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Evaluation of Farmers Market Information System to Connect with Some Social Stakeholders

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Abstract: A large part of the population in Tanzania consists of rural smallholder farmers. Due to lack of market information, farmers sell crops to middlemen at lower prices and hence don't get enough profits. Previously we developed a WEB and SMS (Short Message Service) based Farmers Market Information System using a Waterfall model which automatically replies to farmers' requests for market prices of crops through SMS. We then improved the system so that, farmers can access crop buyers' details and crop demand reports through SMS while crop buyers can access farmers' details and crop demand reports through SMS or WEB. We also evaluated the effectiveness of the system to crop buyers' incomes and times for accessing market information after implementing the system in Tanzania in the SWAHILI language. In this paper we further evaluate the system effectiveness. Findings reveal that the system helped farmers to get improved incomes and access market information in shorter times. The system also helped farmers and crop buyers to sell and buy larger quantities of crops respectively. The findings also reveal that young people can learn and use the system more easily than old people. Users can also easily learn and use the system if they can read and write in the SWAHILI language regardless of their education levels.

Keywords: Short Message Service, WEB, farmers' incomes, system usability

1. Introduction

A large part of the population in Tanzania consists of smallholder farmers who live in rural areas and depend on crop farming as their primary economic activity. These farmers don't get enough profits due to lack of market information.

After growing and harvesting crops, the farmers sell their crops to the middlemen who are crop buyers. As a typical sight, the farmers wait for the trucks of the middlemen along the roads so as to sell their crops. A middleman buys and picks up their crops and transports them to a market by truck. The price of crops is decided in the discussion between middlemen and farmers. Thus a middleman has two roles, to buy their crops and also to transport their crops to markets, because the farmers don't have their own transportation system and also there is no public transportation system. This situation means that the discussion between farmers and middlemen is not based on the market prices. As a result, their lack of market information causes farmers to sell crops to middlemen at exploited prices [1], [2]. A system that removed this lack and gave information concerning the fair market prices would solve these problems.

Due to the increased use of mobile phones among Tanzanians, several mobile operators in Tanzania established USSD (Unstructured Supplementary Service Data) services (for example TIGO KILIMO [3]) to provide farmers with market information such as the market prices of crops and details of crop buyers through mobile phones. However these services are faced with several challenges including the difficulty of using them due to menu navigations and timeouts. Other challenges of USSD services include complex and irrelevant information to farmers and poor coverage among farmers in Tanzania [3]. These USSD services are also not suitable for crop buyers who prefer WEB service. Apart from those challenges of USSD services, little is known about the effectiveness of SMS and WEB based systems to rural farmers and crop buyers in Tanzania.

In order to overcome the challenges of USSD, we developed Farmers Market Information System (FMIS) in which farmers use SMS (Short Message Service) and buyers use SMS or WEB to access market information. We also evaluate the effectiveness of this system and help to fill the existing information gap on effectiveness of SMS and WEB based systems to farmers and crop buyers in Tanzania.

In our first work [4], we developed a SMS and WEB based system in which farmers request the market prices of crops through SMS and the system automatically replies farmers with market prices through SMS. The market prices are registered and updated by market officers through WEB. In our second work [5], we added system functions to connect farmers directly with crop buyers. Farmers use SMS to post crops for sale and access buyers' details. Buyers use SMS or WEB to post crop buying re-

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quests and access farmers' crops for sale.

In this paper we evaluate the effectiveness of the system in helping rural farmers to get improved incomes and access market information in shorter times as well as the effectiveness of the system in helping rural farmers to sell larger quantities of crops and buyers to buy larger quantities of crops after implementing the system in Tanzania in the SWAHILI language. We also examine system usability as well as the association between the system usability and the age and education level of the user.

2. Related Work

There are several mobile based systems which have been developed to help rural farmers to access market information and other agricultural information. However these systems are faced with several challenges.

Marketing information system [6] is a system which allows rural farmers in South Africa to access market information such as crop buyers' details through WEB and USSD applications. Although it was reported that the system was easy to use, this study lacks information about the effectiveness of this system to farmers and crop buyers. Also the use of USSD presents difficulties of timeouts and menu navigations. Also the Internet is needed to access this system hence it is not suitable for farmers who can't access the Internet.

"Buuza Omulimisa" (Ask the extension officer) [7] is an SMS based question and answer platform to help rural farming communities in Uganda to interact with extension officers in local languages. Farmers send questions through SMS to a WEB system, then extension officers use the WEB system to send back the answers to farmers through SMS. Although it was reported that local language increases the chance of system adoption, this system is faced with several challenges including lack of flexibility and availability due to lack of SMS querying since user requests are interpreted and answered by humans.

There are several studies which have examined the impact and role of mobile phones in improving the incomes of rural farmers. However there is still an information gap existing in these studies.

One of these studies [8] was conducted to examine the contribution of mobile phones to rural livehoods and poverty reduction in the Morogoro region, Tanzania. It was found that the use of mobile phones helped rural farmers to access better markets and prices for their produce and overcome the problem of being cheated by middlemen. However this study lacks information about the effectiveness of SMS and WEB based systems to farmers as it focuses only on using mobile phones through voice calling which has several drawbacks such as the difficulty of keeping information records and lack of flexibility in requesting information.

Another study [9] was conducted to examine the impact of cell phones (mobile phones) on the grain market in Niger. It was found that cell phones improved consumer and trader welfare by reducing search costs and price dispersion across grain markets. However this study also lacks information on the effectiveness of SMS and WEB based systems to farmers and crop buyers as it focuses on using mobile phones through voice calling which has the drawbacks mentioned previously.

