Effective Mobile Query Systems for Rural Farmers

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This thesis is submitted in partial fulfilment for the
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Declaration

This thesis has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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Abstract

This thesis considers the appropriate arrangement and access of knowledge to help rural farmers in Nigeria improve the ways in which they produce crops and raise livestock.

A review of the trends in mobile computing-based extension delivery in Nigeria was conducted. The review showed that there is a high penetration of mobile telephony in Nigeria, but agricultural support systems have not been adequately developed to take advantage of this mobile phone coverage. One of the major challenges identified was that although farmers have access to mobile phones and the Internet, they find it difficult to access information easily and quickly to address their local farming needs. This led to the exploration of effective ways of facilitating farmers' access to locally relevant information.

Requirements for effective mobile farm query systems were developed and established. They include (1) Minimal input by the user (2) Effective selection of information relevant to the user (3) Restricted access to the Internet (4) Wide range of help for farmers (5) Easy expansion of the system (6) Availability in minority languages and (7) Sustainability within developing country budgets.

A mobile query technique that meets the identified requirements of providing access to information for rural farmers by ontology-based partitioning was developed. The technique requires the repeated partitioning of the domain so that the user can select the appropriate partition at any level, and gradually home in on the desired answer. This technique has been used to develop a farming advice system for rural farmers in Jos, Plateau State, Nigeria. The farming advice system partitions the farming advice domain into three major groups i.e. Grains/tubers, Vegetables and Animals. These groups are further partitioned into sub-groups based on how local farmers group farming concerns and with some inspiration from case based reasoning.

Question and Answer (Q/A) pairs were collected from local small holder farmers with the active collaboration of local agricultural experts from the Federal College of Animal Health and Production Technology, (FCAH&PT), Vom, Plateau State, Nigeria. The local agricultural experts conducted focus group discussions (FGDs), one-to-one meetings and questionnaire surveys with the local farmers. This information was curated, and the mobile query technique was used to arrange the Q/A pairs in the farming advice system.

Farming advice for fifteen species of animals and crops were captured in the mobile farm query system. It was observed that within an ontological partition, similar sub-partitioning occurs e.g. for crops - sowing, harvest, storing, fertilizer, general production, pest/disease and weeding. Animals - Breeding, Disease, Feed/water, general production and vaccination. As more crops and animals are added to the system, the set of concerns can be used as a guide in the collection of Q/A pairs from local farmers and extension workers.

The application of the mobile query technique to other domains was explored by considering how it could be used for making FAQs about Aberystwyth University Information Services accessible. A third domain explored was the provision of personal health advice.

The three domains used in implementing the mobile query technique are very different but the developed principles for breaking down a domain have proven effective in each.

The mobile farm query system developed using the technique is being trialled by small holder farmers in Plateau State, Nigeria. The system provides small holder farmers with an easy and timely way of accessing farm query information. This is very important to farmers because of the critical nature of timely information. The system provides extension agents who may not have immediate answers to all farmers' queries when on the field quick access to this information even in areas where there is no mobile signal or Internet access. It also provides a database of farmers' problems and concerns. As farmers use the system, the frequency of their consultation of Q/A pairs, the season when these Q/A pairs are consulted and the location from where they are consulted can be used to build a big picture of farming problems and concerns within an area. This information can be used to properly channel much needed help to small holder farmers.

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Chapter 1

Introduction

1.1 Thesis Summary

This thesis considers the appropriate arrangement and access of knowledge to help rural farmers in Nigeria improve the ways in which they produce crops and raise livestock. The primary research question addressed is :

> *How can agricultural information be presented to make it easy for rural/small holder farmers to access this information?*

In order to be able to answer this research question, we also consider:

- What are the agricultural extension needs of smallholder farmers in Jos South local government area of Plateau State, Nigeria?
- What are the perceptions of smallholder farmers in Jos South local government area of Plateau State, Nigeria of the present level of agricultural extension support they receive from extension agencies?
- How can agricultural information be arranged on mobile phones to make it easy for rural/small holder farmers to access this information?

These subsidiary questions collectively feed into the primary question. In order to provide information to small holder farmers their information needs have to be clarified, this was done using a survey and focus group discussions (FGDs). A survey was also conducted have a view of how these smallholder farmers perceive their present level of access to agricultural information. A review of literature as well as a survey was conducted to determine which platform is most suitable to provide information to these smallholder farmers.

Although the survey and the FGDs conducted to gather data for this work were done in Jos South LGA, the results and insights apply to most small holder farmers especially those in developing countries. They all face the same challenges which bother around lack of timely and actionable information.

The main goals of this thesis are:

- To identify the agricultural extension needs of smallholder farmers in Jos South local government area of Plateau State, Nigeria as well as their perception of the present level of support they receive from extension agencies.
- To develop techniques and structures that support the agricultural extension needs of smallholder farmers.
- To apply these techniques and structures to develop a farmer query application for smallholder farmers in Jos South local government area of Plateau State, Nigeria.

1.2 Motivation for the work

According to the Food and Agriculture Organisation (Jaggard *et al.*, 2010) food production needs to grow by 70% globally and double in developing countries to feed the estimated population of 9.1 Billion people by 2050.

Timely access to agricultural information by farmers is critical to improving agricultural productivity. Intelligent mobile phone-based systems have the potential of improving agricultural information delivery and farmers' productivity.

Most Nigerian farmers live in rural areas which are largely underserved by ICT infrastructure like Internet services, broadband connection and telecommunications services. The recent upsurge in mobile telephone activities in Nigeria and the vast coverage of mobile telephony services provides an opportunity to improve access to agricultural extension services by rural farmers. Nigeria remains the largest mobile market in Africa and as at 2018 had 97.5 million unique subscribers and 53 million smart phone users(GSMA, 2018).

Providing access to information on mobile phones and enabling access to this information is very critical in leveraging on this vast mobile telephony coverage. Within the past two decades there has been a burst of research activities in the area of agriculture in Nigerian universities and agricultural research centres. Far reaching innovations that are capable of boosting the small-scale farmer's agricultural production and Nigeria's economic development have been discovered. Unfortunately, these have not had a corresponding effect of improved agricultural productivity due to the poor dissemination and adoption of these findings. According to (Madukwe *et al.*, 2002), effective integration of communication elements, enhances sustainability in communication of ideas and consequent transfer of agricultural technology to farmers. Many developing countries in collaboration with developmental agencies have begun to leverage ICT to improve access and ultimately improve productivity of rural farmers.

Information is an essential ingredient in agricultural development programs, but Nigerian farmers seldom feel the impact of agricultural innovations either because they have no access to such vital information or because it is poorly disseminated (Ozowa, 1995). The same study also stated that the inability to propagate agricultural information hinders agricultural development.

So, it has become imperative to provide small holder farmers with the appropriate ICT tools to access the much-needed agricultural information and resources

to help improve their agricultural productivity. Mobile phones have the potential to grant wide access to agricultural information by small holder farmers. This information has to be presented in a format that would be easy for small holder farmers who are largely illiterate.

Presently access to information via mobile phones is not easy and efficient. It has therefore become imperative to present the information to be provided to rural farmers in such a manner that is easily accessible to them.

