SMS Based Agricultural Information System for Rural Farmers

Alemu Kumilachew Tegegnie(✉), Tekeste Demessie Dagne, and Tamir Anteneh Alemu

Faculty of Computing, Bahirdar institute of Technology (BiT), Bahirdar University, Bahirdar, Ethiopia
alemupilatose@gmail.com, lolteke@gmail.com, tamirat.1216@gmail.com

Abstract. Agriculture is the back bone of Ethiopia's economy. Despite the strength and volume of agriculture related information and training available through Ethiopia's vast public extension system, ensuring farmers receive up-to-date data and knowledge in a timely, complete and quality manner remains a great challenge. The existing practice for delivering agricultural information through agricultural extension officers, farmer-to-farmer visit and mass Medias couldn't satisfy the information needs of rural farmers. This is attributed by few numbers of extension officers, budget bottle neck and absence of electricity and network. This paper presents a SMS based agricultural information system (SMSbAIS) aimed to solve such challenges in agricultural sector. The SMSbAIS was developed based on a conceptual framework, developed during the course of this research, is used as a platform where rural farmers and agricultural extension officers can get agricultural knowledge service, request agricultural information and supply any information that demands the intervention of higher agricultural officers. It helps users not only to request for agricultural information; it also used to deliver such information to the hands of users via their mobile phones. The system is developed using Rapid Application Development (RAD) methodology with a series of iterative development and testing is done based on System Usability Scale (SUS) method. Testing and evaluation is targeted the systems usability, accuracy and performance. Therefore, it was found that on the SUS scale that ranges from 0 to 100, the system scored 87.6 with feedback from 20 users. The Query Understanding engine (QUE) accurately translated 90% of all incoming user requests. The mean average response system time is found to be 3.34 s. These results show that problem of lack of appropriate and easily accessible agricultural information can be solved using a system like the one developed in this research based on a framework that seeks solutions to challenges faced in accessing agricultural information in rural community.

Keywords: Agricultural information · Agricultural knowledge service · SMS · SMS based agricultural information system · Rural farmer · Usability

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1 Introduction

Agriculture is the back bone of Ethiopia's Economy. More than 80% of the country's Population employed in this sector [1]. Agriculture constitutes products of the major key resources such as land, livestock, plants, water and minerals. The sector is dominated by agrarian society (largely small-scale farmers).

Accelerating agricultural growth in Ethiopia has wide-ranging impacts beyond smallholder farmers and rural development. Little has been done to transform the peasants' in Ethiopian agriculture information system [2, 3]. Despite the strength and volume of agriculture related information and training available through Ethiopia's vast public extension system, ensuring farmers receive up-to-date data and knowledge in a timely manner remains a great challenge.

ICT in Ethiopia is acknowledged as having the potential to accelerate the socio-economic development of the country. However, the area is dominated by traditional practice of agricultural information system such as farmer-to-farmer visit, meetings, broadcasting special programs via mass media, etc., along with insufficient budget and little modern practices that lead to a tremendous bottle neck in the area. One of the perceived benefits of modern ICT is greater access to information on farm related information which has an impact in improving the capability of farmers for effective cultivation and reduction farm related disease.

Agricultural information system can facilitate an effective knowledge service for supporting the farmers in problem-solving, decision making, and early warning through the application of mobile phones. They are an essential tool for sustainable economic development in the area of agriculture thorough providing effective communication in the areas of travel, harvesting, productivity, and understanding of market analysis [4–6]. Providing real-time agricultural information using SMS (Short Message Service) text messaging via mobile phones can be used to deliver shorter often time critical messages. SMS is a better way for giving knowledge service, especially automatic interchange of short text messages, by providing the information from an automatic agricultural information system. A system for the bulk distribution of these text messages can be send to targeted farmers to notify important weather, proactive alerts, seasonal agriculture information and other farm cultivation tips. Besides the agricultural knowledge service, the system shall notify farmers with the possible occurrence of a plant and crop disease, pest, sudden flood, unseasonal rain, wind, drought, crop harvestation, preparedness, and other warning notifications.

In an effort to address the aforementioned issues, this research project is aimed investigate the possibilities and evaluation of designing and developing SMS based agricultural information system platform that enables the stakeholders of the agricultural sector share agricultural information.

