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Farmers' Requirements in an Artificial Intelligent System for Diagnosis of Maize Diseases in Kenya

Hillary Thadias Nyang'anga[1], William O. Okelo[2], Fred I. Mugivane[3]. Demesi, J. Mande[4], George T. Opande
[1]*(Department of Agricultural Economics University of Nairobi, Kenya)*
[2]*(School of Computing and Informatics, University of Nairobi, Kenya)*
[3]*(.Department of Agricultural Economics University of Nairobi, Kenya)*
[4]*(Department of Clinical studies, University of Nairobi, Kenya)*
[5] *(Department of Botany, Maseno University, Kenya)*

Abstract: *A study was conducted to determine the following: commonly used sources of agricultural diagnostic information by maize farmers, content of information which farmers would like to receive for full satisfaction on diagnostics, formats and form farmers prefer to receive the information and ICT tools, channels and features which farmers have high self- efficiency. These aspects were vital for developing of an artificial intelligent system for agricultural diagnostics. The study was conducted in Uasin Gishu County, Kenya where population targeted was maize farmers. A case study design was used in Uasin Gishu County.A case of maize diagnostics formed the representative area and crop for farmers in Kenya. Ninety (90) farmers were interviewed, Descriptive statistics was used to analyze data using SPSS version 16.*

The study findings revealed that farmers gathered information mostly from extension officers, agro vet shops, from themselves, from internet, radio, televisions and mobile phones. Farmers preferred to access full information on pests and diseases regarding their scientific and common names, symptoms, management options and prescription, and where to purchase the prescription.

It was therefore desirable to develop a system with a system manager to search, collect and input new diseases and pests diagnostics information. Information on the disease diagnostics is to be included in the system development. The final information content delivered by the system must be in a printable format and which must be accessible to farmers through Webpage and internet based application using mobile phones and computers as ICT tools.

Keywords: *Artificial intelligent system, Diagnostic, Maize Farmers, Uasin Gishu.*

I. Introduction

1.1 Background

In order to develop a computer aided artificial intelligent system for agricultural diagnostics, it is necessary to determine farmers' needs. Agricultural diagnostic services are mainly provided by the extension officers. However different alternative models of delivering diagnostics services have emerged in the global arena.

Automation of this service requires an understanding of the various socioeconomic factors affecting farmers. It was also necessary to understand the available ICT tools, channels and features perceived as useful and easy to use.

This study was designed to determine the types of the diagnostics information sources available to farmers, the available ICT tools, channels and features/technologies which the farmers are comfortable using to access and share information. The ICT tools were mobile phones, computers, television and radio. The ICT channels were frequency modulated waves (FM), GSM, Internet and Television waves. The application/features/evaluated in study were short message services (SMS), calling application, web-based mobile application, Unstructured Supplementary Service Data (USSD) code based application and SIM based application. An expected outcome of the study was improved likelihood of adoption of the completed diagnostic system.

1.2 Problem Statement

The government has deployed extension officers for agricultural diagnostic services to farmers. However the ratio of extension officers to farmers is 1:1500; compared with the FAO recommended ration of 1:400. Budgetary allocation is inadequate to support effective operations and movement of extension officers to meet farmers in the county. Poor road network and infrastructure further increases the logistical costs; rendering some areas inaccessible to the few extension officers. In spite of the many challenges service providers in the telecommunication industry have expanded their networks conveying over 80% of the country. Government has facilitated internet access by connecting all major towns through the through the fiber optic cables. The government is committed to its policy to provide laptop computers to all class one pupils. These trends will facilitate the upcoming generations to embrace knowledge and use of computers in all sectors of life, including agricultural extension will be used in this study.

1.3 Justification of the Study

To achieve ease of adoption of the artificial intelligent system, there was need to use a user centric approach which involved collection of user's requirement in the artificial intelligent system for diagnosis and management of maize diseases. This will lead to the fulfillment of the compliance for the technology acceptance model which is based on two factors: perceived usefulness and perceived ease of use. Its compliance namely with meeting these two requirements, the adoption and usage of the technology is increased through this study. This study aimed to understand the perceived ease of use, which guided the development of the system. The perceived usefulness will be determined after the development of the system and pilot testing the system among farmers.