1.3 Summary of methodology

In this study, we adopted a mixed method research approach. The study made use of literature review, surveys, one-to-one interviews and focus group discussions (FGDs). A review of literature about agricultural extension delivery in developing countries with emphasis on the role Information communication technology (ICT) plays was done to have an understanding of the present state of ICT enabled agricultural extension delivery in Nigeria.

Figure 1.1. shows the thesis workflow. The review of literature revealed that there is a substantial use of mobile phones in Nigeria. It also revealed that mobile phones are used in the agricultural sector amongst farmers. This led us to conduct a survey of poultry farmers in Plateau State, Nigeria in 2016 which further confirmed that many smallholder farmers in Jos South LGA have access to mobile phones. A survey was also conducted to assess perception of the present level of interaction between farmers and extension agencies in Nigeria in relation to the level of support given to the farmers via farm/extension information delivery.

Also, the review of literature led us to conduct FGDs between 2017 and 2019 to get preliminary information about the needs of the farmers and their perception of agricultural extension delivery and to generate question and answer pairs for the mobile farm query system (see Appendix B).

Requirements for a mobile farm query system were developed based on the information gotten from the survey and the FGDs. These requirements were then used to develop a technique for arranging knowledge in a domain for use in mobile phones. This technique involved the repeated partitioning of the domain so that the user can select the appropriate partition at any level, and gradually home in on the desired answer. The partitioning of the domain is inspired by card sort which seeks to represent the domain in a way that the user understands the domain.

The question and answer pairs collected from the farmers as well as those developed by the team from the Federal College of Animal Health and Production (FCAH&PT), Vom were classified using the farm query technique (see Appendix A) and the data used to implement a mobile farm query system for farmers in Plateau State, Nigeria. This system is presently being tested with farmers from Riyom and Ganawuri communities, Jos South LGA of Plateau State, Nigeria.

The mobile farm query technique has been implemented in two additional application areas(see Appendix C).These application areas were chosen because of the potential benefit of an effective mobile query system will have on these datasets.

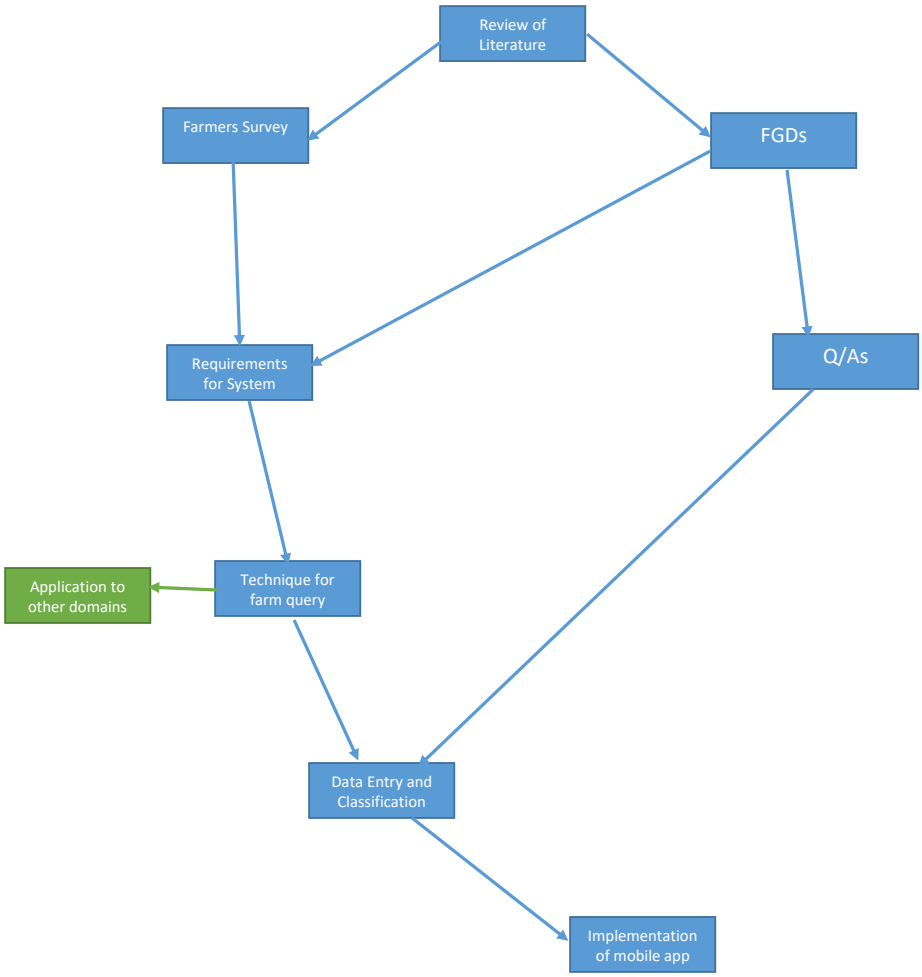

Figure 1.1: Thesis workflow

1.4 Chapters for thesis

1. Introduction

   An overview of the thesis is done including research questions. The motivation for the work is also put forward. An overall summary of the methodology of the work is also put forward with the aid of a workflow diagram. The implementation of the system for farm advice, Aberystwyth University Information Systems and personal health data is highlighted. The plan of the thesis is also outlined.

2. Background to the Study This is a context chapter that tells us why this study is important and the purpose it will serve. The state of agricultural extension in Nigeria and current smallholder farmer access to information is discussed. Gender issues in small holder farmer's information delivery were also discussed. The present state of mobile phone deployment as it affects rural and small holder farmers in Nigeria was also discussed. These discussions were tailored towards justifying the need for the deployment of a mobile application for agricultural information delivery in Jos South Local Government of Plateau State and by extension Nigeria.

3. Methodology The methodology of the thesis is discussed highlighting how farmers were surveyed, how their needs are identified and the requirements for effective mobile query systems. It discusses how the extension expert team for the study was formed. The methodology also highlights how the mobile farm query system is developed and how knowledge is collected to populate the knowledge base.

4. Literature Review A review of literature on the potentials of ICT in agriculture is done. There is particular emphasis on the ICT especially mobile phones and their potential to improve agricultural information dissemination in developing countries.

5. Survey of smallholder farmers in Jos, Plateau State The survey which was conducted in 2016 provides a justification of the need to deploy mobile phones for agricultural information dissemination to farmers in Plateau State. The results are also used to develop the requirements for the mobile farm query system.

6. Collection of Knowledge

   Here we discuss the practical collection of knowledge over a span of almost 3 years. This process involved visits to small holder farmers in Nigeria where focus group discussions (FGDs), one-to-one discussions and questionnaire surveys were conducted with the help of local extension experts from the Federal College of Animal Health and Production Technology, Vom, Plateau State, Nigeria.

7. Clarifying the application area

   A survey of farmers in Plateau State, Nigeria to access their perception of extension support is conducted. Requirements of effective mobile farm query systems are outlined. Related application areas which include Aberystwyth University Information systems FAQs and Personal Health queries are discussed. Some work already done in supporting small holder farmers in developing countries is discussed against the requirements for mobile phone help to farmers. They include Farmer Query system (FQS), Intelligent Advisory system for Farmers (IASF), Electronic wallet system for small holder farmers in Nigeria, Esoko, Ezarat, TensorFlow app for Cassava Disease Diagnosis. A mobile farm query technique which meets all the requirements for effective mobile farm query systems is proposed.

