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# A Multilingual Translation System for Enhancing Agricultural e-Extension Services Delivery

Muhammad Bashir Abdullahi[1], Ibrahim Shehi Shehu[2], and Yahaya Mohammed Sani[3]
Department of Computer Science, Federal University of Technology, Minna, Nigeria
{[1]el.bashir02, [2]ibrahim.shehu} @futminna.edu.ng, [3]saniyahaya84@yahoo.com

***Abstract*—Agricultural extension is the application of new knowledge and scientific research findings to agricultural practices through farmer education. As a result, agricultural extension agents or workers are people from government research institutes who educate or pass on information to farmers on how to use the new knowledge and scientific research findings. However, the conventional method of communicating the agricultural research outputs or findings to farmers through only face-to-face meeting has many challenges such as geographic dispersion between farmers and extension workers, poor communication capacity, poor transportation facilities, bad roads, inadequate funding and dialectical problems, which create great problems to effective communication of agricultural information to farmers. Furthermore, this mode cannot adequately handle urgent (time bound) information that should circulate within the farming populace. In this paper, a multilingual translation system was developed to enhance agricultural e-extension services delivery. The system employs a serial integration of rule-based and statistical machine translation techniques to translate agricultural information or scientific research findings from the extension workers in English (source language) into farmer's registered native or preferred language. Four (4) target languages were considered, which include Arabic, Hausa, Ibo and Yoruba. The system was implemented using Per Hypertext Processor (PHP) language version 5.3.5 and Structured Query Language (MySQL) version 5.0.2. The system integration test shows 65% accuracy in translating research outputs in English to farmer's registered native language. It is therefore recommended that the implemented system be adopted for its efficiency and accessibility in enhancing agricultural e-extension services delivery.**

***Keywords-language translation; agriculture; e-extension services; farmers; information system***

## I. INTRODUCTION

Extension agents or workers are people who possess an acceptable level of edification, engaged by government to bridge the fissure connecting the government and the farmers in terms of agricultural services. These groups of people educate or pass on information to farmers on how to use information derived from government research institutes. Such information empowers farmers to take control over decision-making processes and resources for increased productivity [1]. More so, the various roles and contributions that policy makers and extension workers continue to make in the current food production cannot be down played.

An effective agricultural extension depends on how fast and useful the extension services reach or meet the farmer's information need. Thus, it is likely that the farmers benefit from agricultural research findings with the eventual goal of improving agricultural productivity.

Unfortunately, in most developing countries today, extension agents still depend largely on traditional extension approaches of transmitting agricultural information to farmers. The traditional approaches of communication are classified as one-way multipurpose and two-way multipurpose sources. The one-way multipurpose sources include: television, radio, public campaign, leaflet, pamphlet, newspapers and magazines. While the two-way multipurpose communication sources include: village fairs, field demonstrations, trainings and study tours. Also included in this category are: extension workers, private agencies, para-technicians, farm input dealers, non-governmental organizations (NGOs), credit agencies, fellow progressive farmers, output buyers/food processors and primary cooperative societies [2],[3],[4].

These sources of transmitting agricultural information to farmers are no longer effectual for urgent agricultural research findings needed by farmers. However, the rising face up to farmers in this new millennium is how to manage with the information explosion and global trend in agro-technology. There is the need therefore, for inter-related systems to diffuse information and technological innovations to farming populace in developing countries [5].

In addition to the identified problems, farmers are even more confronted with myriads of challenges now than ever before in relation to information generation and communication, which is as a result of lack of sufficient agricultural knowledge and information that will enhance farmer's participation, collaboration, and integration in agricultural decision making processes. Also, lack of investment from other agricultural stakeholders, for example, government agro-allied industries, and non-governmental organizations have lead to low output in both production and sustainability. It is also arguable that farmers' illiteracy in Information and Communication Technology (ICT) is so high in the rural areas as most of the farmers lack access to agricultural technology, innovations and education. There exists also (i) dialectical disparity in which the research findings are communicated, (ii) near absence of training and re-training of both the extension workers and farmers on new innovations [6], and (iii) ineffective ICT policies that are targeted towards empowering farmers via the deployment of ICT tools and even where they are available; there is poor access and reception.