To address the challenges of these systems and studies, we have developed the SMS and WEB based Farmers Market Information System and evaluated its effectiveness. The system uses SMS to overcome the challenges of USSD and ensure farmers can access market information on any kind of mobile phone without the need of the Internet while crop buyers can choose to use SMS or WEB to access market information which ensures flexibility. The system uses SMS querying in which users' SMS requests are processed and replied to automatically by the system to ensure flexibility and availability at any time. The use of SMS and WEB ensures information records are easily and securely stored. Finally we evaluate the effectiveness of the system in helping rural farmers in Tanzania to get improved incomes, access market information in shorter times and sell larger quantities of crops and buyers to buy larger quantities of crops. This will help to fill the existing information gap in the role of SMS and WEB based systems to rural farmers and crop buyers especially in Tanzania.

3. Research Design

3.1 Social Stakeholders

As farmers grow their crops, there are people who can affect farmers' activities or can be effected by farmers' activities. These are the "social stakeholders". In this study, the following are the social stakeholders.

- Crop Buyers: Crop buyers are the people who buy crops from farmers. After growing and harvesting crops, farmers need to sell their crops to buyers. In this system, the role of crop buyer is to buy crops directly from farmers. After the farmers have posted requests of selling crops, crop buyers can access the phone numbers of farmers and the quantity of crops they sell and then contact them in order to buy their crops.
- Market Officers: Market officers are the Government officials in each market who are responsible for overseeing operations in the markets. Farmers need to access market prices and attain bargaining power in order to negotiate better selling prices with crop buyers. However for this to happen, someone needs to know these market prices, record them and update them so that they can be accessed by farmers. This is the role of market officer in the system. The market officer registers and updates the market prices of crops in his/her market.
- Ministry Officers: Ministry officers are the Government officers in the Ministry of Agriculture, Livestock and Fisheries in Tanzania. This Ministry is responsible for formulating different policies which directly affect farmers. Ministry officers in this system have two main roles, first they can check if the system provides correct market information such as the market prices of crops to ensure integrity of the system and second, they can access various reports which can help them during the process of policy formulation. For example a Ministry officer can view a report which shows number of registered farmers based on sex as well as a crop demand report which shows the most demanded crops in a particular period of time. This information can help Ministry officers when formulating Information and Communication

Technology (ICT) policies which affect farmers.

3.2 Sampling and Contacts with Respondents

It is important to note that, the first author comes from Tanzania. He together with his previous supervisor (second author) travelled to Tanzania in August 2016 for a period of 2 weeks to conduct experiments for evaluating the effectiveness of the system to farmers and crop buyers. A total of 30 respondents participated in this study.

- Farmers: To interact with farmers, the first author requested the assistance of village Government officers who are known to the farmers in villages. Due to the limitations of time and cost, Banana farmers were purposely sampled. A total of 12 Banana farmers (6 in a control group who used middlemen and 6 in a treatment group who used the Farmers Market Information System) from 3 villages in the Rungwe district in the Mbeya region were selected by the first author with the assistance of village Government officers. Only 3 villages were selected because, it was convenient for the first author to access these villages due to the limitations of time and cost.
- Crop Buyers: To interact with crop buyers (retailers in the markets), the first author requested the assistance of market officers (Government officials who oversee operations of the markets). Due to the limitations of time and cost, Banana crop buyers were purposely sampled. A total of 12 crop buyers (6 in the first market for a control group who used middlemen and 6 in the second market for a treatment group who used the system) from 2 markets in the Mbeya Urban district in the Mbeya region were selected by the first author with the assistance of market officers. Due to the limitations of time and cost, only two markets were purposely selected because they are famous for selling Bananas.
- Market Officers: The first author visited the 2 mentioned markets and requested that the market officers to participate in this study. A total of 2 market officers (1 from the first market who did not use the system and 1 from the second market who used the system) participated in this study.
- Ministry Officers: The first author visited the Government Ministry of Agriculture, Livestock and Fisheries in Dar es salaam city and requested the 2 officers who are responsible for research enquiries which involve farmers, to participate in this study.
- System Administrators: In order to perform administrative tasks in the system such as activating or deactivating user accounts, a System Administrator is needed. A total of 2 members of staff at Dar es salaam Institute of Technology in Dar es salaam city (where the first author works) were selected to participate in this study. Because of the limitations of time and cost, only 2 members of staff were purposely selected because of their technical knowledge of ICT systems.

4. Developed System

4.1 Methodology

4.1.1 Mechanism for SMS Querying

The developed system allows mobile users (farmers and mobile crop buyers) to post or request market information through SMS querying. The conceptual mechanism for SMS querying is shown in **Fig. 1**. In the first step, an incoming request SMS from a user is received. In the second step the keyword (first word) in the incoming SMS is extracted and compared against a predefined set of keywords. If a match is found, the corresponding query under that keyword is executed and a query response is prepared ready to be sent back to the user. If a match is not found, an error is retrieved and prepared ready to be sent back to the user. In the third step, a response SMS or error SMS is sent back to user.

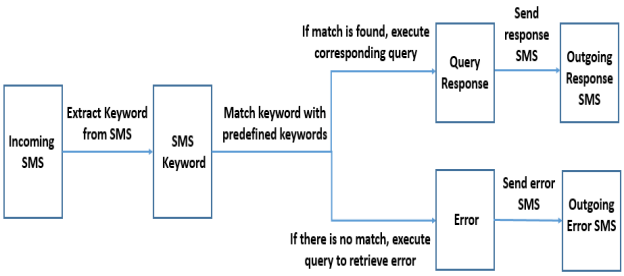

Fig. 1 Conceptual mechanism for SMS querying.