8. Review of related techniques

   Related search techniques are reviewed for their suitability or otherwise for mobile farm query activities. These include: Text-based matching/Approximate string matching, case-based reasoning and machine learning techniques. Relevant knowledge acquisition techniques are also reviewed. They include Card Sort and Semantic web ontology.

9. Techniques for arranging knowledge in a domain

   A general technique for mobile query systems which involves repeatedly partitioning the domain so that the user can select the appropriate partition at any level, and gradually home in on the desired answer is developed. This technique is used to partition the farming domain. We discuss how the knowledge tree is constructed. We look at how to order the characteristics of the farming domain and how to decide a good split. We also look at how a new item is inserted into the domain. The system is also tested against all the requirements for an effective mobile query system. We also discuss how to improve the knowledge base of the farming domain.

10. Application to Advice for Rural Farmers

    We implement the mobile query technique to advice for rural farmers. Specifically highlighting how we enter data into the knowledge base and classify the data. We also show some operations of the farming advice system. These include adding items to a category, splitting a category, reordering a list of items, and exporting updates to the farmer advice database. An evaluation of our implementation is also discussed.

11. Conclusion

    A summary of work done is given. Also, future work is discussed. Specific emphasis is placed on deploying the mobile farm query system to farmers in Jos, Plateau State, Nigeria. Sustainability of the application is also discussed. We also look at the opportunities to expand the coverage and scope the mobile farm query system to other developing countries. The kinds of

information that can be taken from usage of these systems and what can be done with it is discussed.

Chapter 2

Background to the study

2.1 Agricultural Extension delivery in Nigeria

Agricultural Extension is the science of educating farmers with relevant scientific research and knowledge and is concerned with transferring actionable and useful information to farmers. This task has rested on the shoulders of Agricultural Extension experts who interface between agricultural knowledge base domiciled with researchers and academics and the farmers who need the knowledge. Over the years Agricultural extension experts have transferred knowledge to farmers via many methods which usually require them to visit farmers on their farms.

Unfortunately the agricultural extension system in Nigeria has been beset by a myriad of problems. According to (Agbamu, 2005)these problems include:

- Inadequate agricultural research extension linkages
- Poorly trained extension workers at the local level
- Poor logistic support for field staff
- Inadequate funding for extension services
- Inappropriate and ineffective agricultural technologies for farmers

Other problems include:

- Inability to access extension services especially in small towns, villages and farm settlements
- Ill equipped extension agents
- Difficult access especially in rural areas and
- general apathy towards extension services
- Inadequate feedback from farmers about extension service delivery

According to (Olowu & Oyedokun, 2000) the lack of access to information has the greatest effect among other factors to the low contribution of agriculture to Nigeria's GDP. These problems have limited the capacity of small holder farmers to produce and distribute agricultural produce at optimal levels. Although radio and television are widely used by farmers, they reduce the possibility of feedback to the farmers.

The government has tried to resolve these problems by introducing several agricultural extension agencies at state and Federal level. They include the Agricultural Development Project (ADP) which was established in 1975 to improve agricultural information dissemination to farmers especially small-holder and rural farmers (Olujenyo, 2006). There are presently 37 ADPs; one in each of the 36 states and one in the Federal Capital Territory, Abuja. Many agricultural based universities and research agencies have some form of agricultural extension service. The Federal Government also established the Agricultural Extension and Research Liaison Services with the mandate to develop and disseminate agricultural innovations to farmers. They are also involved in research into new agricultural extension methodologies and policy. There is a lot of collaboration between all these agricultural extension agencies.

In 2012 the Federal Government of Nigeria established the Growth Enhancement Support Scheme (GESS) as part of the Agricultural Transformation Agenda (ATA).The main aim of GESS was to improve the delivery and facilitate provision of farm inputs such as fertilizer and seedlings at subsidized rates to farmers (Uduji *et al.*, 2019).

2.1.1 Agricultural Development Projects (ADPs)

ADPs started as a World Bank intervention in 1975/76 (Idowu, 2004). It was established to boost the agricultural production of small holder farmers as well as improve their socio economic status and food security of the nation. It was established as a joint state and federal government collaboration to improve extension services and to provide a robust monitoring system of small holder farmers and their activities.

The ADP programme has recorded significant success in the area of revitalizing the extension services in Nigeria; it has also brought about the dissemination of much needed technological transfer to farmers. It has however been plagued by lots of problems ranging from political manipulation, corruption, high turnover of staff and rivalry between the states and the federal government, inefficient tools for information dissemination, restricted access to small holder farmers etc. One of the major problems was the withdrawal of funding from the World Bank. The total funding going to the ADPs was reduced which had the effect of reduction in the number of extension agents, a significant drop in SMSs between extension agents and farmers. Total number of farm visits as well as farm demonstrations and trials dropped(Idowu, 2004).

In recent years the ADPs have been actively involved in the success of the e-wallet approach of the Nigerian government. ADPs supplied 3-5 helpline staff per local government (Adebo, 2014) who connected to the farmers daily to help

to resolve issues. However, in a study conducted by (Obidike, 2011), some of the problems encountered by rural farmers in Nnsukka L.G.A. of Enugu State, Nigeria served by an ADP include lack of access roads for regular visits by extension officers, poor public relation of some extension staff, poor radio and television signals, lack of funds to purchase newsletters, leaflets on agricultural information; illiteracy and inability of radio and television stations in Enugu State to broadcast agricultural information programmes in native Nnsukka dialect. These problems are also experienced by most rural farmers served by ADPs throughout Nigeria. The ADPs are the major agents for information dissemination to farmers in Nigeria. It has become therefore become imperative that their methods of disseminating information be improved. ICT's especially mobile phones can be exploited for this purpose.

2.2 Small holder farmer access to information in Nigeria

According to (Mgbenka *et al.*, 2015) farmers who have farms of less than 10 hectares are regarded as small holder farmers. These kind of farmers constitute more than 80% of farmers in Nigeria. They also contribute about 99% of the national product and produce about 98% of the food that Nigerians consume(Mgbenka *et al.*, 2015). It therefore becomes imperative to support these farmers who provide a bulk of the food for the nation.

According to (Mgbenka *et al.*, 2015) Nigerian farmers do not feel the impact of the vast amount of innovation available either because they have no access to that very vital information or because it is not properly disseminated. They also opined that other factors like the differences in status between extension workers and farmers, limited knowledge of how communications technology works, lack of cooperation by different agencies within the agricultural value chain especially when it comes to planning and implementation of extension activities and the general lack of interest in traditional media have contributed in no small way to the inefficiency of extension delivery to small holder farmers in Nigeria. They also observed that extension information delivery in Nigeria is treated as a matter of course. According to (Ozowa, 1995) the focus of agricultural extension dissemination is on policy makers and researchers with less attention being paid to the small holder farmers who are the targets of these innovation and policy decisions.

Most agricultural input providers are located far away from the rural areas where the input users (small holder farmers) are located. Most of these farmers are limited in their ability to access timely information needed for production, processing and marketing(Alleman *et al.*, 1994).Most of these farmers access information about inputs and other factors of production via extension workers who share such information with them. Other listen to radio and Television programs that are aired over local and television stations. Others gain information from word of mouth via other farmers who have access to these information. The traditional ways of accessing these information is not efficient for most of these farmers.