Finally, the present understanding of Agricultural extension is supporting people engaged in agricultural production by facilitating, empowering and linking them to markets and other players in the agricultural value chain; to obtain information, skills and technologies to solve their problems [7].

The remainder of this paper is organized as follows: section 2 presents the related work. Section 3 describes the research methodology used. The results and discussion of the system testing and evaluation were presented in section 4. Section 5 gives the concluding remarks.

## II. RELATED WORK

### A. Machine Translation

Machine Translation (MT) is one of the most essential applications of computational linguistics that uses the computer software or web application to translate text from one language to another. One of the benefits of machine translation is that it helps people to understand an unknown language without the aid of a human translator. However, MT is often perceived as low quality based on outdated perception created by its use of older translation technologies or freely available generic translation tools from Google or Bing that have not been customized for a specific purpose [8]. Many technology advances have been made in recent years that are changing this perception with customized machine translation engines [8].

### B. Machine Language Translation Techniques

A few different types of machine translation are available in the market today. According to [9] the most widely used techniques include: Statistical Machine Translation (SMT), Rule-Based Machine Translation (RBMT), and Hybrid Machine Translation, which combine RBMT and SMT. These techniques are briefly explained as follows [9]:

*1) Rule-Based Machine Translation (RBMT) Technique:* The RBMT relies on countless built-in linguistic rules and millions of bilingual dictionaries for each language pair. The RBMT system parses text and creates a transitional representation from which the text in the target language is generated. This process requires extensive lexicons with morphological, syntactic, and semantic information, and large sets of rules. The software uses these complex rule sets and then transfers the grammatical structure of the source language into the target language. [9]. There are no human interventions during the conversion from one language to another language. Human intervention only takes place, if at all, after translation to manually correct errors in the machine translation output.

*2) Statistical Machine Translation (SMT) Technique:* The SMT is a corpus based approach, where translation is generated on the basis of statistical models whose parameters are derived from the analysis of bilingual text corpora [9]. A massive parallel corpus is required for training the SMT systems. The SMT systems are built based on two probabilistic models: language model and translation model [9]. The merit of SMT system is that linguistic knowledge is not a requisite for building the system. The complexity in SMT system is creating massive parallel corpus.

*3) Hybrid Machine Translation (HMT) Technique:* HMT was built owing to the drawbacks of the two approaches and their prospect to be integrated [9]. Statistical and Rule-Based are two MT techniques, whose methods of translation are orthogonal to one another. SMT do not need to learn about the language at all, but RBMT is based on gathering language rules. Due to this difference, integrating or hybridizing SMT and RBMT gives a better performance. The hybrid technique can be used in a number of different ways. In some cases, translations are performed in the first stage using a rule-based approach followed by adjusting or correcting the output using statistical approach. In the other way, rules are used to pre-process the input data as well as post-process the statistical output of a statistical-based translation. This technique is better than the previous two and has more power, flexibility, and control in translation [9],[10].

### C. Review of Existing E-Extension Services Delivery Systems

Kalna-Dubinyuk [11] developed an electronic extension service in Ukraine using extension service model that links Ukraine’s extension service system and the outside world. This system has developed the market economy in Ukraine and moves forward in increasing the number of farmers and the formation of new forms of agricultural business entities. The major constraint of this system is that it only capitalizes on the market economy of agricultural produce and ignores agro-technology innovation and adaptation.

A mobile-based Agricultural Extension System was developed by [12] in Tanzania called M-FAIS (that is Mobile Phone Farmers Advisory Information System). The system was designed using a GSM modem and Independent Service Architecture (ISA). The research finding shows that the M-FAIS allows farmers to get advice in various agricultural issues such as agronomic practices, livestock husbandry, post-harvest operations, veterinary services, forestry, financial and market support services. The system depends on third party software (Serial Splitter) for sending and receiving short messaging service (SMS) operations. This makes its use on public domain vulnerable to malicious attack.