2 Related Work

2.1 Overview of Mobile (SMS) Based Information System

The Short Message Service (SMS) allows text-based messages to be sent to and from Mobile phones on a GSM network. The applications of SMS based systems are getting a prior choice in Africa due to the fact that there is poor and inadequate telecom infrastructure that does not entertain voice and IP services [7]. Unlike voice and IP services, SMS is a ‘best effort service’ in which a message can get through even when the ‘network is busy’ for hours or when there is not enough free capacity in the network.

SMS based systems can be applied for services that require instant messaging to the consumer which have varied set of objectives from providing market price information for national planning to government institutions to providing information for monitoring of household livelihoods to donors funding various interventions. Such systems has been becoming increasingly popular in developed countries and some of African countries in which the information system content management is done in local language via SMS on mobile phones. Various applications developed showed that SMS messaging has shown great potential in Africa. FAMIS in COMESA region; RATIN in East Africa; ESOKO in Ghana and MFARM in Kenya [7, 8] are some of the mentioned mobile (SMS) based applications.

2.2 SMS Based Systems in the Case of Ethiopia

Mobile phones have recently started being used in Ethiopia for sending SMS-based information through a mobile phone. It has been used by organization for promotion, announcement, collecting funds, and sending comments [9]. Full-fledged mobile (SMS) based systems are rare except a little effort by Commercial Bank of Ethiopia (CBE) and Ethiopian Agricultural Transformation Agency (ATA).

SMS (USSD) Banking, Commercial Bank of Ethiopia (CBE). The recently started CBE’s Mobile Banking (MB) services enable you to access your bank accounts, make fund transfers, payments and balance inquiries as well as get instant notifications on all your accounts linked with MB services-using the SMS, XHTML and DOWNLOADABLE application channels.

8028- Hotline IVR System by Agricultural Transformation Agency (ATA). To ensure farmers receive up-to-date data and agricultural knowledge service in real time, ATA is initiated and developed an Interactive Voice Response (IVR) platform to deliver information directly to farmers through mobile phones [10]. However, significant calls and callers has been becoming increasing after the service is launched, the delivery of the service content is still a bottleneck. The usability issue of the system is also in question for several reasons. First, long list procedure of user registration process and selection of menus to get a customized content delivery is also tiresome. Second, a farmer is just only forced to listen to the computer voice (one way communication, no way to speak back). Third, it is not possible to get the service offline. Currently a computer voice is not downloaded into your handset and won’t be able to play back.

Even if, we can provide a record-and-play back service, it is not suitable for all kinds of mobile handsets. Lastly, even though, the system can provide different statistics (e.g. the number of callers), it is impossible to evaluate its usability and satisfaction of the user, i.e. critical input to extend/improve the services. This study used the 8028 hotline IVR system as an initial bench mark to design and develop the system.

3 Design of the Study

3.1 Research Methodology

Population. The population included mobile service provider (Ethio telecom), farmers, extension officers, agricultural and system experts. This choice has been made as it affects the objective of the study and this group of people was interviewed for data collection.

Sampling Size and Technique. As a research comprises farmers and extension officers, system and agricultural experts, a purposely selected 20 participants of which (ten rural farmers, two agricultural knowledge experts, five agricultural extension officers, and three system experts) are included in this study. The selection is influenced by the knowledge and experience they had and the accessibility of those people by the researcher.

Data Source. The data source constituted ethio-telecom, software companies, agricultural research institutes, Agricultural Bureau and ministry of Agriculture.

Data Collection Methods. The relevant data is collected using interview and questionnaire method. The questions that respondents were asked (or tried to filled) were based on SUS (System Usability Scale) method developed by Brooke in 1986 [11]. Queries sent in and responses sent out were recorded in the database are collected and used for data analysis.

Experimental Setup and Evaluation Procedures. The development process of a prototype system is passed through a series of iteration. Different version of a system is produced at each level of iteration and usability testing is made for each version by technical and end users using SUS method. They were interviewed and their responses used to fill a System Usability Scale (SUS) as shown in Table 1. Individual SUS score is determined from each individual response using SUS method as shown in Eq. 1. The sum of the whole respondents SUS value is used for average SUS value calculation using Eq. 2. Meanwhile, the conceptual design (architecture) of the system is re-designed at each iteration and a final version is drawn.
To calculate the SUS score, first sum the score contributions from each item. Each item's score contribution will range from 0 to 4. For items 1, 3, 5, 7 and 9 the score contribution is the scale position minus 1. For items 2, 4, 6, 8 and 10, the contribution is 5 minus the scale position. Next, the summation is multiplied by 2.5. This raises the possible values from 0, to 40 to a new scale of 0, to 100.