These traditional ways of access to information have not being as regular and efficient as needed by the farmers. According to (Ogbeide & Ele, 2015) access to inputs is denied or slow due to poor information flow to these small holder farmers.

One of the major ways these small holder farmers can be supported is by granting access to much needed information.

According to (Mgbenka *et al.*, 2015) the information needs of small holder farmers revolve around problems of pest control and management, weed control, issues around moisture, infertility of the soil, insufficient and limited access to farm credit and issues around marketing farm produce. This was corroborated by (Ozowa, 1995) who grouped the information needs of small holder farmers into five headings which are extension education, agricultural inputs, agricultural technology, agricultural credit and marketing.

The traditional sources of agricultural information to farmers according to (Mgbenka *et al.*, 2015) are television, agricultural radio programmes, field days, word of mouth from fellow farmers, Agricultural Development programmes (ADPs), and the Ministries of Agriculture both at state and federal levels. They also added that most small holder farmers obtained information about processing, storage, agricultural production, extension service delivery, intercropping, income-generation activities, use of improved varieties, weeding, planting, harvesting from these sources.

However, these traditional ways of accessing information have not been adequate and easily accessible to small holder farmers in Nigeria because of the some problems which include inadequate extension and research linkages, poorly trained extension workers, poor logistics, poor funding for extension activities, difficult access in rural areas where these small holder farmers are and general apathy towards extension service delivery.

It is therefore imperative to look at more accessible and efficient ways of granting smallholder farmers access to much needed agricultural information. Mobile phones present a more accessible and even in some cases cheaper alternative to some of these traditional agricultural information sources.

2.2.1 Gender issues in small holder farmers information delivery in Nigeria

According to (Ogunlela & Mukhtar, 2009) women make up 60 - 80% of the farming population of smallholder farmers. It is however unfortunate that their contribution to the agricultural sector has been ignored for a long time. They are also not normally part of the decision making process when it comes to agriculture in Nigeria. Many women smallholder farmers don't have the same access as their male counterparts have to many traditional forms of agricultural information dissemination. This may be due to socio-cultural and economic factors which alienate many women from owning radios, televisions and other important agricultural information dissemination tools.

In the more conservative parts of the country many women are forbidding from interacting with males and in some cases outsiders due to cultural and religious restrictions. They therefore rely on their male counterparts for access to infor-

mation that comes from extension agents, village meetings, workshops and other human interactive information dissemination methods.

If there is going to be any significant impact of information delivery for small holder farmers then women have to be mainstreamed in any intervention and innovation.

According to (Ogunlela & Mukhtar, 2009) there have been several groups that have emerged in a bid to bridge the gender gap between male and female farmers in Nigeria. One of such groups is the Women's Advancement Network (WOFAN) which was setup in the 1990's with headquarters in Kano. The group collaborates with about 250 women's groups in five states in Northern Nigeria. It is important to leverage on groups like these who represent most smallholder farmers if any intervention and innovation in agricultural information delivery is going to be successful.

Another important intervention was the Women-in-Agriculture (WIA) programme which was started about 1988 (Ogunlela & Mukhtar, 2009) to correct the imbalance in extension service delivery to women in spite of the World Bank's intervention through the ADP scheme. The extension system in Nigeria had hitherto been targeted towards men and their farming needs to the exclusion of women. WIA was therefore geared towards main-streaming women in extension information delivery in Nigeria. One of the major fallouts of this programme was the identification of the need to increase the number of female extension workers in the field. Therefore any innovation that will increase access to information by smallholder farmers has to take the gender issue into consideration. Mobile phones which are cheap and easily accessible by smallholder farmers can be leveraged upon to access the vast majority of female small holder farmers.

2.3 Mobile phones and rural farming in Nigeria

Agricultural extension services in most developing countries have not being as effective as in developed ones. This has had serious implications on productivity of the average farmer in a developing country. Information Communications Technology (ICT) has been deployed successfully in agricultural information delivery. The fast acceptance and widespread nature of mobile telephony has contributed immensely to this success.

The recent upsurge in mobile telephone activities in developing countries and the vast coverage of mobile telephony services in developing countries especially in sub-Saharan Africa provides an opportunity to improve access to agricultural extension services by rural farmers in developing countries.

According to (GSMA, 2018) Nigeria remains the largest mobile market in Africa and as at 2018 had 97.5 million unique subscribers, a mobile penetration rate of 49%, 151 million connections and 53 million smart phone users. These figures are expected to rise to 135 million unique subscribers, 55% mobile penetration, 210 million connections and 144 million smart phone users by 2025.

According to (Ogunniyi & Ojebuyi, 2016) Short Message Service (SMS) which commenced in 1992 has risen to over 4 trillion text messages being sent throughout

the world. The use of SMS has increased the access to rural populations which were once inaccessible by communication services.

These statistics show that there is wide spread access to mobile telephony in Nigeria. This wide access can be leveraged upon to provide much needed extension services to small holder farmers. Women who have been largely underserved by traditional extension services have an opportunity to be included due to the ubiquity of mobile phone access in rural population. Mobile phones being one of the cheapest and most inclusive forms of disseminating agricultural information to small holder farmers will increase access to women who make up a majority of the agricultural workforce in rural areas. However, it must be noted that women are still 23% less likely to own a mobile phone than their male counterparts in Africa (Ogbeide & Ele, 2015).

(Ogunniyi & Ojebuyi, 2016) in their study on the use of mobile phones for agribusiness in Southwest Nigeria observed that mobile phones increased the income and productivity of farmers. It also had the effect of a reduction in transport and transaction costs. According to (Aker, 2008) mobile phones have reduced the dependence of farmers on face-to-face agricultural extension services. This has being a mitigating factor to some of the problems facing this type of extension delivery which have being highlighted in section 2.1.

However, (Akpabio *et al.*, 2007) identified some constraints to ICT deployment for extension services in the Niger Delta area of Nigeria. They include and are not limited to poor ICT infrastructure, high cost of access to ICT facilities and most importantly electricity. It is important to note that these constraints are not unique to the Niger Delta region but apply to the whole of Nigeria. They are more pronounced in rural areas where most small holder farmers can be found. Farmers in Southwest Nigeria also faced the problem of epileptic electricity supply according to (Ogunniyi & Ojebuyi, 2016).

In spite of these constraints mobile phones provide an opportunity for small holder farmers to gain access to much needed information that has the potential of improving their productivity. However the issue of adoption of the technology is a challenge that needs to be addressed.

2.3.1 The Electronic Wallet (e-wallet) approach for Small Holder farmers in Nigeria

The fertilizer subsidy scheme in Nigeria had been plagued by lots of corruption and inefficiencies. One of the major problems was the fact that most of the fertilizer meant for farmers end up with middlemen who then resell the fertilizer and other government subsidized products at commercial rates to the unsuspecting farmers. According to (Uduji *et al.*, 2019), the Federal Government Nigeria spent N30 billion ($180 million) in 2011 to provide agricultural inputs for 800,000 smallholder farmers; whereas they spent N5 Billion ($30 million) in 2012 to provide 1.2 million smallholder farmers with these inputs. The government was only able to distribute about 10% (Cellulant, 2018) of its budgeted fertilizer and seed subsidies. The Electronic Wallet (e-wallet) approach was started in 2012 to mitigate this problem. It facilitates the distribution of seeds, fertilizer and other agricul-

tural inputs directly to small scale farmers at subsidized rates via an electronic wallet on their mobile phones.