1.4 Objective of the study

To determine the requirements by farmers for an ideal artificial intelligent system for diagnosis and management of Maize diseases in Kenya

1.4.1 Specific Objective

The specific objectives of the study were;

1.) To determine the most common sources of agricultural diagnostic information source

2.) To describe how socio-economic factors affect the preferred sources of agricultural diagnostic information by farmers.

3.) To determine the ICT tools, channels and features preferred by farmers.

1.5 Research question

What are the requirements by farmers for an ideal artificial intelligent system for diagnosis and management of maize diseases?

1.5.1 Specific Research Questions

a) What are the most commonly used agricultural diagnostic information sources by farmers?
b) What content of information on agricultural diagnostics is considered satisfactory by farmers?
c) Which ICT tools, channels and features do farmers consider easy to use and are familiar with?

II. Literature Review

Communication in Agricultural extension

In chapter two item numbers 2.4, the literature review highlighted the communication modules by Shannon Shannon (1948) and Schramm (Schramm, 1954). It was identified that there is a gap in agricultural communication which leads to either farmers receiving distorted information or failing to receive the information. This is because , transfer of information from researchers to farmers through the extension officers is highly influenced by: how the extension officer decoded the information from the researcher, how the extension officer encoded the information to the farmers, the noise interferences between extension officers and farmers, how the farmer will decode the information from the extension officer, the field of experience and social factors of the researcher and extension officer and the field of experience and social factors of the extension officer and the farmers.

Because of these factors, information in most cases gets to the farmers in such a way it was not fully intended for. Gaps therefore exist in the communication model for agricultural extension. This study will look into finding a solution which will link the farmers to the researcher directly without necessarily passing the information through the extension officers.

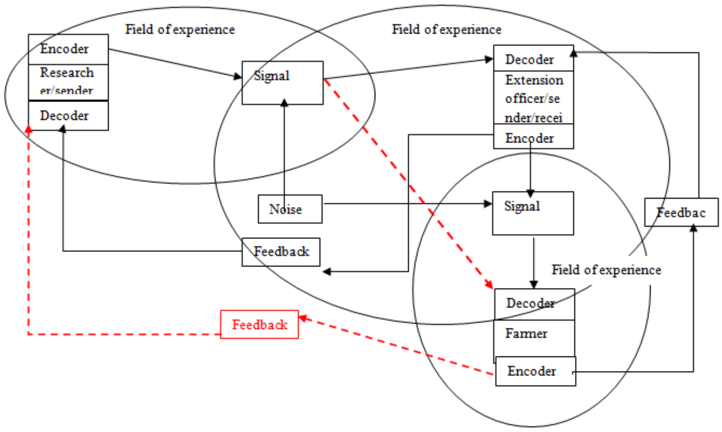

Figure 4.1: Gap in Communication module in agricultural extension in Kenya (source: Author)

Agricultural extension

Extension officers play an important role in provision of diagnostic services to farmers. Extension approaches in Kenya includes: Focal Area Approach (FAA)– (Use of common interest groups (CIGs); Farmer Field Schools – Farmer to farmer extension; Commodity-based approach - commercial enterprises; Multidisciplinary Mobile Extension Teams especially in arid and semi arid areas. Despite the various extension approaches employed by the private and public sector, several challenges are encountered in public sector. These challenges include: reduced staffing and funding for operations and maintenance of extension service delivery. In private sector the challenges include dissemination of conflicting messages, s; unnecessary competition, duplication of efforts, and general lack of synergy among extension service.

These challenges have led to limited access to credible extension services in most parts of the country. The national extension staff to farmer ratio is 1:1,500 (Africa Science News Saturday, 16 November 2013). An agricultural system is considered sustainable when it satisfies producers' needs and preserves natural resources for current and future generation. Development of the system should be based on three pillars: economic feasibility, social fairness and environmental sustainability (Carlos, 2006). This study was designed with the objective of enhancing provision of extension services, by developing a computerized artificial intelligent information system that meets economic,, social, and environmental feasibility. The system was designed to improve delivery of diagnostic and management services for maize diseases in Kenya.