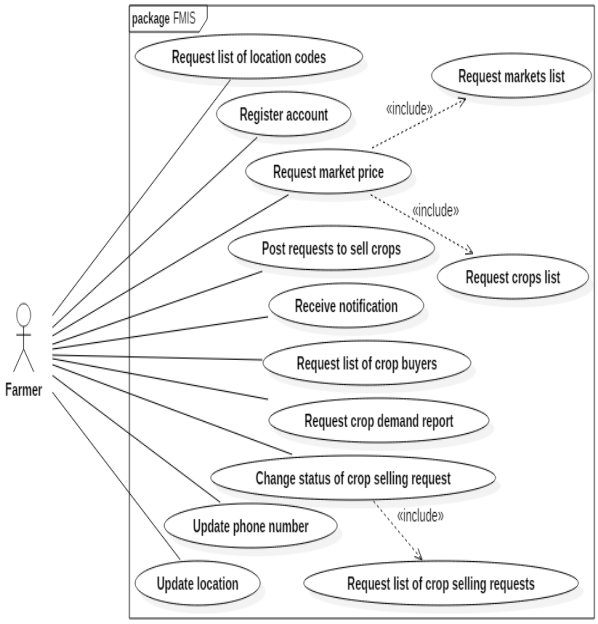

Fig. 2 Use case diagram for farmer.

4.1.2 Software Development Methodology

Firstly a survey was conducted using questionnaires among stakeholders in Tanzania to collect user requirements for the system and then the system was developed by using a Waterfall software development model [10].

4.2 Requirements Analysis and Specification

4.2.1 Requirements Modeling

Use Case Diagram and Sequence Diagram are some of the UML (Unified Modeling Language) diagrams which were used to model requirements. Use Case Diagram shows how the actor interacts with the system using different functions. Use Case Diagram for farmers is shown in **Fig. 2**.

Sequence Diagram is used for modeling the behavior of the system. It shows how and in which order the objects interact with

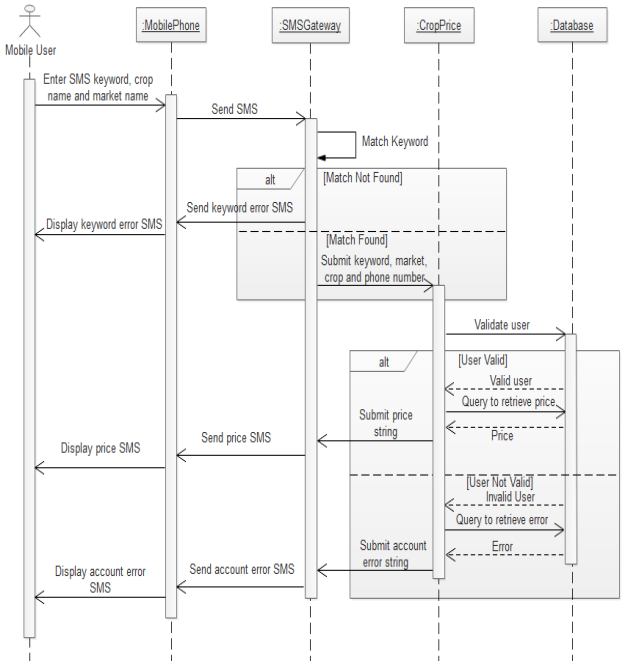

Fig. 3 Sequence diagram for mobile user (farmer or mobile crop buyer) when requesting market price through SMS.

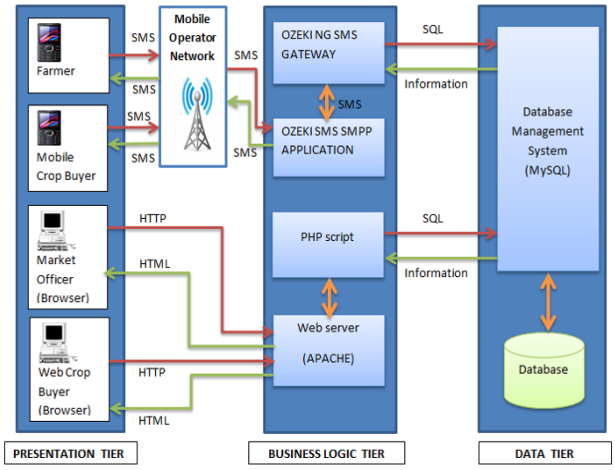

Fig. 4 System design based on 3-Tier architecture.

each other. Interaction between objects is arranged in time sequence. Sequence Diagram for mobile users (farmer or mobile crop buyer) when requesting market price of crop through SMS is shown in **Fig. 3**.

4.2.2 System Features and System Overview

Users requested several features to be in the system including system availability, security and short response time.

Farmers use SMS and crop buyers can use SMS or WEB to request market information from the system. The system authenticates farmers and crop buyers and responds to their requests within a short time.

4.3 System Design

4.3.1 System Architecture

System design is based on 3-Tier architecture (refer to **Fig. 4**). Stored Procedures in MySQL Database Management System together with Ozeki NG SMS Gateway [11] interpret SMS requests, authenticate mobile users, execute SQL queries and send back responses automatically to users through SMS. This ensures security, availability and a short response time. WEB requests are automatically processed and replied to by PHP scripts together with Apache WEB server and MySQL Database Management System. This ensures security, availability and a short response time for WEB users.