The most important component of the e-wallet system is the database of farmers connected to other agricultural stakeholders. The platform seamlessly connects farmers and agricultural stakeholders for the purpose of providing support and services to the farmers. Farmers can connect to a particular agricultural stakeholder and receive vouchers for agricultural produce which they redeem by presenting these vouchers. The government leveraged on this platform to subsidize the provision of fertilizer in collaboration with fertilizer producers. In 2014 the e-wallet system added about 30-40 billion dollars to Nigeria's GDP (Alabi et al,2016).

In a study of three sample sets of farmers conducted by (Adebo, 2014) on the e-wallet approach in Kwara State, Nigeria, 53.5%, 51.0% & 87.2% of the respondents' respectively benefited from improved seeds of maize, rice and two bags of fertilizers each. This program has helped to eliminate corruption and has improved access to timely farm inputs which is critical to improved productivity.

The e-wallet approach provides direct linkage between the farmers and the government which enables government to distribute valuable information to farmers and provide support for the program. (Adebo, 2014) identified some challenges of the system to include telephony network failure, low level of awareness among farmers, cumbersome procedure of getting approval from the mobile provider, low density coverage of agro-dealers, and supply of fertilizer and maize seeds.

Despite its challenges the e-wallet approach has proven to be an effective example of the application of mobile telephony in improving access to agricultural information and inputs which have a direct effect on agricultural productivity.

The e-wallet system is an example of how mobile phones can be used to provide help to farmers in a developing country.

2.4 Conclusion

The Nigerian agricultural system which has been beset with a myriad of problems has had a long and unstable history. The Agricultural Development Projects (ADPs) intervention by the World Bank in the 1970s provided the much needed support for agricultural extension services. However, the program has suffered many problems especially the stoppage of funds coming from the World Bank.

Small holder farmers form about 80% of farmers and produce about 98% of the food consumed by Nigerians. It is therefore important that they should be supported. However, most farmers do not feel the impact of the vast amount of innovation due to challenges with getting these innovations across to them in a timely manner.

Female farmers are not as supported as their male counterparts when it comes to agricultural information dissemination. This is largely due to socio-cultural and economic factors. There have been initiatives like the Women in Agriculture (WIA) programme in Kaduna State, Nigeria (Tologbonse *et al.*, 2013) to improve their access to much needed agricultural information but these can be further supported with the use of mobile phones which are cheap and easily accessible to

many female smallholder farmers.

Agricultural extension services in developing countries still have a long way to go when compared with those in developed countries. The recent upsurge in mobile telephone penetration in sub-Saharan Africa and Nigeria provides a window of opportunity for agricultural information to be more easily and widely available to small holder farmers.

There are still significant challenges in adopting mobile technology for agricultural information dissemination in Nigeria. However, the adoption and the use of mobile phones in the dissemination of agricultural information will go a long way in mitigating the many challenges of other more traditional modes of agricultural information dissemination.

Chapter 3

Methodology

3.1 Introduction

In this study, we adopted a mixed method research approach. The study made use of literature review, surveys, one-to-one interviews and focus group discussions (FGDs). A review of literature about agricultural extension delivery in developing countries with emphasis on the role Information communication technology (ICT) plays was done to have an understanding of the present state of ICT enabled agricultural extension delivery in Nigeria.

3.2 Ethical Approval

Ethical approval was sought from the Aberystwyth University authorities before the study was undertaken. An application was made to the university authorities which was subsequently approved (See Appendix D). The survey questionnaire which was circulated among the respondents made it clear that the information being gathered was going to be anonymised. The FCAH&PT management was duly briefed about the nature and purpose of the survey and FGDs. They also granted approval for some of their staff to be part of the team conducting the FGDs. Farmers involved in the FGDs were all briefed about the nature and purpose of the survey before every FGD was conducted. All the information gathered during the interviews and surveys were anonymised to protect the identity of the respondents.

3.3 2016 survey

In an attempt to answer the primary research question of this study which seeks to look for a way to present agricultural information to small holder farmers so they can easily access them, a survey to poultry farmers in Jos, Plateau State, Nigeria was conducted. The idea of the survey was to find out the perception of small-holder farmers in Jos, Plateau State, Nigeria of the present level of agricultural extension support they receive from extension agencies.

These poultry farmers were chosen for the survey because of their relative small flock size of less than 5,000 for most of the farmers and because they have been receiving regular support from an extension agency i.e. Evangelical Church Winning All (ECWA) rural development program.

One hundred and twenty (120) semi-structured questionnaires were distributed to farmers. The questionnaire was divided into four (4) sections. The first section was designed to elicit demographic data about the farmer and the farm. The second section was composed of information about the extension support given to farmers by agricultural extension agencies. The third section sought to ascertain the perception of poultry farmers to extension support received and the fourth section was designed to determine the level of mobile phone and Internet penetration among poultry farmers in Plateau state. The Likert scale was used to design some questions in section two and three especially the question seeking to elicit perception of extension support to farmers. One hundred and seventeen (117) questionnaires were returned back at various levels of completion.

Seven (7) staff from Evangelical Church Winning All (ECWA) rural development program which provides most of the extension services for poultry farmers in Plateau State were used to elicit information from the respondents. This was done because of the trust level that had been built up between the farmers and ECWA staff. In addition three (3) staff of the Federal College of Animal Health and Production Technology (FCAH&PT), Vom and one freelance enumerator was also engaged. There was an average of one staff to ten (10) farmers. The staff either gave the farmers the questionnaire to fill themselves or helped the farmers to fill the questionnaire by asking the questions and giving them the options.

The choice of these staff was based on the fact that farmers would be more comfortable with people they know. These staff were also professionals and would have a better understanding of eliciting information using questionnaire. The results of the questionnaire were analysed using descriptive statistics to determine common trends.

3.3.1 Survey area

The study was carried out in Jos the capital of Plateau State, Nigeria and its surrounding environment. Plateau State is a large producer of poultry products and Jos with its cool environment provides a suitable atmosphere for poultry production. Most of the farms surveyed were located at the outskirts of Jos. Plateau State was chosen for this survey because of the importance the poultry industry to Plateau State and the present challenges it is facing especially concerning extension information delivery and dissemination.

3.3.2 Data Collection

Data for this study was collected using both primary and secondary sources. Primary sources were the main source of data. Community-based participatory research (CBPR) was used in getting the primary data for this study. The use of CBPR was predicated on the fact that we needed to equitably involve community

members, researchers and organisational members in all aspects of the research process. The purpose of doing this was to increase knowledge and understanding of the present state of agricultural extension delivery to small holder farmers in Nigeria and particularly Jos South Local government area of Plateau State. We also needed to understand the extension needs of the small holder farmers to appropriately develop a suitable farmer advice application that will be useful to the farmers. In 2016 a questionnaire survey was conducted to review the trends in mobile computing-based extension delivery in Jos, Nigeria. Applications of mobile help to farmers in developing countries were also reviewed.

3.3.3 Data Analysis

Data collected through the survey of small holder farmers in Jos was subjected to a series of treatments. Descriptive and inferential statistics was used to analyse the data to achieve the objectives of the study.

3.4 Formation of extension expert's team

In January 2017 a team of local extension experts was setup to conduct focus group discussions (FGDs) and one-to-one meetings with local farmers in Jos, Plateau State, Nigeria to determine the type of agricultural produce they are involved in, their concerns and their agricultural extension needs.