Conceptual Framework

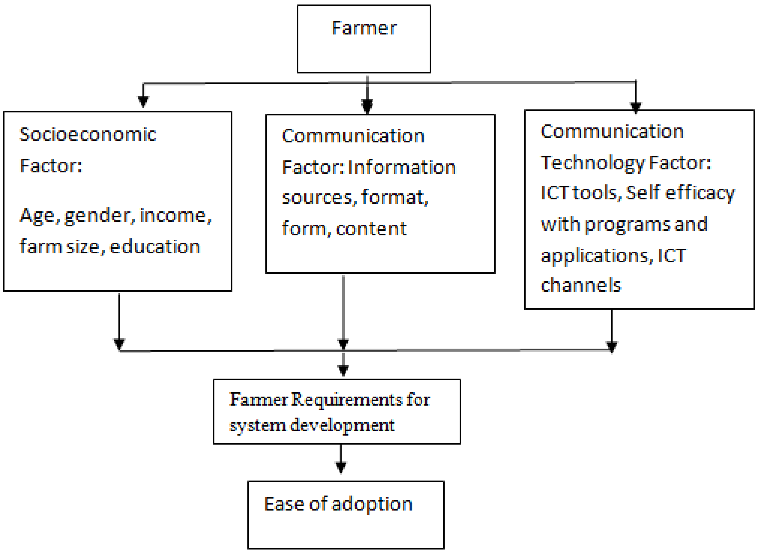

Figure 4.3: Conceptual Framework (source: Author)

III. Methodology

The study was conducted in Uasin Gishu County one of the 47 counties and the second largest maize producer in Kenya. The county extends between longitudes 340 50' and 340 57' East and latitude of 00 3' South to 00 1' Northern area of 2,955.3 km^2 (1,141.0 sq m). The 2009 population census in was estimated at 894,179 people and 202,291 households. (http://www.scribd.com/doc/36672705/Kenya-Census-2009). There are two rainy seasons with an annual rainfall ranging between 900 to 1200 mm. Seated on a plateau; the county has a cool and temperate climate, with annual temperatures ranging between 8.4 °C and 27 °C. The wet season is experienced between April and May, while the dry season is encountered between January and February. The county was purposively selected due to its favorable climate to maize production, the large number of experienced maize farmers and extension officers and the high prevalence/incidence of diseases and pests affecting maize occurrence.

Data was collected using interview guide (appendix I B). The study sample size was estimated using the formula proposed by Mugenda and Mugenda (2003):

$$n = \frac{Z^2 pq}{d^2}$$

Where;

n = the desired sample size for N>10,000,

Z = constant associated with the required confidence level; in this study = 95%, value= 1.96,

p = proportion of the population that possessed the target characteristics. Since this was not known, it was estimated to be 50%= 0.5,

q = 1-p= 0.5 and

d = the level of precision estimated to be 10%= 0.1

$$n= [1.96^2 *0.5*0.5] /0.1^2= 96.04$$

The sample size arrived at was 96 farmers (rounded to the nearest whole number).

Systematic random sampling technique was applied to select the households. The 11000 maize farming households formed the sampling frame.

The sampling interval (k) was determined using the formula $k = N/n$, where **N** is the population size and **n** is the sample size. The sampling interval, k was therefore **11000/96= 114.5=115**. The first respondent who was the head was randomly selected. .List of maize farming households, which was provided by the extension officer. By use of the formula, $K = n + k$, where **K** is the next household to be included in the sample, **n** is the previous member included and **k** is the sampling interval (Mugenda and Mugenda, 2003). The K^{th} household was determined and the process repeated until a sample size of 96 was achieved. In this study the second household was **1+115=116**; the third was **116+115=231**, and so on until the sample size was achieved.

A total of 90 farmers were successfully interviewed. As six respondents did not finish the interview, their interview guides were incomplete and therefore were not included in the analysis. Each farmer represented a household. Primary data was collected using an interview guide. Data was analysed using SPSS version 16.

IV. Results and Discussion

The study found out that sixty six percent (59/90) of the farmers were male, while 34.4% (31/90) were female. Majority (31.1%) of the farmers were in the age between 36-40 years, 60 % of the respondents were 40 years and below. Forty six percent (41/90) of the respondents had primary school education, while 23.3% had secondary school education. Sixty nine percent of the respondents had secondary and primary school education. 33.3% of the respondents had between 21-30 acres of land. The average annual farmer income from maize was at Ksh 350,766.67 per farmer.

4.1 Current source of agricultural diagnostics information

Farmers were provided by various sources of agricultural diagnostic information and requested to select the various sources from where they received their information. More than one source of information could be chosen depending on where they have been getting their information. Table 1.1 shows the results.

