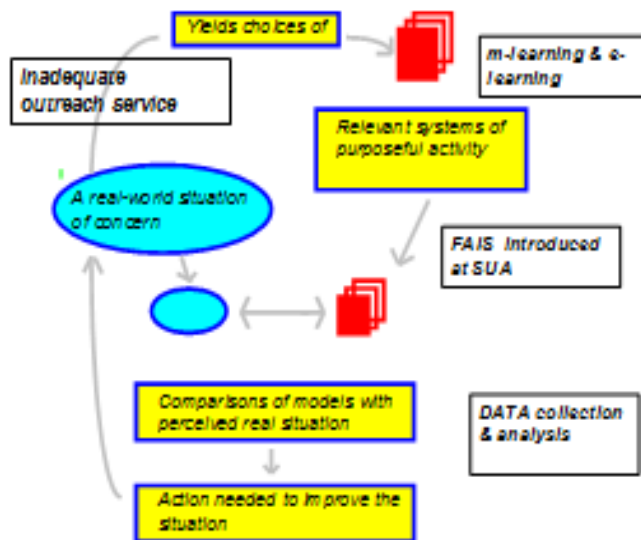
Figure 3: *How SSM guided this study*

The real problem of concern for which SUA faces is to delivery effective outreach services due to: lack of enough instructors; inadequate teaching or learning materials; few extension materials; and lack of infrastructure. These problems have led to: (i) poor delivery of information to farmers through outreach programmes; (ii) lack of effective communications among instructors/researchers, agricultural extension officers and farmers (Figure 3); (iii) lack of effectively communications between farmers (who are scattered in different villages) with extension staff from the Institute of Continuing Education at SUA. After the identification of these problems then the rich picture was formulated (Figure 4).
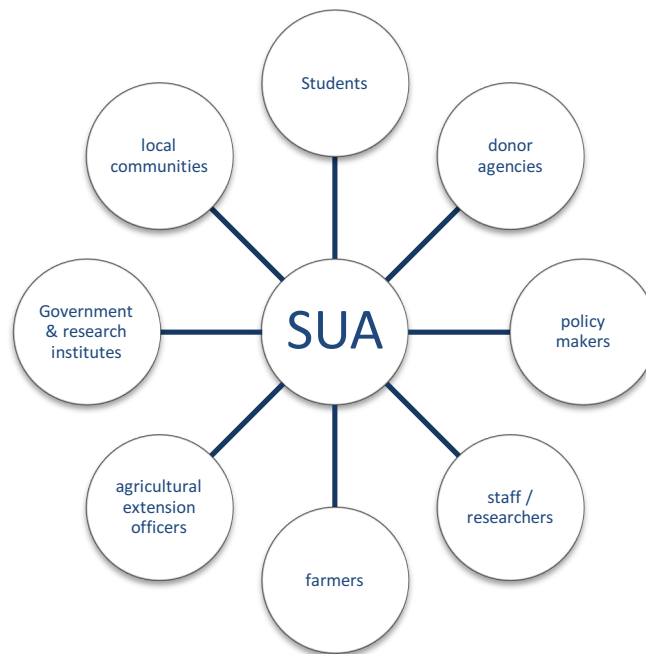
Figure 4: *Stakeholders of SUA*

The choice of "relevant systems" was done in an inception workshop with 20 key stakeholders (i.e. farmers, processors, traders, researchers from SUA, policy makers, radio presenters from Kilosa Community radio, manager of private tele-centre (KIRSEC)). These stakeholders formed an innovation platform. It was formed in 2012 in Kilosa District. The results of the inception workshop helped to obtain user and system requirements which later facilitated the development of e-learning and m-learning. The Web-based Farmers' Advisory Information System cater for e-learning, while the Mobile-based Farmers' Advisory Information System cater for m-learning. The project has trained 19 agricultural extension officers in Kilosa District from 20 villages and in turn they have trained 380 farmers on how to use M-FAIS. Currently, more than 700 farmers are using the system (Sanga *et al.*, 2016).

The screenshot for M-FAIS and W-FAIS is as shown in Figure 5.

How farmers and other agricultural actors ask questions?