The team was made up of staff on the West Africa Agricultural Productivity Programme (WAAPP) in the Federal College of Animal Health and Production Technology (FCAH&PT), Vom, Nigeria. FCAH&PT, Vom was one of the beneficiaries of the programme. The college setup the above-mentioned team to run the programme. The FCAH&PT WAAPP intervention included setting up of WAAPP Outreach centres in nearby villages. These outreach centres had the mandate to setup demonstration farms which were used to deploy new innovations and technologies as well as provide training on new techniques for the local farmers. It was therefore fitting for this team which had ongoing interactions with local farmers to be used for the FGDs. The WAAPP Team included:

- Mr. Philemon Dabi (Agricultural economist)
- Mr. Sam Shwarpshakka (Crop science)
- Dr. Thomas Adisa (Agricultural extension)
- Dr. Irmiya Jabil (Agricultural economist)

3.5 2017 FGDs

The FGDs were conducted in Riyom and Ganawuri local government areas of Plateau State, Nigeria. A purposive sample was employed in choosing these locations from amongst rural farming locations in Jos South Local government of

Plateau State which was the scope of our study. They were chosen because they had benefited from intervention from the WAAPP team. The WAAPP team had already established a good relationship with the farmers and had an idea of their extension needs. The familiarity with farmers in these farming communities made it easy for the team to conduct FGDs in those areas.

Transcripts of the discussions were written down by the facilitator. Preliminary information about the needs of the farmers and their perception of agricultural extension delivery was sought. In Riyom and Ganawuri the farmers listed the common crops and animals they were involved in. They also listed their needs and concerns in farming these crops and animals.

3.5.1 Riyom

In Riyom, four farmer representatives were selected. These farmers were representing farmers of the four main farming groups. Many of the farmers were of the opinion that the FGDs were an extension of the WAAPP program which had been discontinued due to lack of funding. The farmers were therefore keen on attending in person rather than via representatives in case they would benefit in kind.

The farmers were gathered into a group and were asked questions about their agricultural information needs as well as their perception of agricultural extension delivery. These questions were asked in both English and Hausa which are the most widely spoken languages by farmers in these communities.

In Riyom, the farmers listed the following commonly grown crops and animals in the region as : Maize, Millet, Sorghum, Irish potatoes, Sweet potatoes, Soy beans, Rice, Tamba and Vegetables (Assorted). The farmers also listed commonly kept livestock to include: Sheep and goats, Poultry, Pigs and Fish. It was noted that all the farmers were small holder farmers who cultivate more that one type of crop in addition to keeping different types of livestock.

3.5.2 Ganawuri

In Ganawuri all the farmers decided to take part in the FGDs as against their representatives. The farmers consisted of both male and female as well as school children in the Ganawuri community. As in Riyom many of the farmers decided to attend in person because they thought that the FGD was a continuation of the WAAPP program.

The comments that came from the interactions with the farmers in Ganawuri were similar to those in Riyom town. Many of the farmers complained about lack of timely information and extension support to resolve issues of pest and diseases (P&D) to their crops and livestock. They were most concerned about P&D in crops like rice, Acha, cabbage, and sweet pepper (which are major crops produced in the area).They also complained about access to markets and customers of their products. They implicated this as the major problem affecting the commercial success of their farming activities.

3.6 2019 FGD

Additional FGDs were carried out to the same group of farmers in January 2019. These FGDs were conducted to get more information from the farmers about their agricultural extension information needs. The information gathered were question and answer pairs for concerns they had with the crops and animals they were farming. Examples of the question and answer pairs can be seen in Appendix B.

3.7 Data Analysis

The data gathered from the FGDs were analysed to determine themes and patterns. The farmers' activities were grouped into crop and animal farming. A summary of the transcripts of the FGDs which contained information about the crops and animals that the farmers needed was collated and then further edited by the team to conform to standards that can be useful to small holder farmers. It was observed that farmers only enumerated problems/concerns they presently had thereby eliminating potential problems that could occur. For example one of the farmers who had experienced wilting of maize leaves in the previous season sought to know how to prevent and control the reoccurrence of the problem (See Appendix B.1 Que.8). Their concerns were dependent on their locality. For example one of the questions sought to know the best time to sow maize (See Appendix B.1 Que. 2). This answer may differ depending on which part of the Nigeria you are in although it is similar for farmers in Plateau State. In order to capture concerns across all seasons and with a wider coverage the team had to rely on their expertise to generate some more concerns based on past experience working with farmers in that area. For example team members who had experience of handling stalk borers were able to generate questions and answer pairs on how to prevent and treat the problem (see Appendix B.1 Ques 4 and 5). These generated questions were then edited to make them more easily understandable to local farmers (see Appendix B.2 Que. 7).

3.8 Developing requirements for mobile farm query systems

The survey conducted on poultry farmers in Jos, Plateau State, Nigeria and the transcript summary from the FGDs highlighted some needs of the farmers which led to the development of requirements for the mobile farm query system. Many of the farmers do not have access to the Internet all the time which makes it important to develop a system where they can access information even when they are not within an Internet coverage area. Most of the farmers who were surveyed and those who attended the FGDs were involved in farming more than one crop or rearing more than one type of livestock. This is the case with smallholder farmers in Nigeria and indeed the world. Where large landowners can specialise and become experts in one crop or animal, subsistence farmers have a broader range of crops and animals, partly for their own use, and partly to reduce risk,

and need to know about a wider range of crops and animals than they can possibly be experts in. The farmers are largely not educated and they speak more than one language. Nigeria is a multi-ethnic country with many languages and this was also taken into consideration when developing the farm query system. They are basically subsistence farmers and don't generate so much income from their farming activities therefore any intervention targeted towards them has to be affordable. A review of related techniques (see 8.2) revealed that doing a text search on a mobile phone will produce so much results. This will be a problem to the average small holder farmer to sort through in search of an answer to their query. Closely aligned to this is the challenge of the limited amount of information that can be displayed on a mobile phone screen at any one time. Another important issue that came up as a result the FGDs was that many small holder farmers are illiterate and therefore will find it difficult to construct long queries needed for a text based search system. Therefore these requirements for a farm mobile query system were proposed:

1. As little input as possible by the user
2. Limited data visible to the user
3. Usable when Internet is not available
4. Wide range of help for farmers
5. Easy expansion of the system
6. Availability in minority languages and
7. Sustainability within developing country budgets

3.9 Developing farmer mobile query technique

General principles for the arrangement of information on mobile phones were reviewed to determine their fit for mobile farm query purposes. A mobile query technique that meets the requirements of providing access to information for rural farmers was developed. The technique requires the repeated partitioning of the domain so that the user can select the appropriate partition at any level, and gradually home in on the desired answer. This technique was used to develop a farming advice system for rural farmers in Jos, Plateau State, Nigeria. The farming advice system partitions the farming advice domain into three major groups i.e. Grains/tubers, Vegetables and Animals. These groups are further partitioned into smaller groups based on how local farmers group farming concerns and with some inspiration from case-based reasoning.