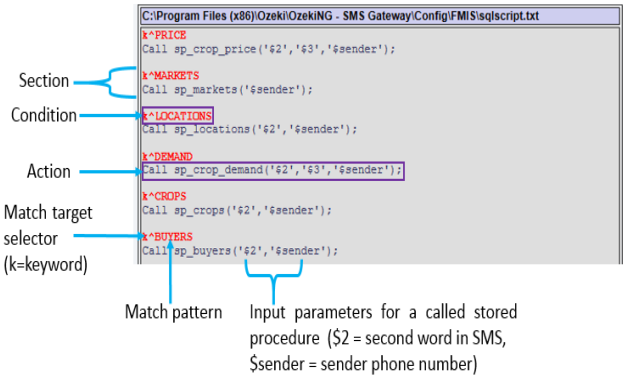

Fig. 5 SQL script file.

4.3.2 Control of SMS Query Execution

To control which SQL query is executed when an incoming request SMS arrives, SQL script file was prepared and stored in Ozeki NG SMS Gateway. SQL script file (refer to **Fig. 5**) contains several sections which are separated by empty lines. A section contains two parts, a condition and an action. A condition is the first line in a section and it has two parts, the match target selector which determines which part of the incoming SMS is checked for matching and the match pattern which is a standard regular expression [12]. An action is MySQL Stored Procedure which contains SQL commands to be executed if the condition matches the incoming SMS.

Once the incoming SMS arrives, the SMS Gateway checks the SQL script file, then sections are read sequentially. MySQL Stored Procedure in the first section that matches an incoming SMS is executed and a response is sent back to the user as SMS by the SMS Gateway.

4.3.3 Component Level Design

In component level design, flowcharts were used to design algorithms for programs. An algorithm for a program to retrieve the market price through SMS is shown in **Fig. 6**.

4.4 Sample Codes

Programs for SMS functionalities were written in MySQL Stored Procedures while programs for Web functionalities were written in PHP. Sample codes for a program to retrieve the market price through SMS is shown in **Fig. 7**.

4.5 System Functions

In our first work [4], we included functions to allow farmers and mobile crop buyers to request the market prices of crops through SMS. In our second work [5], we improved the system to include functions which allow farmers to post crops for sale and access crop buyers' details through SMS and crop buyers to post crop buying requests and access farmers' crops for sale through SMS or WEB. After that we improved the system to allow farm-

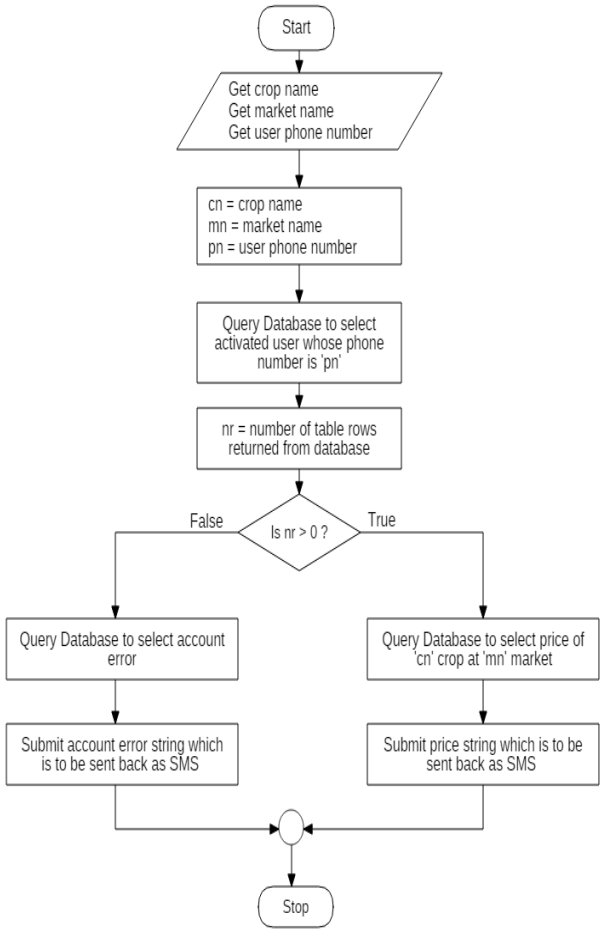

Fig. 6 Algorithm for retrieving the market price through SMS.

```
delimiter //
CREATE PROCEDURE sp_crop_price
(
IN CropName VARCHAR(50),
IN MarketName VARCHAR(50),
IN PhoneNumber VARCHAR(50)
)
BEGIN
DECLARE Num1 INT;
DECLARE Num2 INT;
DECLARE PhoneNumber1 VARCHAR(50);
DECLARE CropName1 VARCHAR(50);
DECLARE MarketName1 VARCHAR(50);
SET PhoneNumber1 = PhoneNumber;
SELECT COUNT(First_Name) INTO Num1
FROM farmer_registration WHERE Phone_Number=PhoneNumber1 AND Activation='ON';
SELECT COUNT(First_Name) INTO Num2
FROM crop_buyer_registration WHERE Phone_Number=PhoneNumber1 AND Activation='ON';
IF ((Num1 >= 1 AND Num2 = 0) OR (Num1 = 0 AND Num2 >= 1)) THEN
SET CropName1 = CropName;
SET MarketName1 = MarketName;
SELECT PhoneNumber,pr FROM price where (Crop_Name=CropName1 AND Market_Name=MarketName1);
ELSE
SELECT PhoneNumber,Feedbackmsg from feedback where Type='registerfirst';
END IF;
END//
delimiter ;
```

Fig. 7 MySQL stored procedure for retrieving market price.

ers and crop buyers to access crop demand reports through SMS or WEB before deciding to sell or buy crops.