A farmer or other stakeholders can access the system using either SMS or Web or e-mail. A farmer can ask any unstructured question by writing an SMS using the mobile phone numbers: +255 - 688099408.
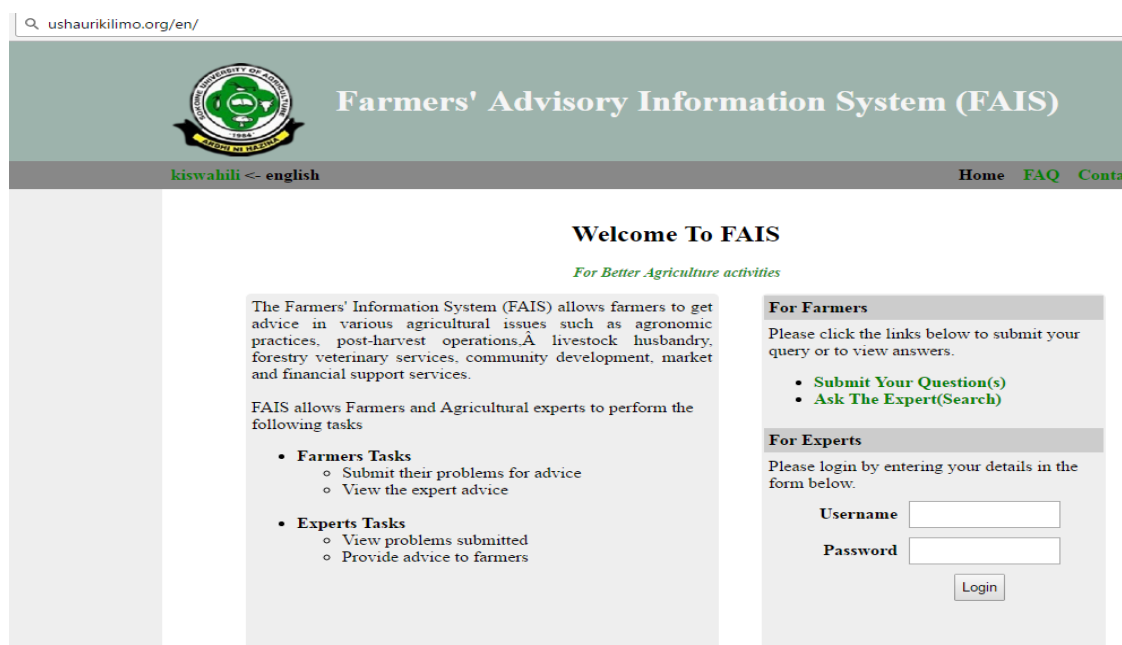
Figure 5: *Homepage of M-FAIS & W-FAIS*

A farmer or other stakeholders can also access the Web link (W-FAIS) using a form shown in Figure 6.

Figure 6: *Web form used by farmers to submit query to extension agents*

Farmers in Kilosa District were willing to pay for the agro-advisory services they asked through their mobile phones and in two years (2015-2016) we were able to collect more than 1500 questions sent through M-FAIS. Agricultural extension agents were willing and ready to participate in answering SMS questions asked by farmers. During the same period, more than 1354 questions

answered by agriculture extension agents (Figure 7). Questions that could not be answered by field agriculture extension agents were relayed to researchers, other agricultural extension officers and SUA experts. The M-FAIS website is http://ushaurikilimo.org/maswalimajibu.php, and is called locally UshauriKilimo.

*Figure 7: List of advisories given by extension agents*

Through the UshauriKilimo a diversity of questions were received, which was different from the project target of only receiving questions on the maize value chains, a crop of our concern. This showed that farmer in Kilosa District and elsewhere in the country practice crop farming and livestock husbandry (i.e. pastoral or agro-pastoral communities). The themes of questions were in: crop husbandry (annual and food crops), preparation of animal feeding, livestock diagnostic and treatment, simple business plan for farming and livestock keeping, climate change issues (e.g. late onset of rainfall from last season, etc.) and farm structure (how to build barns for livestock).

Other issues asked by farmers included financial assistance, information on materials/resources (books, booklets etc.), how to join academic programs offered at SUA, markets for crop producers, post-harvest (e.g. how to store maize in special sacks), early warning (e.g. disease outbreaks of crops and livestock), farm inputs (e.g. seeds) and livestock policy (e.g. movement of livestock between districts).