3.10 Data entry and classification

The questions and answers crowd sourced from the farmers and those generated by the team were edited by the team at FCAH&PT. The edits were done to make

sure that question and answer (Q/A) pairs were accurate and easily understandable by small holder farmers. They were then transmitted via email to the team at Aberystwyth University. The team in Aberystwyth University further edited the information for context and grammatical errors. The information was then classified using the farmer mobile query technique. The Q/As were first classified into either crops or animals. This is the top level of the Farmer Advice system. The crops and animals were further subdivided into more closely related groupings i.e. poultry, large animals, maize, rice etc. They were then organised into concerns or issues e.g. pest/disease, storing, sowing etc. This was done with the help of a classifier built for this purpose. The classified information was then uploaded to the Farmer advice system. The process was repeated whenever any data was received from the team in Nigeria.

3.11 Implementation using mobile app

An Android based mobile application was used to implement the farmer mobile query technique. The Android platform was preferred over other mobile phone platforms because a vast majority of mobile phones run the Android application in Nigeria.

In December 2019 another FGD was organised in the FCAH&PT college premises. Farmers' representatives from Riyom and Ganawuri were gathered. A presentation of the farmer advice system was done and the farmers were asked to evaluate the system. The farmers observed that some commonly farmed crops and animals were missing from the farmer advice system. They also reordered the concerns for the crops and animals to align with their farming cycle from land preparation to marketing. The farmer advice app was distributed to the farmers via the google app store.

3.12 Application to other domains

The mobile query technique was also used to arrange Q/A pairs from the Aberystwyth University IS and information from the personal health data domain. These application areas were chosen because of the potential benefit an effective mobile query system will have on these datasets. Details of these implementations can be found in Appendix C.

3.13 Conclusion

This work was conducted with the primary aim of developing a mobile query system that will make it easy for small holder farmers to access much needed locally relevant agricultural information. Nigeria has a large number of small holder farmers which will benefit from this kind of intervention. There is a lot of agricultural information available but little trickle down to these smallholder farmers. One of the major challenges identified is the lack of timely access to much

needed agricultural information by these small holder farmers. This challenge is also mirrored in most developing countries.

A survey of smallholder poultry farmers as well as FGDs were conducted in Jos, Plateau State Nigeria to understand the needs of these smallholder farmers as well as their present level of help from extension agencies. The information was gathered over a couple of years. The survey was carried out on these farmers because of their access to extension support, their low income levels, their smallholder status and the almost even distribution between male and female farmers. The FGDs were conducted on smallholder farmers in rural parts of Jos, Plateau state because they are representative of most farmers in the developing world who are rural based smallholder farmers A review of literature about ICT intervention for small holder farmers and techniques for searching information online was also done. These led to the development of some requirements for effective mobile farm query systems (see 3.8). A mobile query technique which meets the requirements for smallholder rural farmers by ontology-based partitioning was developed. The technique requires the repeated partitioning of the domain so that the user can select the appropriate partition at any level, and gradually home in on the desired answer. This technique was used to develop farming advice system for rural farmers in Jos, Plateau State Nigeria. This system can be modified and used for most smallholder farmers in the world because these farmers share the same characteristics.

The technique was also applied to two other domains namely FAQ Aberystwyth University and Personal Health Service for the UK. The developed principles for breaking down a domain have proven effective for these domains.

Chapter 4

Literature Review

4.1 Introduction

Agricultural development has evolved over the world with lots of innovation and intervention. Much of this evolution has not been properly communicated to small holder farmers especially to those in developing countries. Although as at 2005 there were over 500,000 agricultural extension workers worldwide (Anderson & Feder, 2007), this has not translated in improved uptake of agricultural innovation and technology by farmers especially those in Sub Saharan Africa. Farmers in developed countries have benefited immensely from lots of these innovation and intervention. This has had the effect of a massive improvement in productivity which is represented by increase in yield per hectare, marked improvement in farmers' incomes and general well-being of the farmers.

Timely access to agricultural information by farmers is critical to agricultural productivity. ICT has the potential of improving agricultural information delivery and farmers productivity. Information communications technology (ICT) has had a very great impact on the improvement of outcomes for many farmers in developed countries. However, the same cannot be said of farmers especially smallholder farmers in developing countries.

However, it is good to note that there has been a flurry of ICT intervention in agriculture in developing countries in recent years. An increase in mobile phone penetration in developing countries has led to a revolution in rural connectivity amongst small-holder farmers in developing countries (Duncombe, 2016). This has come on the back of increased ICT infrastructural deployment in developing countries. The wide use of mobile phone services in recent years especially amongst small holder farmers in developing countries has led to an enhancement in communication and information exchange and an innovation in service delivery (Donner, 2009).

4.2 ICT in Agriculture

Agriculture is the oldest profession in the world however, it is the least developed when it comes to ICT intervention. Information Communications Technology

(ICT) has become more ubiquitous in different fields of endeavour. From its early days as just a tool to aid calculation to the Internet of Things (IOT), Artificial Intelligence and Quantum computing. According to (Chowhan & Ghosh, 2020) modern agriculture has become so dependent on the use of ICT. However, the agriculture sector has not adopted the use of ICT as quickly as other sectors. There is also a digital divide in the adoption of ICT in agriculture. Whereas countries in Europe, North America and recently Asia have fully embraced ICT in agriculture the same cannot be said for countries in Africa, South America and some parts of Asia and the Middle East.

There have been many factors that have been implicated with the slow adoption of ICT for agriculture in developing countries. These range from economic to socio cultural factors. Most of the ICT interventions in Agriculture are developed in western countries and are often tailored to meet the needs of their local farmers. These interventions have not been domesticated to meet the needs of farmers in developing countries and in most cases when they are domesticated they are too expensive for the local African farmers.

According to (Gelb *et al.*, 2008) there are several other factors that impede the adoption of ICT in Agriculture. They include the paucity of ICT infrastructure especially in rural areas. This is one of the major impediments to ICT adoption in agriculture especially in sub Saharan Africa. This is however being mitigated by the widespread adoption of mobile telephony by most countries within the region.

Another factor implicated by (Gelb *et al.*, 2008) is the lack of integration of indigenous and localised information into the ICT deployment technology. There is so much indigenous agricultural knowledge in sub Saharan Africa that have been successfully utilised by the local farming population. This knowledge has been restricted within communities and farming families for many years and ICT can be a very important tool to disseminate and improve upon this knowledge for the benefit of most farmers.

Other constraints to ICT adoption include the lack of understanding of the needs of rural small holder farmers within a particular community. These needs vary as the small holder farmers and their communities vary. It is therefore important to have a good understanding of the farmers' specific needs when deploying ICT tools for them.

According to (Haider *et al.*, 2019), lack of education and information on how to use ICT tools is a major challenge in the adoption of ICT in agriculture. Unlike in some other sectors many small holder farmers in sub Saharan Africa are not well educated and therefore have a challenge in understanding how to use many ICT interventions. There is therefore need to strengthen agricultural extension services in these areas.

4.3 ICT and Agricultural Information delivery

Agricultural Information delivery has been linked to improved productivity among farmers. In their study of extension information delivery in Pakistan (Raza *et al.*, 2019) remarked that there was a link between increased crop yield and knowledge

of agricultural innovations by the farmers. This has brought to the fore the need to prioritise the dissemination of relevant agricultural information to small holder farmers especially in sub Saharan Africa which has a much lower yield as compared to other regions of the world.