Table 1. System Usability Scale (SUS)

		Strongly disagree			Strongly agree	
		1	2	3	4	5
1	I think that I would like to use the 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					

SUS method for one respondent

$$2.5\sum((\times^{+ve}-1)+(5-\times^{-ve})) \tag{1}$$

SUS value for the whole respondent,

$$\frac{\sum_{n=1}^{n} 2.5\sum((\times^{+ve}-1)+(5-\times^{-ve}))}{n} \tag{2}$$

Determining the accuracy of the system is done by measuring how many of queries sent by users are correctly understood by the Query Understanding Engine (QUE) and correct responses are sent to the user, as follows.

$$Accuracy = \frac{the\ number\ of\ correct\ responses\ determined\ by\ the\ system}{the\ number\ of\ expected\ responses\ stored\ in\ the\ database} \tag{3}$$

In the other hand, system performance testing is done for functional and non-functional system modules and speed. Functional and non-functional performance testing is done in the lab by the researcher together with system experts. Whereas, speed testing is evaluated by measuring the amount of time taken by the system to process user queries (inputs) and corresponding responses sent to the user. The response time is recorded for each user interacting in three of the system modules. Since users interacted with a system a number of times, different time statistics is measured. Hence, average of the maximum registered time, average of the minimum registered time, and the average of these two are computed and used as a system's response time. The minimum (mt) and maximum (Mt) response time is labeled by the researcher after computing mean average response time (at) as follows.

$$\begin{aligned} min.time\,(mt) &= any\,time\,(T)\; < \; Avg.Res.time\,(at) \\ Max.time\,(Mt) &= any\,time\,(T)\; \geq \; Avg.Res.time\,(at) \end{aligned} \tag{4}$$

Development Tool and Methodology. The system was developed using Rapid Application Development (RAD) methodology with iterative development and testing done. Choosing RAD as opposed to other methodologies is due to the fact that it is fast and less error prone. GlassFish server and Java Programming Language are selected for programming tool due to its familiarity with the researchers.

3.2 Design of the System

Overview. In going about this research project, a systematic approach was followed. To achieve the research objectives, applications which are accessed and run on the user mobile were considered and studied comparatively. Together with this, the major impediments to achieving a usable, affordable and accessible system were analyzed. To design and develop the system, a conceptual framework that guides the development of the system is developed considering major impediments.

The developed system consisted of key functional modules which include Query Understanding Engine (QUE), SMS gateway, database and web interface. The system is attempted to handle five major activities within this module: user registration, message broadcasting, Broadcast message to multiple users, handle system driven AIS services, maintain incoming SMS into database, and perform Automatic Request Response (ARR) as shown in Fig. 1.

Testing and Evaluation was done at each series (version) of the development and final version of the prototype system using two methods: using M-choice SMS/USSD simulator software and temporarily hosting a final version on Ethio-Telecom server. M-choice similar is used for functional test; whereas, the later is used for practical testing and evaluation of the system's usability, accuracy and performance (speed) using standard mobiles and smart phones.

Design of the Interaction. The system involves the key system functional modules, system functions and actors who use these functions as shown in Fig. 2.

Conceptual Framework. In order to addresses the challenges mentioned in earlier sections, a conceptual framework was formulated that guides the design and development of SMSbAIS. Pictorial representation of the framework is shown in Fig. 3.

Accessibility entails the availability of ubiquitous media in which rural farmers in Ethiopia to have reach of systems that avail agricultural information to them. Agricultural services should be tailored to local languages where majority of the population speaks. This framework prioritizes a more flexible syntax where users can send in SMS using a preset syntax or using a natural question asking format. Such kinds of systems