A mobile user sends an SMS with keyword and data after which the system interprets the keyword, performs querying to process the data and returns results back to the user through SMS. A Web user fills and submits a Web form, after which the system processes the request and returns and displays results to the user.

Screenshots of some functions in the system are shown and described as follows. In **Fig. 8**, a farmer sends an SMS to register crops for sale after which the system saves the farmer's crops for sale into the Database and sends back an acknowledgement SMS. In **Fig. 9**, a mobile crop buyer sends an SMS to request the farmers' crops for sale, after which the system retrieves crops for

Fig. 8 Farmer posts crops for sale through SMS.

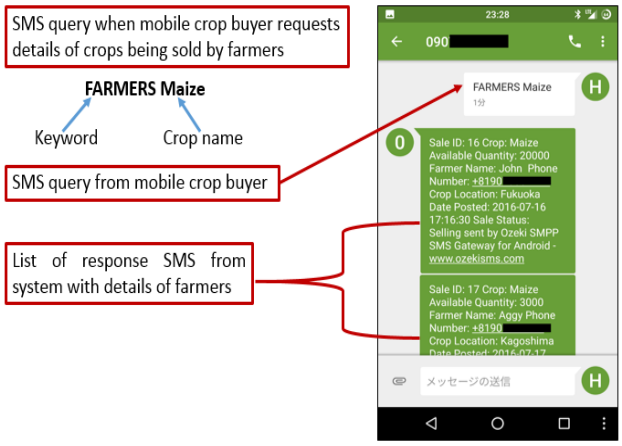

Fig. 9 Mobile crop buyer requests crops for sale through SMS.

Fig. 10 Farmers' crops for sale being displayed in Web system.

sale from the Database and sends back an SMS with the farmers' details to the mobile crop buyer. In **Fig. 10**, a Web crop buyer can search and view farmers' crops for sale in the Web system. In **Fig. 11**, a crop demand report which shows the five most demanded crops based on crop transaction quantity between farmers and crop buyers is shown in the SMS after being requested by a farmer.

5. Evaluation of System Effectiveness

Farmers Market Information System was deployed in Tanzania

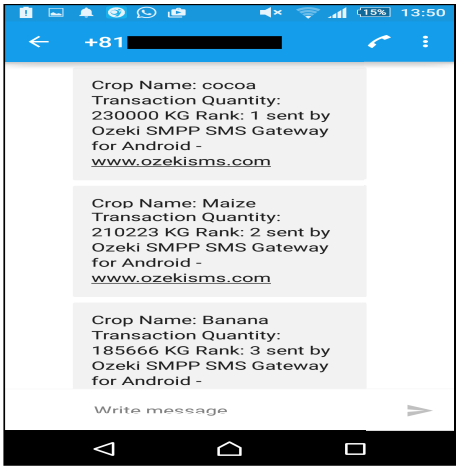

Fig. 11 Crop demand report through SMS.

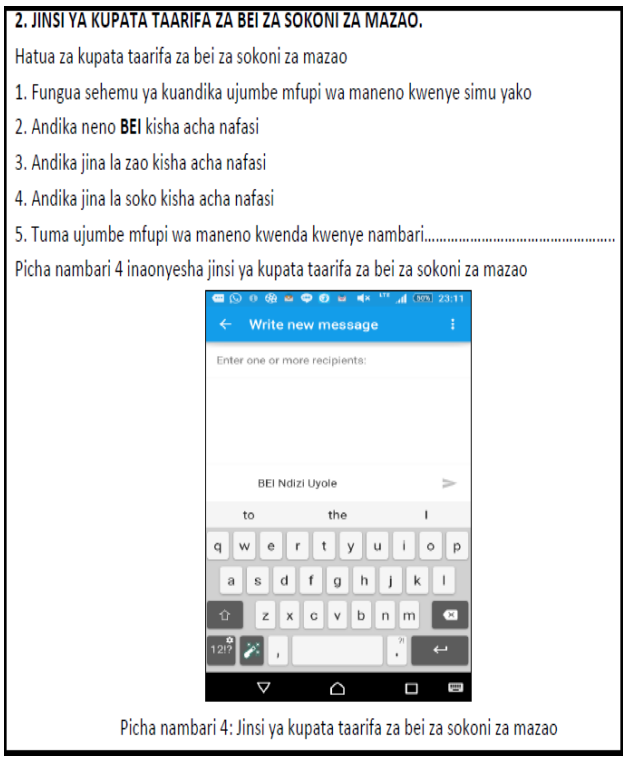

Fig. 12 A user guide in the SWAHILI language which shows how to request market price of crop through SMS.

for 2 weeks in August 2016 to evaluate its effectiveness to farmers and crop buyers.

5.1 The Field Work

Experiments to evaluate the effectiveness of the system and system testing were carried out in Tanzania in August 2016, from August 23rd, 2016 to September 2nd, 2016. Before the field work started, required Research permits were obtained from the Regional and District Governments. The following are the details of the field work.