Table 1.1: Source of Information for farmers

Source	Frequency(N=90)	Percent
Extension officer (if yes)	51	56.7
Radio (if yes)	50	55.6
Agro-vet shop (if yes)	43	47.8
Television (if yes)	31	34.4
Self (if yes)	29	32.2
Internet (if yes)	17	18.9
SMS (if yes)	9	10.0
Mobile Applications	1	1.1

56.7% of the respondents access/obtain agricultural diagnostics information from extension officers, 55.6 % from Radio and 47.8% from Agro vets shops. Mobile phone, short messages (SMS) and mobile applications were used by 10% and 1.1% of respondents respectively.

Table4.3: Correlation coefficient between farmer characteristics and sources of information on agricultural diagnostics.

	Gender	Age	Education	Farm size	Annual Income	Extension officer	Internet	Self	Agro vet shop	Radio	TV	SMS	Mobile app.
Gender	1												
Age	.220*	1											
Education	-.027	.171	1										
Farm size	.040	.284**	.067	1									
Annual Income	.112	.190	-.117	.301**	1								
Extension office	-.121	-.125	-.063	.043	-.095	1							
Internet	.188	.223*	.142	-.193	-.013	-.208*	1						
Self	-.049	-.183	-.195	.040	.070	-.069	-.211*	1					
Agro vet shop	.102	-.104	-.055	-.062	.089	-.241*	-.234*	.007	1				
Radio	-.058	-.014	-.021	-.030	-.138	.030	.203	-.245*	-.443**	1			
TV	.016	-.019	.112	-.220*	-.201	-.121	.367**	-.200	-.319**	.648**	1		
SMS	-.008	-.135	-.042	.089	.073	.142	.028	-.151	-.319**	.298**	-.008	1	
Mobile app.	-.077	.017	.031	-.048	.022	-.121	.220*	-.073	-.101	.095	.146	-.035	1
***. Correlation is significant at the 0.05 level (2-tailed).**													
****. Correlation is significant at the 0.01 level (2-tailed).**													

The correlation of farmers who access agricultural diagnostic information from extension officers, internet and agro vet is negative as shown on Table 4.3. This implies that as the number of respondents who access agricultural diagnostics information from extension officer increases, the number of farmers who access the same information from the internet and agro vets within the same sample population decreases.

There was a positive correlation between Internet, radio and television. Similarly to Agro vet, radio, television and SMS are positively correlated. Radio, TV and SMS are positively correlated. Implication: it is possible and easy to transform farmers who rely on television, radio and agro vet to using a mobile phone based information source. Farmers who depend on extension officers do not embrace any other source of information. This group could change to any other source of information through training by extension officers. An artificial intelligent system that is fully supported by extension officers as shown in the previous chapter would be valuable in moving these farmers to another technology will be easy. Moving farmers who rely on extension officers for information to internet based or mobile phone based information source would require greater efforts through training and using the extension officers as Trainers of Trainers.

4.2 Sufficient diagnostic information content

Farmers were presented with different content of agricultural diagnostics and disease management information. The farmers were requested to select the content of the diagnostic and disease management information which they considered sufficient. Table 4.4 represents their response

Table 4.4: Distribution of the different content required by farmers in an agricultural diagnostics and pest management information system

Specific information	Frequency	Percent
Management option	80	88.9
Name of chemical to apply and dosages	72	80.0
More symptoms	69	76.7
Name of disease and pest	45	50.0
How to apply prescription	22	24.4
Where to purchase the chemical	18	20.0
Scientific name of disease and pest	17	18.9

Table 4.4 represents the results of different content required by farmers in an agricultural diagnostic system. The most common content preferred by farmers included management options (88.9%), name of chemical to apply and dosages (80%).More symptoms (76.7%) and name of the diseases and pests.

Other minor content requested were; how to apply prescriptions (24.4%), where to purchase the chemical (20.0%) and scientific name of diseases and pests (18.9).

Table4.5: Correlation between farmer characteristics and specific information needed.