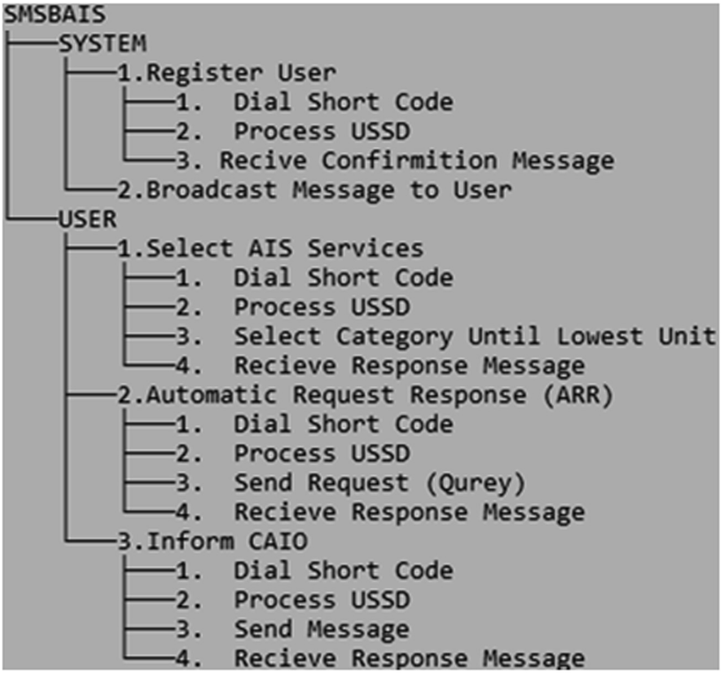

Fig. 1. Functional decomposition of the SMSbAIS

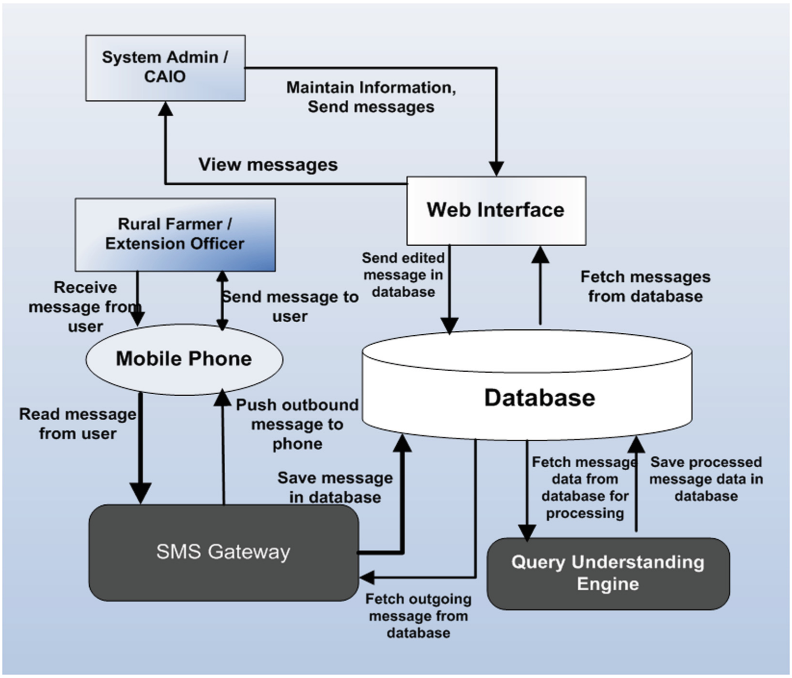

Fig. 2. Actors, functions, and functional modules of the system

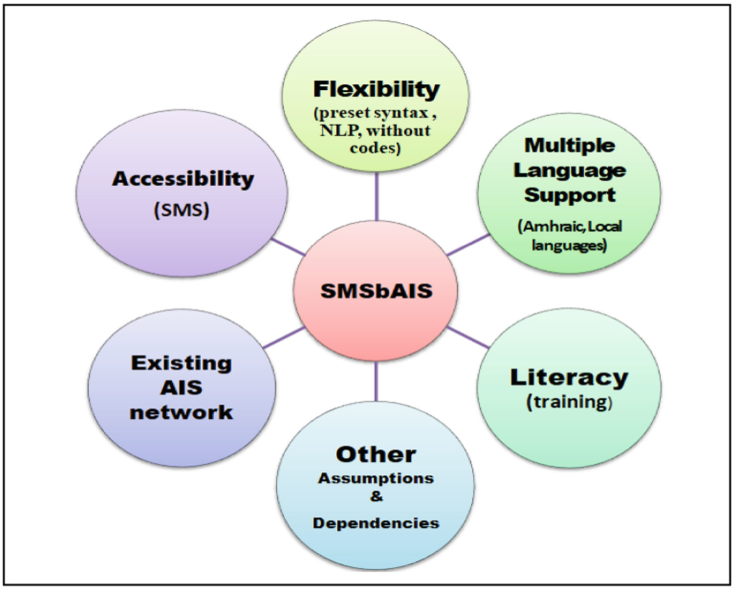

Fig. 3. SMSbAIS Conceptual framework

require basic literacy skills: reading and writing in their own languages. The framework assumed the existing AIS model rural community in Ethiopia.