- User Training: Respondents who used the system were first trained by the first author and were then given user guides in the SWAHILI language with procedures of how to access various services in the system (refer to **Fig. 12**). After that step, the respondents used the system to access various services based on their roles.
- Translation of texts: The first author translated texts in documents such as questionnaires from the English language to the SWAHILI language for the respondents who did not understand the English language.
- Data Collection: The first author with the assistance of the mentioned officers visited farmers in their households or farms as well as crop buyers in the markets in order to collect data. Ministry officers and System Administrators were visited by the first author in their offices in order to collect data. For respondents who used the system, data such as agreed selling prices of crops and quantity of crops sold between farmers and crop buyers were recorded by the first author after completion of the experiments. An SMS log analysis was used to collect data on time to access market information. Questionnaires were used to collect data such as System Usability Scale (SUS) responses as well as comments from users on system testing and how to improve the system. For respondents who did not use the system, questionnaires were used to collect data such as farmers' crop selling prices to middlemen, time to access market information and quantity of crops sold by farmers to middlemen. Observation was used in collecting data about how farmers sell crops to middlemen at collection centers along the roads as well as the status of rural infrastructures such as rural roads.
- Timetable of the field work: **Table 1** shows the timetable of the field work.

Table 1 Timetable of the field work.

No	Dates	Activities
1	From August 23rd, 2016 to August 26th, 2016	Conducting experiments, system testing and collecting data from farmers
2	From August 27th, 2016 to August 29th, 2016	Conducting experiments, system testing and collecting data from crop buyers
3	August 30th, 2016	Conducting system testing and collecting data from Market Officers
4	August 31st, 2016	Conducting system testing and collecting data from Ministry Officers
5	From September 1st, 2016 to September 2nd, 2016	Conducting system testing and collecting data from System Administrators

5.2 Experiment on Farmer's Time to Access Market Information

The aim of this experiment is to compare time to access market prices and details of crop buyers between farmers who used the Farmers Market Information System and those farmers who used middlemen. A total of 12 Banana farmers from the Rungwe district, Tanzania were purposely sampled to participate in this experiment. Control group (farmers who used middlemen) consisted of 6 farmers while treatment group (farmers who used the Farmers Market Information System) also consisted of 6 farmers.

Before this experiment started, 6 crop buyers were trained how to use the system and then registered into the system (3 buyers used SMS and 3 buyers used WEB) and posted requests for buy-

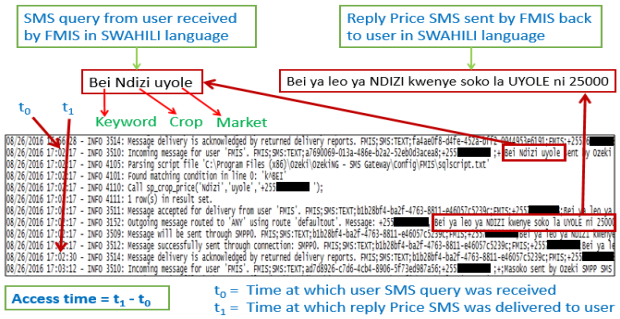

Fig. 13 SMS log analysis to determine time for accessing market prices.

Table 2 Farmer's time to access market prices.

Resource	N	Mean	SD	T-test
By middlemen	6	2,700	985.901	p = 0.0000552 *
By System	6	12.667	4.227	

N : Number of people
Mean : Mean time in Seconds
SD : Standard Deviation of time in seconds

Table 3 Farmer's time to access crop buyers' details.

Resource	N	Mean	SD	T-test
By middlemen	6	2,400	929.516	p = 0.0000896 *
By System	6	11	2.191	

N : Number of people
Mean : Mean time in Seconds
SD : Standard Deviation of time in seconds

ing crops. A market officer was registered through WEB and was trained how to use the system. The market officer then registered market prices into the system. The following steps were used to conduct this experiment.

(1) Farmers in the treatment group were trained how to use the system. They then registered into the system through SMS.
(2) Farmers in the treatment group used SMS to request market prices and details of buyers from the system. Farmers in the control group filled questionnaires to record the time they used to access market prices and details of buyers.
(3) The SMS log (refer to **Fig. 13**) was analyzed to determine the time to access market prices and buyers' details for farmers in the treatment group. Questionnaires were analyzed to determine the time to access market prices and buyers' details for farmers in the control group.
(4) T-test was conducted to determine if there is a significant difference between the mean times of the two groups.

The Farmers Market Information System was more effective than middlemen in reducing a farmer's time to access market information. It can be observed from **Table 2** that farmers who used the system reduced Mean time to access market prices by 213 times compared to farmers who used middlemen while from **Table 3** it can be observed that farmers who used the system reduced Mean time to access details of crop buyers by 218 times compared to farmers who used middlemen.

5.3 Experiment on Farmer's Income

The aim of this experiment is to compare net income per one bunch of bananas between farmers who used the Farmers Market Information System and those farmers who used middlemen. This experiment involved the same 6 farmers and 6 buyers as in the experiment to find a farmer's time to access market information. The following steps were used in this experiment.

Table 4 Farmer's net income per one bunch of Banana.

Resource	N	Mean	SD	T-test
By middlemen	6	7,333.333	1,751.19	p = 0.0000232 *
By System	6	13,500	1,048.809	

N : Number of people
Mean : Mean Net Income in Tanzanian Shillings
SD : Standard Deviation of Net Income in Tanzanian Shillings

(1) Farmers in the treatment group used SMS to request details of crop buyers including the quantity of crops needed and buyers' phone numbers from the system. Simulation was conducted by requesting these farmers to call crop buyers whom they have accessed through the system and agree on selling prices for their crops. Agreed prices between farmers and buyers were recorded.
Farmers in the control group filled questionnaires to record prices at which they sold crops to middlemen.
(2) Net income was calculated by subtracting other costs (such as transport cost and crop tax) from the selling price.
Net Income = Selling Price − Other Costs
(3) T-test was conducted to determine if there is a significant difference between mean net incomes of the two groups.