An implementation of e-extension system that uses mobile phones for knowledge sharing was done by [13]. It uses social network tools to share quick and instant information. It maximizes the use of information and communication technology to attain a modernize aquaculture sector. It also focuses on creating an electronic and interactive bridge where farmers, fishers, and other stakeholders rally and transact to enhance productivity, profitability and global competitiveness. The shortcoming of this system is that not all farmers have internet access and ICT literacy to operate in the social media.

An ICT-based agricultural extension service delivery system was proposed for Nigeria by [14]. The system is to be used in agriculture center(s) in village(s) where extension service is required. The purpose is to stimulate farmers driven extension; by allowing farmers to request for guidance and assistance based on their unique needs. However, it does not adopt the use of phone-based application and not all farmers have access to internet in the rural communities, even where the facilities are available.

E-sagu was implemented by [15]. It is a web-based agricultural expert advice dissemination system, which farmers can use to send a digital photograph of their problems to an agricultural expert. The role of extension agent is excluded on the system since the agricultural expert has direct link with the farmers and knows about their problems. The shortcoming of this system is however that of dialectical problem.

Shrikant and Shinde [16] developed a web-based information and advisory system for agriculture using software engineering's classic life cycle method. Classic life cycle is also called linear sequential model and it is a widely used paradigm for system development. The system provides farmers with relevant and updated crop information. The information it provides is restricted to crops. Information regarding Livestock, market and weather are not provided by this system. In addition, not all farmers can have access to web-based facilities, since in many rural communities, where majority of the farmers reside, have no internet facilities.

E-agriculture framework was developed by [17]. The framework proposes an implementation of an e-farming system that can be used in aiding sustainable agricultural farming practices. The incorporation of IT into farming involves the integration of diverse technologies, with each capable of positively impacting the efficiency of farming activities, thereby, promoting sustainability in agricultural practices. This framework has overcome farmers' literacy level problems since the framework proposed is meant to compliment and replace the traditional extension services delivery. The major limitation of this framework is that language translation from source language of the agricultural information to the target local language understood by the rural farmers is not taken in to account.

## III. RESEARCH METHODOLOGY

### A. *Multilingual Translation System*

The proposed multilingual translation system is based on the hybrid machine translation technique, which is a serial integration of the rule-based and statistical machine translation techniques. It is designed to translate source text from English language into any of the four preferred target languages: Arabic, Hausa, Ibo and Yoruba. The operational process of the multilingual translation system, as shown in Fig 1, is divided into six modules: deforming and pre-editing, analysis, transfer, generation, reforming and post-editing, and statistical error checking. These modules are explained as follows:

*1) Start:* This is the beginning of the process.

*2) Input Text:* When a source text/sentence (in English language) of Agricultural Information (AI) is entered as input, the following process ensued:

*3) Deforming and Pre-Editing:* This is a preprocessing module. In this module, deforming is performed as a process in which the machine checks the part of the source AI text/sentence that does not require translation such as pictures, figures, diagrams and identifies only the portion of the source text/sentence that can be translated. Similarly, pre-editing involves fixing up the punctuation marks that does not require translation. This is to make the machine language translation of the AI easier, faster and efficient.

*4) Analysis:* In this module, the source text of AI is analyzed based on the linguistic information provided to produce a complete parsing of a source language sentence. Thus, it comprises of two components: tagger and parser.

*a) Tagger:* This component identifies the linguistic property of individual word of AI in the source text through the following processes:

(i) *Morphological Analysis:* This aspect determines the form of AI word such as number, tense or part of speech (POS) tagger.

(ii) *Syntactic Analysis:* This determines whether AI words are subject verb or object.

*b) Parser:* This component breaks AI words/sentence into smaller elements, according to a set of linguistic rules that describe its structure through semantic and contextual analysis which determines the proper interpretation of AI text/sentence from the result produced by syntactic analysis. This is achieved by using lexical and semantic analyzer created by parser.

*5) Transfer:* In this module, the syntactic/semantic structure of the AI source text is then moved in to the syntactic/semantic structure of the AI target languages.