	Gender	Age	Education	Farm size	Annual Income	Name of disease and pest	Scientific name of disease & pest	More symptoms	Managementg t option	Name of chemical to apply & dosages	How to apply	Where to purchase the chemical
Gender	1											
Age	.220*	1										
Education	-.027	.171	1									
Farm size	.040	.284**	.067	1								
Annual Income	.112	.190	-.117	.301**	1							
Name of the disease and pest	.070	-.130	-.282**	.021	.104	1						
Scientific name of the disease and pest	-.111	-.294**	-.027	.044	.072	.499**	1					
More symptoms	.013	-.089	-.176	-.237*	.153	.526**	.132	1				
Management option	-.041	-.006	-.123	-.036	-.040	.671**	.080	.495**	1			
Name of the chemical to apply and the dosages	-.164	-.182	-.222*	-.237*	-.027	.610**	.028	.318*	.588*	1		
How do apply the prescription	-.086	-.341**	-.559**	-.090	.076	.507**	.254*	.302*	.537**	.255*	1	
Where to purchase the chemical	-.070	-.243*	-.213*	.005	.071	.167	.255*	.079	-.177	.111	.556**	1
***. Correlation is significant at the 0.05 level (2-tailed).**												
****. Correlation is significant at the 0.01 level (2-tailed).**												

The results indicate a positive (.499**) correlation between the name of the diseases and pests and the scientific name of the diseases and pests. This means that, as the number of farmers who need to know the name of the disease increases, in the same respondent, the number of farmers who need to know the scientific name of the disease and the pest increase. There was a positive and significant correlation (.526**) between the name of the diseases and pests and their symptoms. This implies that as the number of the farmers who want to know the name of the pest and diseases affecting their crop increases, within the same population of respondents, the number of the farmers who needs to know more symptoms of the disease and/or pest also increases.

There was a strong and significant positive correlation between the name of the pest and/or disease and the management option. This implies that as the number of farmers who want to know the name of the diseases and/or pest increases, the number of farmers within the same respondent population, who want to know the management options also increases. The trend continues to include the name of the chemical to be applied and how to apply it. The two factors were positively and significantly correlated to the name of the disease. It is concluded that the farmer who wishes to know the name of the disease and/or pest also wishes to know the symptoms, management options, name of the chemical to apply and the dosage, and how to apply the prescribed treatment option (product).

The data in Table 4.3 indicates a positive correlation between the scientific name of the diseases and/or pest and how to apply the dosage and where to purchase the drugs/chemicals. This implies that as the number of the respondents who wish to know the scientific name of the disease and/or pest increases, the number of the farmers within the same respondents who wish to know how to apply the chemicals and/or dosage and where to purchases the chemical/drug also increases. It can be deduced that those farmers who wish to know the scientific name of the disease and/or pest also wish to know where to purchase the drugs/chemicals and how to apply it.

An additional finding was the fact that symptoms are positively and significantly related to management options, name of the chemical to be applied and how to apply it. This shows that as the number of the respondents who wish to know more symptoms increases, the number of respondents within the same population who wish to know the management options, name of the chemicals to be used and how to apply the chemical also increases. Therefore, it can be deduced that farmers who wish to know more symptoms on the diseases and/or pests affecting their maize, would also wish to know the various management options, name of the chemical/drugs to apply and how to apply the prescribed chemical/drug.

Based on the study findings, it was concluded that farmers consider agricultural diagnostic information adequate only when the content includes the following; the name of the disease and/or, the scientific name of the disease and/pest, more symptoms of the disease and/or pest, the management options available to control, prevent and cure the disease and/or pest, the name of the chemical/drug to apply/administer, how to administer/apply the prescribed drug/chemical and where to purchase the chemical/drugs from.

4.3 ICT Tools

Different ICT tools were presented to farmers who were requested to choose those they owned. The objective was to determine the most commonly owned ICT tools by most famers and to select the tools through which agricultural diagnostic information can be provided. Table 4.6 shows the various ICT tools and percentage of the farmers who owned theses tools.

Table4.6: ICT Tools owned by farmers in Uasin Gishu County

ICT Tools owned	Frequency	Percent
Mobile phone (if yes)	88	97.8
Radio (If yes)	72	80.0
Smart Phone (If yes)	45	50.0
Television set (If yes)	36	40.0
Computer (if yes)	19	21.1

Data revealed that 97.8% (88/90) of the farmers own mobile phones. Fifty percent (50% (45/90) of the farmers have smart phones. This means that 47.8% (97.8%-50%=88-45) have feature phone. The feature phones presented were those that had internet/ wireless Application protocol (WAP). Eighty percent (72/90) of farmers used radio as an ICT tool.. It can be deduced that transfer of agricultural diagnostics information through mobile phones will be the most preferred mode of communication. However, the above finding is not conclusive therefore it is important to obtain a deeper understanding of the correlation between the ICT tools for better conclusion. Table 4.7 below shows the correlation between the various ICT Tools and the farmer's personal characteristics.