Architectural Design of the System. An agricultural information system can be constructed based on a mobile platform to send and receive short agricultural messages and also receive expert advice through agriculture expert knowledgebase. Figure 4 depicts the proposed architectural for SMS based Agricultural information system.

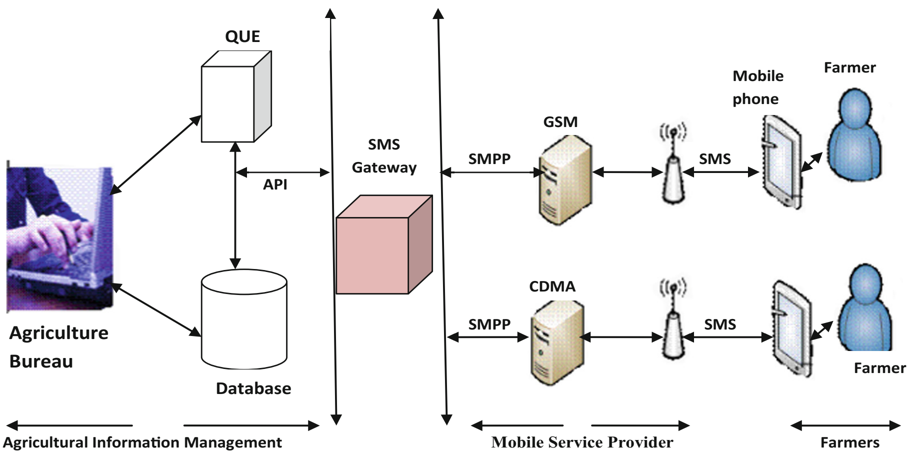

Fig. 4. Architectural design for SMS based Agricultural Information System (SMSbAIS)

The Prototype System. SMSbAIS is designed provide both push and pull services. Push services are just broadcasting SMS, where messages will be automatically sent to you based on pre-set criteria. Whereas, pull services are services given on demand/request, where you can extract information by texting us the codes. Each function of the system has facilities that help a user back to the previous option and/or automatically end the interaction using * and # keys respectively. Figure 5 depicts major services of the prototype system, identified as pull services. Once, a user has got registered, he/she can access to the system and would get services labeled 2, 3 & 4.