Farmers Market Information System was more effective than middlemen in increasing the farmer's net income. It can be observed from **Table 4** that farmers who used the system increased Mean net income by 84.1% compared to farmers who used middlemen.

5.4 Experiment on Quantity of Crops Sold

The aim of this experiment is to compare the quantity of crops sold between farmers who used the Farmers Market Information System and those farmers who used middlemen. This experiment involved the same 6 farmers and 6 buyers as in the previous experiments. The following steps were used in this experiment.

(1) Farmers in the treatment group used SMS to request details of crop buyers including the quantity of crops needed and buyers' phone numbers from the system. Simulation was conducted by requesting these farmers to call crop buyers whom they have accessed through the system and agree on the quantity of crops to sell. Agreed crop quantities between farmers and buyers were recorded.
Farmers in the control group filled questionnaires to record the quantities of crops they sold to middlemen.
(2) T-test was conducted to determine if there is a significant difference between mean crop quantities sold by the two groups.

The Farmers Market Information System was more effective than middlemen in increasing the quantity of crops sold by farmers through group selling. It can be observed from **Table 5** that by using group selling (one farmer contacts a buyer in order to sell all crops of members of the group), farmers who used the system sold higher quantities of crops (15 times more) compared to farmers who used middlemen.

From **Table 6** it can be observed that, without group selling, there is no significant difference in the quantity of crops sold by

Table 5 Quantity of Banana sold by farmers in one week when farmers who use the system sell crops in groups.

Resource	N	Mean	SD	T-test
By Middlemen	6	4.167	1.602	p = 0.00126 *
By System	6	61.167	31.435	

N : Number of people
Mean : Mean quantity of Banana in bunches
SD : Standard Deviation of quantity of Banana in bunches

Table 6 Quantity of Banana sold by farmers in one week when farmers who use the system sell crops individually.

Resource	N	Mean	SD	T-test
By Middlemen	6	4.167	1.602	p = 0.127
By System	6	8.333	5.922	

N : Number of people
Mean : Mean quantity of Banana in bunches
SD : Standard Deviation of quantity of Banana in bunches

Table 7 Quantity of Banana bought by buyers in one week.

Resource	N	Mean	SD	T-test
By Middlemen	6	27.5	7.583	p = 0.0289 *
By System	6	61.167	31.435	

N : Number of people
Mean : Mean quantity of Banana in bunches
SD : Standard Deviation of quantity of bananas in bunches

farmers who used the system and those farmers who used middlemen. This can be explained by the fact that farmers in both groups are smallholder farmers who grow crops in small sized lands and harvest small quantities of crops.

5.5 Experiment on Quantity of Crops Bought

The aim of this experiment is to compare the quantity of crops bought between buyers who used the Farmers Market Information System and those buyers who used middlemen. This experiment involved the same 6 farmers and 6 buyers as in the previous experiments. Before this experiment started, the 6 farmers posted requests of selling crops through SMS. The following steps were used to conduct this experiment.

(1) Buyers in the treatment group used SMS and WEB to request details of farmers including the quantity of crops being sold and farmers' phone numbers from the system. Simulation was conducted by requesting these buyers to call farmers whom they have accessed through the system and agree on the quantity of crops to buy. Agreed crop quantities between buyers and farmers were recorded.
Buyers in the control group filled questionnaires to record the quantities of crops they bought from middlemen.

(2) T-test was conducted to determine if there is a significant difference between mean crop quantities bought by the two groups.

The Farmers Market Information System was more effective than middlemen in increasing the quantity of crops bought by buyers. It can be observed from **Table 7** that buyers who used the system increased the quantity of crops bought (2 times more) compared to buyers who used middlemen.

5.6 Experiment on System Usability

The System Usability Scale (SUS) questionnaire (refer to **Fig. 14**) was used to collect responses on system usability. This

		Strongly Disagree 1	2	3	4	Strongly Agree 5
1	I think that I would like to use this system frequently					
2	I found the system unnecessarily complex					
3	I thought the system was easy to use					
4	I think that I would need the support of a technical person to be able to use this system					
5	I found the various functions in this system were well integrated					
6	I thought there was too much inconsistency in this system					
7	I would imagine that most people would learn to use this system very quickly					
8	I found the system very cumbersome to use					
9	I felt very confident using the system					
10	I needed to learn a lot of things before I could get going with this system					

Fig. 14 System Usability Scale (SUS) questionnaire.

Table 8 System Usability Scale (SUS) scores.

User	N	Mean	SD
Farmers	6	85	7.906
Crop Buyers	6	91.25	6.072
Ministry Officers	2	86.25	12.374
System Administrators	2	72.5	7.071
Market Officer	1	87.5	

N : Number of people
Mean : Mean SUS score
SD : Standard Deviation of SUS score

experiment involved the same 6 farmers, 6 buyers and 1 market officer as in the previous experiments together with 2 ministry officers and 2 system administrators. They all used the system.

(1) Ministry officers and system administrators were registered through WEB and trained how to use the system. Farmers, buyers and the market officer were already registered and trained in the previous experiments.