Table 4.7: Correlation between farmer characteristics and ICT Tools owned.

	Gender	Age	Education	Farm size	Annual Income	Computer	Mobile phone	Smartphone	Radio	Television set
Gender	1									
Age	.220*	1								
Education	-.027	.171	1							
Farm size	.040	.284**	.067	1						
Annual Income	.112	.190	-.117	.301**	1					
Computer	.198	.143	.049	.069	-.016	1				
Mobile phone	.109	.031	.078	-.002	-.029	.078	1			
Smartphone	.070	.032	.114	-.268*	-.149	.027	.551**	1		
Radio	.012	.081	.153	.046	-.064	-.082	.713**	.456**	1	
Television set	-.019	-.017	.167	-.202	.008	-.033	.123	.181	.408**	1
***. Correlation is significant at the 0.05 level (2-tailed).**										
****. Correlation is significant at the 0.01 level (2-tailed).**										

The data analysis in Table 4.7 revealed that, computers have positive but weak correlation with mobile phones and smart phones. There was a weak negative correlation between radio and television. This implies that ownership of computers was not influenced by ownership of other ICT tools. However, from Table 4.6, 21.1% of the respondents have computers, hence forming a significant portion of the population. It is therefore important to consider using computers in exchange of agricultural diagnostic information between farmers and extension officers.

Conversely, there was a positive and statistically significant correlation between ownership of mobile phones and ownership of smart phones and radio. This implies that as the number of the respondents who own mobile phones increases, among them, the number of those who also own smart phones and radios also increase.

It was also observed that majority of farmers who owned mobile phones also had radios .This may be attributed to the fact that mobile phones contain radio as a feature within them. The study revealed that mobile phones are an important ICT tool used by farmers for communication. There was therefore a strong and significant positive correlation between use of radio and mobile phones. There was also a positive but not significant correlation between use of mobile phone and television. Radios had a positive and significant correlation with television.

These findings imply that conveying agricultural diagnostics information through mobile phones might be easily adopted by people who own mobile phones, smart phones radios and television sets. Mobile phones owned by respondents had internet/web application. It is therefore proposed that web based user interface would be appropriate even for the 21.1%own f respondents who own computers.

4.4 Computer use by farmers

Despite the fact that only 21.1% of the respondents own computers, farmers were asked if they interact with computers from elsewhere and what they actually do with the computers. The farmers were presented with the various functions of a computer. The aim of the study was to establish the self efficacy with the various functions of computers in order to identify the best mode of delivery of agricultural diagnostics information using computers. Table 4.8 shows the various computer uses and the results in percentages using computers per respondents.

Table 4.8: Computer uses by farmers in Uasin Gishu County

Uses	**Frequency**	**Percent**
Listening to music and accessing social media websites (if yes)	75	83.3
Accessing internet (if yes)	18	20.0
Document preparation (if yes)	17	18.9
Sending and receiving emails (if yes)	15	16.7
Developing programs and applications (if yes)	5	5.6
Transaction management (if yes)	3	3.3

Analysis of data presented in Table 4.8 revealed that, 3.3% of the respondents use computers to listen to music and access social media websites. A significant (20%) proportion of the respondents also use computers to access internet. This implies that information which is conveyed through computers should be web based for ease of adoption as the respondents self efficacy with web sites is high, given the experience gained by accessing social media and internet.

Table 4.9: Correlation between farmer characteristics and computer

	Gender	Age	Education	Farm size	Annual Income	Document preparation	Transaction mgt	Accessing internet	Sending and receiving emails	Developing programs and apps.	Listening music &accessing social media webs
Gender	1										
Age	.220*	1									
Education	-.027	.171	1								
Farm size	.040	.284**	.067	1							
Annual Income	.112	.190	-.117	.301**	1						
Document preparation	.248*	.161	.050	.044	-.029	1					
Transaction management	.126	.075	.055	.146	-.014	.385**	1				
Accessing internet	.164	.121	.042	.031	-.019	.894**	.217*	1			
Sending and receiving emails	.115	.072	.019	-.065	-.019	.774**	.083	.894**	1		
Developing programs and applications	.233*	.110	-.086	.025	-.065	.503**	.225*	.485**	.412**	1	
Listening to music and accessing social media websites	-.178	-.116	-.019	.065	-.060	-.089	.083	-.075	-.120	-.022	1

Analysis of data presented in Table 4.9 revealed that preparation of documents was positively and significantly correlated with access of internet, receiving and sending emails and developing of computer programs. Preparation of documents was also positively but not significantly correlated with transaction management. This implies that as the number of respondents who use computers to prepare documents increases, the number, in the same population of respondents, who use computers for accessing internet, sending and receiving email and developing applications also increases. Further, as the number of the respondents who use computers to execute transactions increases, the number of the respondents accessing internet and developing programs also increases but not significantly.