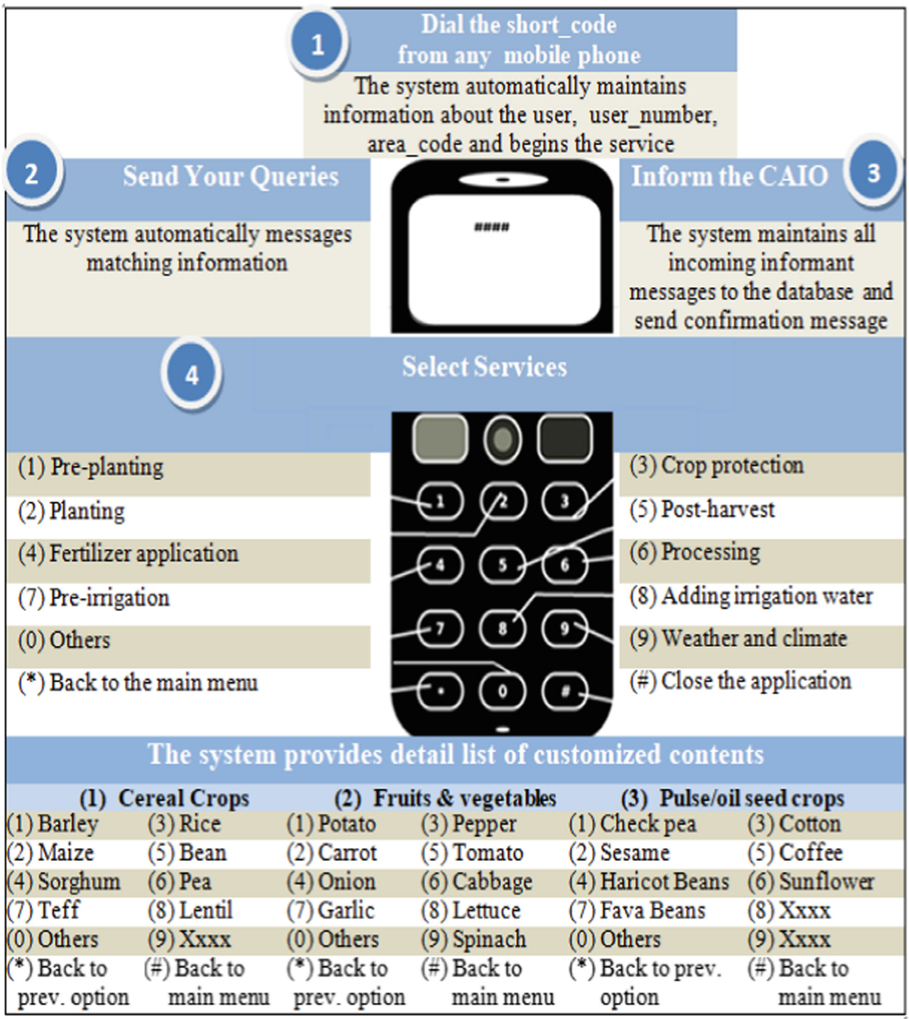

Fig. 5. Overview of SMSbAIS service structure

4 Results and Discussions

Attainment of the objectives set in this research was measured by analyzing data collected using the questionnaire and data generated from the database. The evaluation is made via testing the system based on its usability, accuracy, performance and meeting its research objectives.

4.1 Usability Testing

The collected data is analyzed using the standard SUS formula as shown in Eqs. (1 & 2). Use of the SUS for analyzing usability encompasses all aspects of the system that determined usability performance such as effectiveness, efficiency, user satisfaction, user perception and overall ease of use. Figure 6 shows average SUS score obtained during each iteration of the prototype system from a total of 20 respondents involved in a total of 8 iterations. This gives a total of 200 responses in a single iteration, i.e. 1600 responses in all iterations. The average SUS score is found to be optimal (87.6) during the 5th iteration. Then after, these values have shown a very slight difference because of the fact that the respondents didn't find significant differences and believed to feel the same level of satisfaction and ease of use during the interaction; and because of these they have given the same rating as that of the fifth iteration.

As can be seen from Fig. 6, different version of the system is obtained. The fifth iteration scored the highest SUS score value. In addition, this version of the prototype system gained the highest level of user during the experiment. Because of this fact the system experts and the researchers selected the 5th version as a final version system.

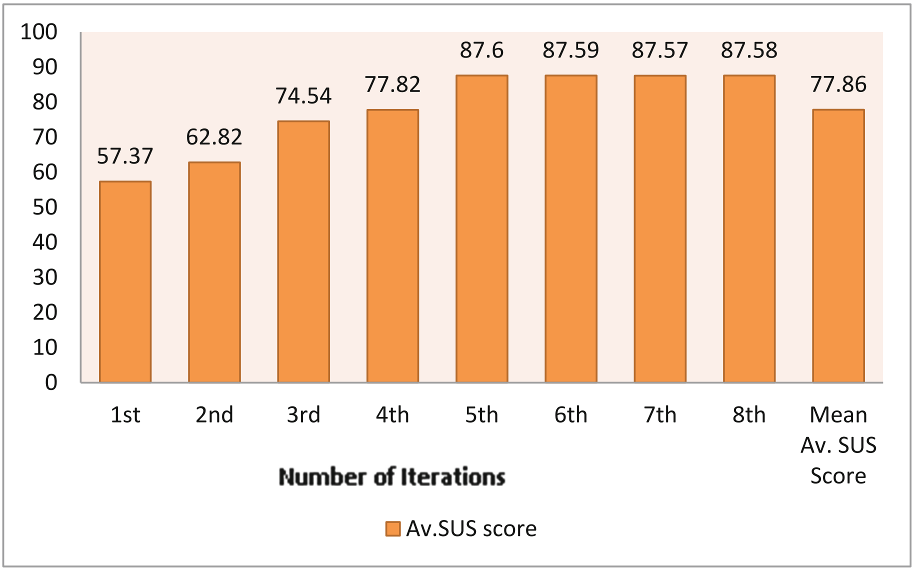

Fig. 6. Average SUS score distribution for 8 consecutive iterations

The remaining measurements done in this experiment was done using this version. Table 2 below shows detail SUS results of the final version.