*6) Generation:* In this module, lexical transfer (the mapping of a source-language lexical item with an equivalent target-language item) occurs and mapping dictionary entries into appropriate inflected forms to yield a target-language equivalent term. This is achieved using Arabic lexicon, Hausa lexicon, Ibo lexicon and Yoruba lexicon to ensure proper interpretation.

*7) Reforming and Post-Editing:* This is a post-processing module. In this module, once the AI text is translated, the target text is reformed after post-editing. This involves re-incorporation of non-translated portion of the source AI to target text for quality and adequate target AI to be disseminated to famers.

*8) Statistical Error Checking:* In this module, to ensure accurate grammatical matching of the target output produced by the rule-based approach into its statistical approach equivalent. Translation error checking is done to ensure good quality translation of the target texts of the AI. But in a situation where the rule-based translation technique does not correspond with its statistical machine translation equivalent, a decision is taken to consider another set of linguistic rules starting through the analysis, transfer down to the generation stage using the rule-based technique until the target text matches that of statistical based target text.

9) *Output Text:* The output target texts/sentences are the proper and accurate equivalent translation of the source AI text (English) in to target AI texts (that is Arabic, Hausa, Ibo or Yoruba) meant to reach the farmers according to their registered target languages with the AEA.

10) *Stop:* This mark the end of the process.

### *B. System Framework Design*

The proposed framework for a multilingual translation system to enhance agricultural e-extension services delivery is shown in Fig. 2. The system connects three major stakeholders of an agricultural extension services namely the farmer, researcher/expert and agricultural extension agent. The role of each stakeholder is explained as follows:

1) *Researcher/Expert:* This stakeholder provides critical research output in response to specific needs of the farmers. The research output cut across different aspect of farming including crop farming, livestock farming and the rest. Whenever a research request get to the research institute, it is handled by an expert in the area requested who after his findings relays a feedback through extension agents to farmers. In this system, the researcher/expert login to the system, read information/research request and communicate research request and finding to the AEA. The medium of communication between the researcher and AEA is through the web and their language of communication is English.

2) *Agricultural Extension Agent (AEA):* This is a trained expert who serves as a link between the farmers, research institute and farm input firms. They convey information responsive to the requirement of any component in the system. The AEA usually pay regular visit to farmers, interact with them in order to know their problems and concerns and then send it to an expert requesting for a solution. The functions of the AEA in this system includes login, update of information, register and manage farmers, send updates of agro information via SMS to farmers and also send research request to researcher/expert. In addition, the AEA interact with researcher through the web-based system and send agro information to farmers from the system to their mobile phones (it could be ordinary phones or android phones).

3) *Farmers:* This is the consumer of agricultural information. This is the component that receives agricultural information from research institutes and farm input firms via agricultural extension agent relevant to their farming requirement(s). This is because timely delivery of agricultural information to farmers means empowerment to them. The multilingual translation system for enhancing agricultural e-extension services delivery is aimed to provide farmers with this timely information they required based on their registered local languages (Arabic, Hausa, Ibo or Yoruba). The role of the farmers includes: registering with the agricultural extension agent, receive/read agricultural information from their mobile phones and also send their comment/query/request to AEA.