The data also showed a positive and significant correlation between accessing internet, developing programs, sending and receiving email. The overlap of factors shows that those who use computers for emails and developing programs also access the internet. This observation indicates that a web based agricultural diagnostics information system would facilitate access among farmers and extension officers.

4.5 Mobile phone uses

Analysis of data in Table 4.6 revealed that, 97.8% of the respondents had mobile phones, 50% of the respondents had smart phones and 47.8% had feature phones. It was therefore important to understand the various functions of the mobile phones with which the respondent had high self efficacy. Table 4.10 represents the various functions of the mobile phones which were presented to the respondents. The respondents were required to choose the functions which they currently use not only for agricultural purposes but also in their day to day life. The aim was to establish the features which farmers have high self efficacy with. An additional aim was to determine the possibility of providing agricultural diagnostic information through a feature which the famers already know how to operate. The results were presented in Table 4.10 below.

Table 4.10: Mobile phone use

Use	Frequency	Percent
Making calls (if yes)	88	97.8
Sending and receiving SMS (if yes)	83	92.2
Accessing internet (if yes)	44	48.9
WhatsApp and social media application access and communication (if yes)	30	33.3
Transaction management (if yes)	28	31.1
Sending and receiving emails (if yes)	18	20.0
Listening to music and accessing social media websites (if yes)	7	7.8
Accessing applications (if yes)	4	4.4
Document preparation (if yes)	3	3.3

The results of the study revealed that (Table 4.10), frequently used function of a mobile phone among farmers (97.8%). Sending and receiving short messages is also a frequently (92.2%) used function by the farmers. Accessing internet is an equally well and was used by 48.9% of the farmers. An additional finding of the study was the fact that the use of application and social media through mobile phone is also embraced by 33.3% of the farmers interviewed.

The aim of this study was to identify the functions with high self efficacy among farmers and with the ability to be accessed remotely by several farmers at the same time. With the above results, it was therefore important to understand the correlation between the above results. Table 4.11 presents the correlation between the various mobile phone functions.

Table 4.11: Correlation between farmer characteristics and mobile phone use

	Gender	Age	Edu	Farm size	Annual Income	Calling	Doc preparation	Tran mngt	Access internet	Access apps	SMS	W& SA	Emails	Music
Gender	1													
Age	.220*	1												
Education	-.027	.171	1											
Farm size	.040	.284**	.067	1										
Annual Income	.112	.190	-.117	.301**	1									
Making and receiving calls	.109	.031	-.004	-.002	-.023	1								
Document preparation	-.004	.030	.021	-.142	-.070	.028	1							
Transaction management	.119	-.101	.094	-.127	-.161	.101	.143	1						
Accessing internet	.180	.158	.240*	-.134	.085	.447**	.066	.063	1					
Accessing applications	.071	.035	.063	-.048	-.046	.033	.861**	.088	.113	1				
Sending and receiving SMS	.123	.013	-.130	-.061	-.025	.238*	-.177	.106	.201	-.139	1			
Whatsapp and social media application access and communication	.182	.063	.106	-.124	.011	.053	.131	-.017	.440**	.191	.117	1		
Sending and receiving emails	.105	.162	.012	.134	.074	.775**	.062	.084	.345**	.162	.145	.118	1	
Listening to music and accessing social media websites	.051	.228*	.085	.099	-.006	.044	.408**	.074	.214*	.541**	.084	.147	.270*	1

Analysis of data in Table 4.11, revealed a positive and significant correlation between the use of mobile phone for calling and accessing internet. There was also a positive and significant correlation between the use of mobile phone for sending and receiving SMS and accessing internet. This implies that as the number of those who use the mobile phone for calling and sending short messages increases, within the same respondents the number of people using the mobile phone for accessing the internet also increases.