Table 2. Detail results of SUS score for 20 participants

Participant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS score
p1	5	1	5	1	5	1	3	1	4	1	92.5
p2	4	1	5	2	5	1	4	1	3	2	85.0
p3	5	1	4	1	4	1	5	1	5	3	90.0
p4	5	2	5	1	5	2	5	2	4	1	90.0
p5	5	1	5	1	5	1	4	2	5	2	92.5
p6	4	1	5	1	4	1	5	1	4	2	90.0
p7	5	3	4	1	3	2	4	1	5	2	80.0
p8	5	1	5	1	5	1	5	2	5	1	97.5
p9	5	1	5	2	4	2	4	1	4	1	87.5
p10	4	2	5	1	5	2	5	1	5	2	90.0
p11	5	1	5	2	5	3	5	1	4	1	90.0
p12	4	2	4	1	3	1	4	1	3	2	77.5
p13	5	1	5	2	5	2	4	1	4	1	90.0
p14	4	1	4	1	4	1	4	2	5	2	85.0
p15	5	2	4	2	5	1	5	1	4	1	90.0
p16	4	1	5	1	4	2	4	2	5	3	82.5
p17	5	2	4	1	3	1	5	1	4	1	87.5
p18	5	1	5	2	4	2	4	1	3	1	85.0
p19	4	2	5	1	5	1	3	1	4	1	87.5
p20	5	1	5	2	3	2	5	1	3	2	82.5
					Avg. SUS score						**87.6**

The average acceptable usability is SUS score of 68. A SUS score above a 68 would be considered above average and anything below 68 is below average [12]. Table 3 shows the general guideline on the interpretation of SUS score. Based to the guideline, the usability of this system is found be Grade A and is has given 'excellent' rate.

Table 3. General guideline for SUS score

SUS score	Grade	Adjective rating	Recommendation
>80.3	A	Excellent	Users are more likely to be recommending the product to a friend
68–80.3	B	Good	You're doing OK but could improve
68	C	Okay	
51–68	D	Poor	
<51	F	Awful	Make usability your priority now and fix this fast

4.2 Accuracy

Analyzing for accuracy of system in understanding queries was done by comparing responses of the system to expected responses. For a total of 150 messages, the system accurately responded to 135 messages. The other 15 messages were not accurately understood, it requires human touch.

$$Accuracy = \frac{135}{150} \times 100\% = 90\%$$

4.3 Performance Testing

An interaction log file that involves that amount of time taken by the system (server) is generated and used to analyze the performance (speed) of the system with respect to users' request. Testing involves for all three of the system modules (services). Table 4 shows the time statistics (generated based on Eq. 4) used by the system during interaction with the user for the given services. Hence, the average response time for 20 participants is found to be 3.09, 3.26 and 3.65 s for Inform CAIO, AIS services and ARR respectively. The average response time for ARR services is significantly higher than the other services since the ARR undergoes further transactions and process that require searching and matching.

As it can be shown from Table 4, each test contains average maximum or minimum response time for each system service from which mean average response time (more representative time) is calculated. These values are collected from a minimum of 15 transactions of the first 20 users in the database for the period of three weeks.

Figure 7 below shows the distribution of mean average response time for each system service. It re-assured that ARR service take more time to respond to user requests for the explained reason. The mean average response time value is taken as the

Table 4. The average response time for each functional module

Test	Inform CAIO			AIS services			ARR		
	Avg. Max Res. Time	Avg. Min Res. Time	Mean Avg.	Avg. Max Res. Time	Avg. Min Res. Time	Mean Avg.	Avg. Max Res. Time	Avg. Min Res. Time	Mean Avg.
p1	3.27	2.64	2.96	3.11	2.96	3.04	4.23	3.06	3.65
p2	3.46	2.71	3.09	3.65	2.89	3.27	4.06	3.65	3.86
p3	4.23	3.01	3.62	3.21	2.69	2.95	3.97	3.06	3.52
p4	3.59	2.41	3.00	4.09	3.12	3.61	3.85	2.89	3.37
p5	3.78	2.35	3.07	4.23	3.01	3.62	4.12	3.25	3.69
p6	3.47	2.01	2.74	3.62	3	3.31	3.76	3.09	3.43
p7	4.09	3.21	3.65	3.99	2.36	3.18	4.23	3.69	3.96
p8	3.21	2.09	2.65	4.03	2.45	3.24	3.96	3.16	3.56

(*continued*)