(2) All users used the system to access various services based on their roles.

(3) After using the system, users were requested to fill an SUS questionnaire.

(4) The individual SUS score was calculated as follows.
- For odd question: subtract one from user response.
- For even question: subtract user response from five.
- Add up all the answers to get total.
- Multiply total by 2.5 to get individual SUS score out of 100.

(5) Mean SUS scores for each user category were calculated.

(6) The Fisher Exact test was conducted in order to analyze the association between SUS scores and the age of users as well as the association between SUS scores and the education level of users.

It can be observed from **Table 8** that Mean SUS scores for each user category are above the acceptable SUS score of 68. Hence it can be said that the Farmers Market Information System is easy to learn and use.

Table 9 shows the association between SUS scores and the education level of users while **Table 10** shows the association between SUS scores and the age of users. A total of 13 users (6 farmers, 6 crop buyers and 1 market officer) were involved in this analysis. It can be observed from Table 9 that, there is no significant difference in system usability between users who have

Table 9 Association between SUS score and education level of user.

Education	69-89 SUS	90-100 SUS	Fisher Exact Test
Primary	5	2	p = 0.5921
Secondary	3	3	

69-89 SUS : Number of users with scores between 69 and 89
69-89 SUS : Number of users with scores between 90 and 100
Primary : Number of people with Primary education
Secondary : Number of people with Secondary education

Table 10 Association between SUS score and age of user.

Age	69-89 SUS	90-100 SUS	Fisher Exact Test
≤ 38 Years	0	5	p = 0.0008 *
≥ 39 Years	8	0	

69-89 SUS : Number of users with scores between 69 and 89
69-89 SUS : Number of users with scores between 90 and 100
≤ 38 Years : Number of users who are 38 years old or below
≥ 39 Years : Number of users who are 39 years old or above

primary education (standard 7 years) and those users who have at least secondary education (from 4 years and above).

However from Table 10, it can be observed that, there is a significant difference in system usability between young and old people. It can be observed that, young people have a better capability of learning and using the system compared to old people.

6. Discussion

6.1 Impact of the System to Farmers' Behavior and Decision Making

The following is the impact of the Farmers Market Information System to farmers' behavior and decision making.

- Decision on selling prices of crops: By accessing market prices, farmers empower themselves with bargaining power and avoid price exploitation by crop buyers. This allows farmers to sell their crops at better prices and improve their incomes.
- Decision on which crops to grow: Apart from market prices, the system also provides farmers with a crop demand report which shows the five most demanded crops during a specific period of time. This allows farmers to decide which crops to grow so as to maximize profits. For example if a farmer accesses a crop demand report and market prices and finds out that a certain crop has been demanded mostly in the past 3 months and it has the highest market price, then the farmer can decide to grow that crop so as to maximize profits.
- Decision on where to sell crops: The system allows farmers to access a wide range of crop buyers who have posted requests for buying crops. This allows farmers to make better decisions of where to sell the crops so as to maximize profits.
- Convenience and flexibility: The system allows farmers to access market information in a short time at any time and place. This brings convenience and flexibility in accessing market information. Instead of travelling or waiting for a particular time to seek market information, farmers can save this time and engage themselves in productive agricultural activities.
- Reduction of transaction costs: Farmers can also reduce transaction costs such as travelling costs for seeking market information. Instead of travelling to seek market information, farmers can access market information through SMS on their mobile phones and save the costs of travelling. Also farmers can decide to sell their crops to one larger crop buyer through group selling. This allows them to share crop transportation costs and maximize profits.

6.2 Impact of SMS, WEB and SWAHILI Language to System Usability

The findings in this study suggest that SMS and WEB based systems implemented in the SWAHILI language are easy to learn and use. This increases the chance of adoption among Tanzania rural farmers and crop buyers.

This is because most of the rural farmers and crop buyers in Tanzania have at least primary education which enables them to read and write in the SWAHILI language, so they can easily understand information which is in SWAHILI and they can easily learn and use systems implemented in the SWAHILI language.

It is also easier to learn and use SMS compared to USSD for rural farmers and crop buyers with low education levels. Finally SMS and WEB provide flexibility which helps crop buyers to have wide options for accessing information.

6.3 Impact of Age and Education Level to System Usability

The findings in this study suggest that the level of education of the user has no significant impact on system usability as long as the user can read and write in the SWAHILI language. This can be explained by the fact that users who have primary or secondary education can read and write in SWAHILI, so they can easily learn and use systems which have been implemented in the SWAHILI language regardless of their education levels.

On the other hand, the findings in this study suggest that the age of the user has significant impact on system usability. Young people have a better capability of learning and using the system compared to old people. This can be explained by the fact that, young people are more exposed to ICT tools like mobile phones and computers compared to old people. Young people tend to use these tools more frequently, so they can easily learn and use ICT systems.

7. Conclusion

In this paper we have evaluated the effectiveness of the Farmers Market Information System. The findings suggest that the system is more effective than middlemen in helping farmers to get improved incomes and access market information in shorter times. The findings also suggest that it is easy to learn and use the system.

In order to help rural farmers to improve their incomes and welfare, systems like the Farmers Market Information System should go hand in hand with other factors such as good agricultural practices for farmers (for example the use of quality fertilizers), good infrastructures (for example reliable roads and systems to help in the transportation of crops) and good weather for cultivating crops.

Apart from that, rural farmers and crop buyers (especially the old people) should be equipped with proper training and skills on how to use these SMS and WEB based systems in order to help them to use these systems effectively.

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