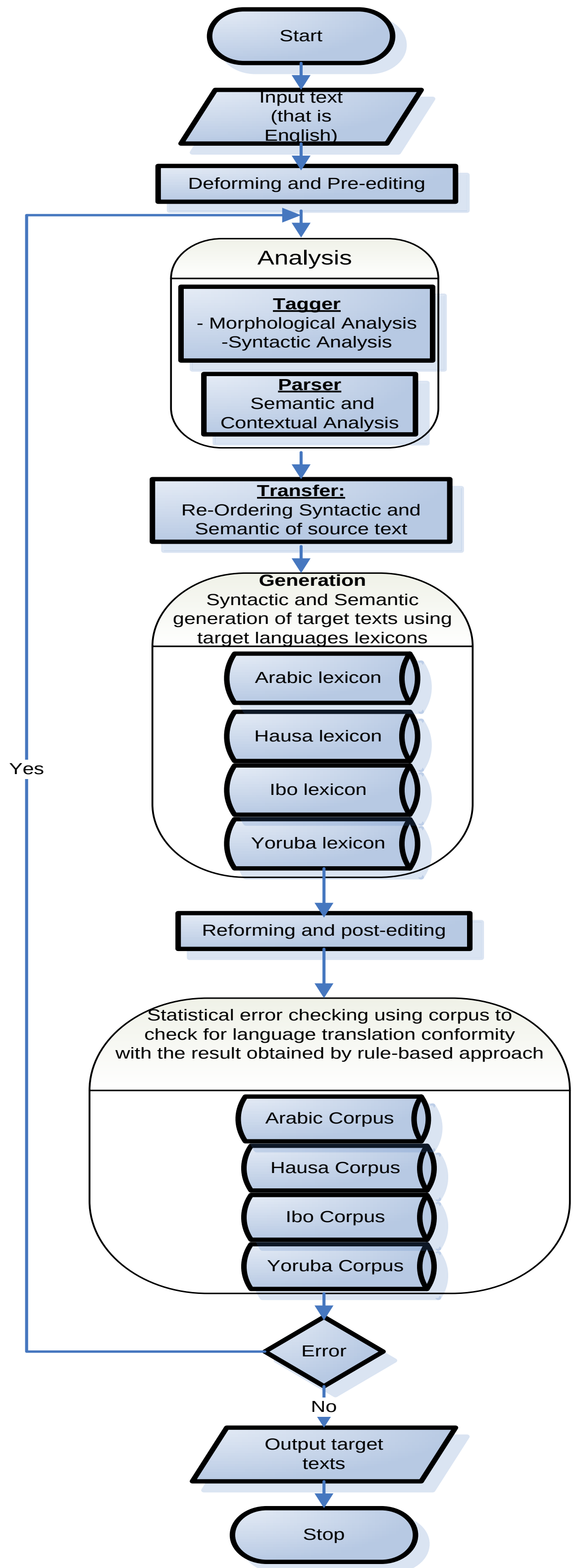


Figure 1. Flowchart for Multilingual Translation System

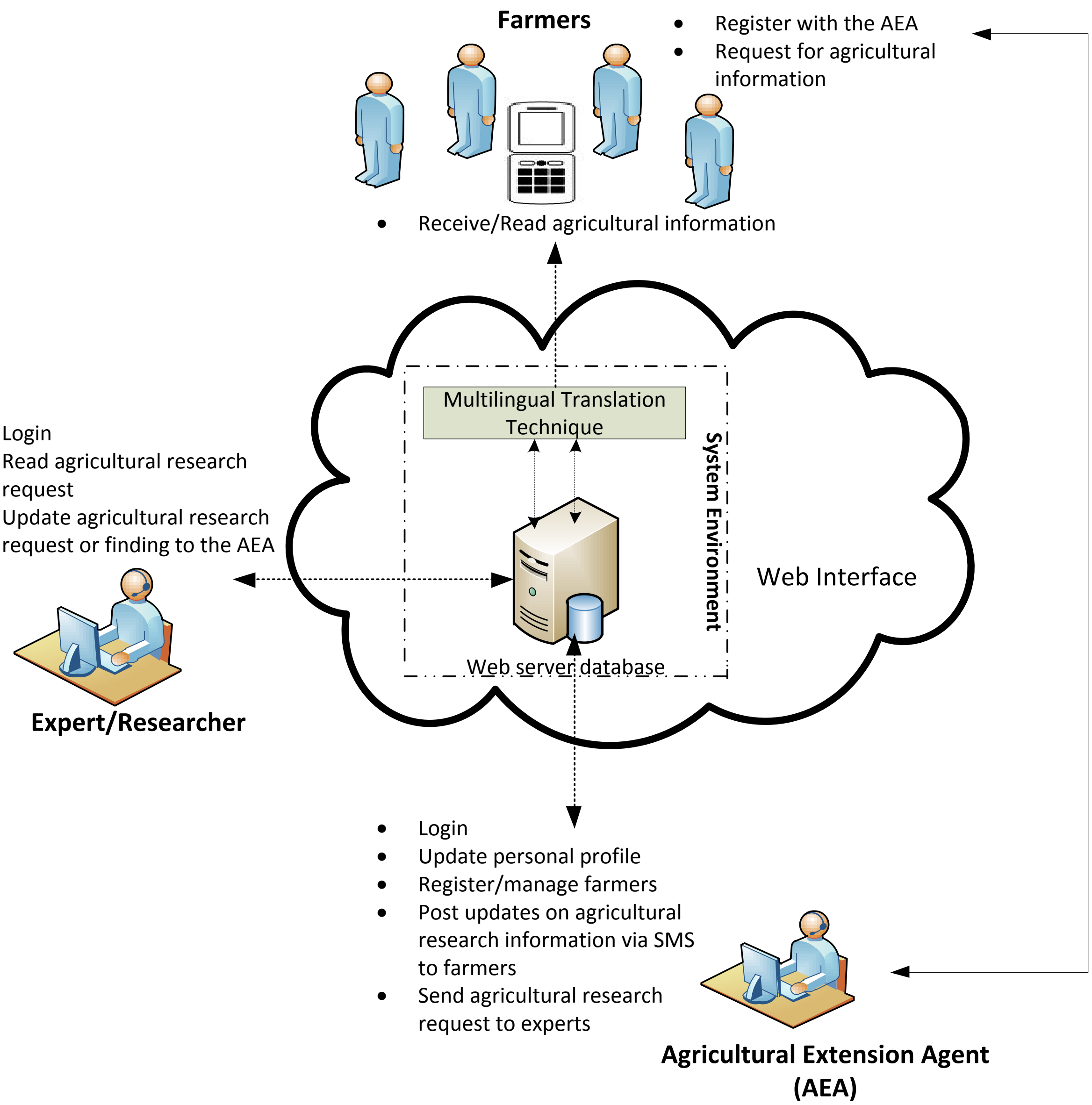


Figure 2. Proposed system framework

### *C. System Framework Representation*

A three (3) tier model was adopted for the proposed multilingual translation system which consists of front-end (presentation tier), middle tier and back-end (data tier) as explained below:

*1) Presentation Tier:* This is also known as the front end and at this level, information is presented to client (i.e. Researcher or AEA) via browsers. This tier was developed using Per Hypertext Processor (PHP) language version 5.3.5.

*2) Middle Tier:* This tier is also known as server side. It is used for processing request through the My Structure Query Language (MySQL). MySQL 5.0.2 was used. This is also where the language translation takes place.

*3) Data Tier:* This tier is also known as back-end. This is the data center for the system which uses the MySQL database management software that store collection of information and organized them so that it can easily be accessed, managed, and updated. MySQL command is used to insert, update, fetch and delete data in this system database.

## IV. SYSTEM TESTING AND EVALUATION

### *A. System Integration Analysis*

To ascertain the workability between unit functions of the implemented system (interoperability of function between components), system integration testing was carried out. Four (4) test cases were tested hundred (100) times each. The test result shows how each component responded to an event that identifies specific functions of the design to whether or not the responses are as expected. Integration testing analysis is shown in Table I.

Test case 01 shows that 80.3% SMS from AEA were sent and received while 19.7% were not. Test case 02 shows that 74.6% of the web messages from AEA to experts and from experts to AEA were successful while 25.4% were not.

On test case 03, 73% experts and extension agent's login to the web application were authenticated by granting access to the web application functions while 27% was not. Test case 04 tested the accuracy of translation from source language (research output in English) to farmer's registered native language, 65% translation was achieved to each of the target languages while 35% were not.

### *B. Evaluation and Acceptance Satisfaction Analysis*

The evaluation of the implemented system was done in order to validate what the research work proposes, and to have a thorough understanding of how well it is working.

In other to ascertain the effectiveness, efficiency and capability of the implemented system for enhancing agricultural e-extension services delivery using the multilingual translation technique, the implemented system was used as a pilot scheme with forty eight (48) respondents. That is thirty (30) farmers, ten (10) extension agents and eight (8) experts or researchers were selected within Suleja and Minna, Niger State, Nigeria.