Table 4. (*continued*)

Test	Inform CAIO			AIS services			ARR		
	Avg. Max Res. Time	Avg. Min Res. Time	Mean Avg.	Avg. Max Res. Time	Avg. Min Res. Time	Mean Avg.	Avg. Max Res. Time	Avg. Min Res. Time	Mean Avg.
p9	3.98	2.13	3.06	3.21	2.17	2.69	4.02	3.57	3.80
p10	4.06	3.34	3.70	3.69	2.36	3.03	4.96	3.89	4.43
p11	3.07	2.46	2.77	3.98	2.26	3.12	4.75	3.21	3.98
p12	3.56	2.94	3.25	3.96	2.65	3.31	3.65	2.79	3.22
p13	3.49	2.67	3.08	4.03	3.01	3.52	3.76	2.86	3.31
p14	3.67	2.46	3.07	3.67	2.99	3.33	3.94	3.01	3.48
p15	4.03	2.79	3.41	3.94	2.98	3.46	3.12	2.56	2.84
p16	3.26	2.54	2.90	3.91	3.21	3.56	3.73	2.79	3.26
p17	3.04	2.06	2.55	3.64	3.01	3.33	4.67	3.67	4.17
p18	3.40	2.41	2.91	4.79	2.09	3.44	4.79	3.29	4.04
p19	3.58	2.34	2.96	4.35	2.04	3.20	3.65	2.79	3.22
p20	3.73	3.01	3.37	3.86	2.17	3.02	4.89	3.77	4.33
Avg	**3.60**	**2.56**	**3.09**	**3.85**	**2.67**	**3.26**	**4.11**	**3.20**	**3.65**

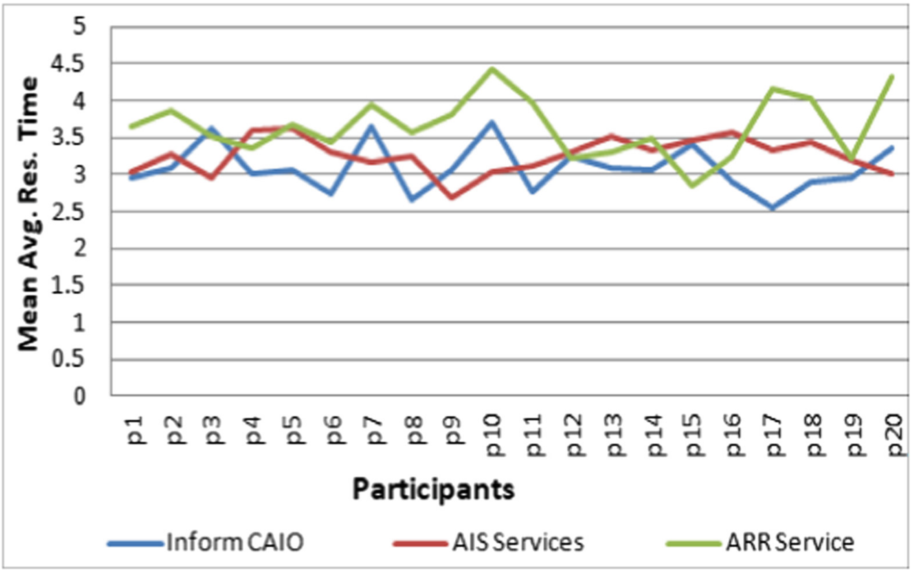

Fig. 7. Mean average response time distribution for system services among 20 users

performance (speed) of the system, which is calculated from the final mean average response time value of the three services (3.09, 3.26 & 3.65 respectively). Therefore, the results found to be 3.34 and it is promising. With further optimization, the system could perform even better.

5 Conclusion and Recommendation

Mobile SMS is a potential solution in that to get the information flow faster and correctly; deliver the right information to the right user; and address effective information with minimum cost and effort. An SMS based agricultural information system built using a framework (developed during the course of this research) that addressed specific challenges faced by rural farmers is possible and meet its objectives. The results of the experimentation show that problem of lack of appropriate and easily accessible agricultural information can be solved using a system like the one developed in this research by following a framework that targets solutions to challenges faced in accessing agricultural information in rural community. The researcher highly recommended future researchers in areas of inclusion of additional languages, enhancement of query understanding engine and learning. Accepting user replies (inputs) using a natural language (e.g. speech) for ARR and Inform CAIO services are also recommended for further work.

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