This was an advantage of using an integrated system (i.e. web and mobile farmers' advisory information system supported by Web 2.0 (i.e. Facebook page & blog)).
i.   W-FAIS (English version) has more than 2000 hits
ii.   W-FAIS (Kiswahili version) has more than 1769 hits
Our facebook page (https://www.facebook.com/Ict4AgriculturalExtensionServices) has 229 LIKES. Further, the study found that the pattern of farmers who specified their locations in their SMS were from different parts of Tanzania (Table 2)

Table 2: *Number of SMS sent to 'Ushaurikilimo' from different Regions*
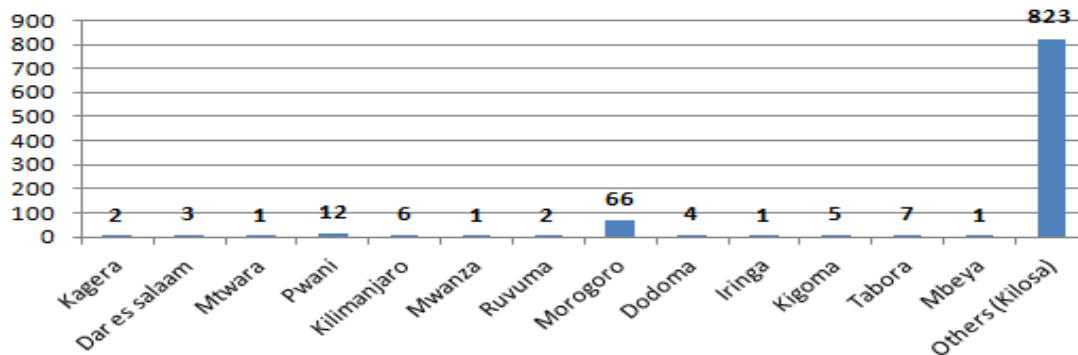
Examples of regions and districts from which questions were received a part of Kilosa (more than 19 villages), Kagera, Dar es Salaam, Mtwara, Pwani (Kiluvya), Kilimanjaro, Mwanza (Kibondo, Sengerema), Ruvuma, Morogoro, Dodoma (Bihawana), Iringa (Ilula), Kigoma, Tabora and Mbeya.

In summary, 'Ushaurikilimo[7]', a Swahili word for 'agro-advisory service', is offering innovative communication applications to farmers and other actors who can ask (query) question and get response from either extension agents or researcher or policy maker etc. This process is called crowdsourcing (Sanga et al., 2016). According to Sanga *et al.* (2016), some of applications which are being offered by 'Ushaurikilimo' are (i) Crowdsourcing platform for agricultural extension service (ii) Early warning system for rabies (iii) Disease surveillance and monitoring system (iv) Open Data system (v) Crowdsourcing platform for agricultural marketing information system (vi) Decision support systems for e-extension (vii) Tool for human web sensor (viii) Ushaurikilimo Mobile Apps (UMA) (ix) Tool for big data in agriculture (x) Cloud-based Agro-advisory Service Information System (CASIS)

4   CONCLUSION

M-FAS and W-FAIS were implemented to address the weakness of agricultural extension service delivery system in Tanzania. Also, it helped to address the shortcoming of outreach services offered at SUA. The findings of piloting M-FAIS and W-FAIS show that these systems can complement the conventional agricultural extension service delivery system. M-FAIS and W-FAIS support m-learning and e-learning respectively. In nutshell, M-FAIS and W-FAIS offer problem based learning (PBL) which is one of the proposed teaching method to solve a number of problem facing developing countries (Dahms & Stentoft, 2008; Dahms & Zakaria, 2015). Thus, M-FAIS and W-FAIS could in the future link SUA with other agricultural research institutes (e.g. Uyole, Ilonga) as well as connect SUA with agricultural extension agents and farmers residing in different regions in the country. M-FAIS and W-FAIS could in the future lessen the problem of agriculture information deficit among our farmers and deliver useful agriculture information to various stakeholders in the country hence increasing agricultural productivity and improve farmers' livelihood. Future studies should concentrate on evaluating the impact of M-FAIS and W-FAIS on succinct information delivery to various stakeholders.

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[7]
https://www.researchgate.net/publication/311013266_Delivery_of_Agricultural_Extension_Service_can_be_Improved_through_Mobile_Phones_-_POLICY_BRIEF

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