Based on the results in Table 4.10 showing call and SMS functions as the most used, it can be deduced that access to internet is also on the increase (capacity building). Inputs in technology transfer such as training would improve adoption of access to internet. An internet based agricultural diagnostics information system would therefore offer high farmers self efficacy, provide access remotely, and can be accessed by several people at the same time as opposed to calling and sending short messages who have limitations in terms of the number of people which can access at the same time and the volume of the content of information to be delivered.

4.6 User interface

The ease of use of any computer aided system begins with the user interface. The respondents were provided with various user interface input technologies in both mobile phones and computers. They were requested to choose the ones they considered easy to use, given the experience they possessed from using other systems with similar technologies in the society. Table 4.12 presents the results.

Table 4.12: Ease of use of input/query interfaces

Commands	Frequency	Percent
Web Based (if yes)	54	60.0
Mobile application (if yes)	26	28.9
USSD code (if yes)	24	26.7
SMS (if yes)	21	23.3

From Table 4.12, web based interface is preferred at 60%. USSD cod interface, SMS based interface and mobile application are also significant at 26.7%, 23.3% and 28.9% respectively. Based on the results, web based user interface will have a higher and quick adoption rate as the self efficacy of farmers with the interface technology is already high.

4.7 ICT channels available to farmers

Farmers were presented with various ICT channels and asked to identify those they had access to. The aim of the study was to identify the channel which can be used to deliver agricultural diagnostic information in a services remote area. Table 4.13 below represents the results.

Table4.13: Access to ICT channels

ICT Channels	Frequency	Percent
(GSM) Global system for mobile communication (if yes)	84	93.3
Frequency modulated (FM) waves(radio waves) (if yes)	83	92.2
Analogue or digital television broadcasting waves (if yes)	76	84.4
Internet (if yes)	44	48.9

GSM channel had the widest coverage at 93.3 percent. Internet on the other hand had the lowest coverage at 48.9 %. The GSM channel had the ability to carry the internet channels through the mobile telephones; the two channels therefore go hand in hand. On the other hand, FM wave was the second largest channel at 92.2 percent. It is important to once again highlight that GSM has the ability to carry FM waves as well through mobile phones.

Based on the study findings, it can be concluded that GSM channels would be the most preferred communication channels as they provide a suitable platform for internet and radio channels.

Table4.14: Correlation between farmer characteristics and ICT channels

	Gender	Age	Education	Farm size	Annual Income	Internet	GSM	Radio Waves	TV waves
Gender	1								
Age	.220*	1							
Education	-.027	.171	1						
Farm size	.040	.284**	.067	1					
Annual Income	.112	.190	-.117	.301**	1				
Internet	.133	.110	.228*	-.031	.077	1			
GSM	-.051	.104	.116	.132	-.051	.401*	1		
Radio waves	.100	.087	.090	.121	-.045	.261*	.655*	1	
TV waves	.053	.087	.106	.081	-.049	.358*	.619*	.500*	1
*. Correlation is significant at the 0.05 level (2-tailed).									

Analysis of data in Table 4.14 revealed a strong positive and significant correlation between GSM, radio waves and TV waves. As GSM channels also provide a platform for internet channels, internet is a subset of GSM. GSM also provides a platform for radio waves and sometimes TV waves. Mobile phones have been produced with internet, Radio and TV enabled feature. Based on the study findings it is concluded that GSM channels provide the best channels for connecting the agricultural diagnostic system to the farmers and extension officers.

V. Conclusions

From the findings it can be concluded that;

1. Farmers use extension officers, radio, TV, and their existing knowledge to access agricultural diagnostic information. They also use internet, mobile phone application and short message services. The mobile phone is gaining dominance .This trend should be considered in developing an artificial intelligence system
2. The contents of agricultural diagnostic information required by farmers should include;
   - The name of the disease and or pest
   - The scientific name of the disease and or pest
   - The symptoms of the disease and or pest
   - The available management option
   - The chemicals and or drugs to be administered
   - How the chemicals and or drugs should be administered
   - Where the chemical and or drugs can be purchased
3. The mobile phones and computers are the most appropriate ICT tools for artificial intelligence system for exchange of agricultural diagnostics information.

4. The internet and GSM (WAP) are the appropriate ICT channels for sharing diagnostics information to many farmers at the same time.
5. Farmers have high self efficacy with browsing the internet and accessing websites using computers and mobile phones.
6. Farmer have high self efficacy with web based user interfaces.

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