TABLE I. ANALYSIS OF INTEGRATION TEST OF THE IMPLEMENTED SYSTEM

| Test case | Test event | Description of test | Expected result | Result in Percentage |
|---|---|---|---|---|
| 01 | Farmers mobile phone receives SMS from AEA | AEA sends research findings SMS via the system to farmer's mobile phone | Farmer's mobile phone receives research findings SMS | 80.3% sent and received. 19.7% not sent and received |
| 02 | AEA sending research request and receiving research information and findings via web | Sending research request to experts | Send and receive web messages | 74.6% sent and received. 25.4% not sent and received |
| 03 | Users login to web application | Authenticate user | Users (experts and agents) have access to web-based system | Login was achieved 73% to the web while 27% was not |
| 04 | System translates research outputs to farmer's native language | Research output translated from English to farmers native language | Research output should be received in farmers registered native language | 65% translation was achieved to each of the target languages while 35% failed |

Some questions were directed to the selected farmers, extension agents and experts and their responses were collected instantly. Simple percentage method (SPM) was used for the calculations as shown in Table II. Out of the forty eight (48) numbers of validation forms distributed only forty three (43) were filled and returned.

Results obtained from the evaluation of the usage of the developed system shows that respondents believed the system will bridge the information gap amongst researchers, extension agents and farmer functionalities, 41(95.3%) are satisfied that the linkage provided by the implemented system is adjudged by the respondents as the best ever, while 2(4.7%) thought otherwise. Meanwhile, 33(76.7%) are satisfied with usability and accessibility of the system for enhancing agricultural e-extension services delivery while 10(23.2%) were unsatisfied.

24(55.8%) were satisfied that the system provides outmost confidentiality on the researchers, extension agents and farmers information as well as security of the system. 19(44.2%) were not satisfied. Similarly, 32(74.4%) believe the implemented system is effective and efficient in enhancing agricultural e-extension services delivery while 11(15.6%) were not satisfied.

TABLE II. RESULTS OF SYSTEM EVALUATION ANALYSIS

| S/N | Question | Response (in number and %) Yes/Satisfied | Response (in number and %) No/Unsatisfied |
|---|---|---|---|
| 1 | Are you satisfied that the system has bridged the communication gap among researcher, extension agent and farmers? | 41 (95.3% ) | 2 (4.7% ) |
| 2 | Are you satisfied with the user friendliness (easy to use) and accessibility of the system as adequate for enhancing agricultural e-extension services delivery? | 33 (76.7% ) | 10 (23.2%) |
| 3 | Are you satisfied with the level of security and confidentiality of farmers, extension agents and researchers information on the system? | 24(55.8% ) | 19 (44.2% ) |
| 4 | Are you satisfied with the efficiency and effectiveness of the system for enhancing agricultural e-extension services delivery? | 32 (74.4%) | 11 (15.6%) |
| 5 | Are you satisfied with the functionalities of the system? | 34 (79.06%) | 9 (20.9%) |

On the general functionalities of the system 34(79.06%) are satisfied with the performance of the system functionalities, as such believe the implemented system is a veritable tool for enhancing agricultural e-extension services delivery while 9(20.9%) were not.

## V. CONCLUSION

The research work implemented a multilingual translation system for enhancing agricultural e-extension services delivery that ensures real time agricultural information is provided to farmers irrespective of their geographical location and language. The implemented system translates the agricultural information from a source language (English) into four(4) other native languages (Arabic, Hausa, Ibo and Yoruba) depending on which the native farmer reads and understand. The implemented system has also brought all the stakeholders (researcher, agricultural extension agent and farmers) in agricultural information generation and dissemination together by enabling the AEA to send farmers research request to researchers or experts and receive research findings from the researchers via the web-based application.

In addition, farmers receive instant text messages from the AEA via their mobile phones and on requests, queries made on agricultural information. The acceptance evaluation of the implemented system shows that the implemented system is efficient and effective for enhancing agricultural e-extension services delivery.

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