Agricultural extension services in most developing countries have not been as effective as in developed countries. This has had serious implications on the productivity of the average farmer in a developing country. Traditional agricultural extension delivery systems that rely on many extension workers and good infrastructure especially in rural areas have challenges especially in sub Saharan Africa. For example, Ethiopia has 65,000 extension workers (Getahun, 2020). However, maintaining these number of extension workers can have a very heavy financial strain of the country's agricultural system. This is the case in many sub Saharan African countries. Infrastructural constraints which range from bad roads to inadequate transportation facilities for agricultural extension workers have put a strain on the agricultural extension delivery system in many sub Saharan African countries.

According to (Matto, 2018) in their study on agricultural information access and use among small holder farmers in Malawi, they observed that small holder farmers had limited access to relevant agricultural information that would have helped them improve their productivity. The farmers also lacked access to market information. This lack of access to much needed agricultural information is common to most sub Saharan African countries.

It has therefore become imperative to look to other cost effective and efficient ways of bridging the information gap that exists between small holder farmers and much needed agricultural innovation and information.

Information Communications Technology (ICT) has been deployed successfully in agricultural information delivery. According to (Chavula, 2014), ICT serves as a link between extension workers and farmers. This link is becoming much more imperative especially in developing countries due to the challenges of traditional agricultural extension methods. The fast acceptance and widespread nature of mobile telephony has contributed immensely to this success.

There is also increasing awareness of the use of ICT tools by smallholder farmers. In their study of the awareness of ICT tools in Koppal district of Karnataka State (Patil *et al.*, 2018) observed that over half of the farmers surveyed had some awareness of ICT tools and services. They also observed that most of the farmers were aware of mobile advisory services.

According to (Mishra *et al.*, 2020), ICT services are useful in the dissemination of much needed agricultural innovations and technology. The technology include agro-processing information, crop yield information, crop production technologies, market information, agro-finance, information about available and useful agricultural inputs and farm management to mention some. It is important to understand the needs of small holder farmers to be able to capture the relevant information they need. It is also important that this information is locally relevant to their circumstances and is culturally sensitive to their needs.

In their study on the preferences of mobile agro advisory services in Tamil Nadu (Prabha & Arunachalam, 2017) observed that most farmers opined that services

which provided information on weather conditions and plant diseases were high on their priority list. They also preferred that this advisory be given on a daily basis in the mornings.

According to (Aldosari *et al.*, 2019) in their study of the perception of farmers in Northern Pakistan regarding their use of ICT, they observed that ICT tools are a useful source of agricultural information to farmers. They however stressed the need for training and education of farmers on the use of these ICT tools for them to have the desired uptake and impact on their agricultural productivity. This has been a major concern with the deployment of ICT tools for rural small holder farmers in sub Saharan Africa. There is therefore the need to prioritise the education and training of these small holder farmers on the proper utilisation and of ICT delivery tools.

4.4 Mobile Telephony: Improving Access to Agricultural Information

Most farmers live in rural areas which are largely underserved by ICT infrastructure like Internet services, broadband connection and telecommunications services. This has had its effect on extension delivery to farmers in developing countries. The recent upsurge in mobile telephone activities in developing countries and the vast coverage of mobile telephony services in developing countries especially in Sub-Saharan Africa provides an opportunity to improve access to agricultural extension services by rural farmers in developing countries. Many developing countries in collaboration with developmental agencies have begun to leverage on this new found tool to improve access and ultimately productivity of rural farmers.

(Razaque & Sallah, 2013) remarked that mobile phones are a very convenient, cheap and time saving tool for bridging the knowledge gap that farmers have. In their study of the use of mobile phones among farmers they observed that mobile phones helped to provide cheap access to a wide range of information from weather forecast information to market information. This they said had a positive impact on the farmers' income. It must be noted that one of the major challenges of the uptake of ICT by small holder farmers is lack of ICT infrastructure and the cost of adoption of ICT tools. With the very widespread deployment of mobile telephony in Sub-Saharan Africa a window of opportunity has been opened to leverage on this upsurge in the use of mobile phones.

In their study on of small holder farmers in Sub-Saharan Africa, (Ogbeide & Ele, 2015) noted that mobile phones have a significant role to play in reducing the inefficiencies in the agricultural value chain. According to them, mobile phones have proven popular among younger farmers who are already familiar with the use of mobile phones for other activities. This is a very important benefit of the use of mobile phones in agriculture. It should be noted that Sub-Saharan Africa has one of the youngest populations in the world. It is therefore imperative to incentivise this young population to actively participate in agriculture if we want farming to be sustainable in Africa. The use of mobile phones provides that incentive to further engage young people in farming.

In their study of the usefulness of mobile services to farmers in Bishnupur District of Manipur State in India (Govind *et al.*, 2018) opined that mobile phones have had the effect of reducing the costs of transferring extension information to farmers. This is very vital to the extension delivery process in developing countries where paucity of funds has limited their ability to fund traditional extension delivery models which require the services of large numbers of extension workers visiting farms on regular basis. The local language needs of the farmers surveyed was also taken into consideration. This is very important especially in sub Saharan Africa and Nigeria in particular where there may be many languages spoken within a small geographical area.

Mobile phone adoption in extension service delivery has proven to be very successful in developing countries. In their study of the deployment of Avaaj Otalo (AO) mobile application among cotton farmers in Gujarat, India, (Cole & Fernando, 2012) observed an increase in the uptake of modern and better farm management practices by the farmers. They also observed an increased desire by the farmers to use mobile phones to access information on agricultural practices. It is however noted that many of the farmers did not understand the information they got from the mobile devices. This brings to the fore the need for farmers to be supported in their use of mobile phones in accessing knowledge.

Some countries have had a head start in the deployment of mobile phones in agricultural information delivery. In their study of mobile phone usage among Cypriot farmers (Adamides & Stylianou, 2013) observed that nearly 98% of the farmers use mobile phones to source agricultural information. They also observed that the usage of mobile phones cuts across all educational and demographic barriers. This study has highlighted the need to spread the benefits of mobile phone usage to developing countries who are affected by lots of constraints which mobile phone usage can help to mitigate.

However, as noted by (Aker, 2011) there are design and implementation constraints in the uptake and deployment of mobile phone solutions in Agriculture. Mobile phones have small screens and therefore cannot take as much information as personal computers and other ICT devices. It is therefore important to provide a system that will minimize the need to view large amounts of information on the screen at the same time. An easy to use interface which provides farmers with the opportunity to choose from options will serve them better.

Chapter 5

Survey of smallholder farmers in Jos, Plateau State

5.1 Introduction

The purpose of the survey was to assess farmers' perception of the present level of interaction between farmers and extension agencies in Nigeria in relation to the level of support given to the farmers via farm/extension information delivery. The result of the survey alongside the results from the FGDs were taking into consideration when developing the requirements for the mobile farm query system. The survey results also provided a justification to deploy a farm query system for small holder farmers in Plateau State, Nigeria.

Within the past two decades there has been a burst of research activities by Nigerian universities and agricultural research centres. Far reaching innovations capable of boosting small holder farmers' productivity have been developed. However these research outputs have not had the corresponding effect of improved productivity due to poor dissemination and adoption of these findings A survey of poultry farmers was embarked upon in Jos, Plateau state, Nigeria.

In this survey we look to answer these following questions:

- What are the Demographic characteristics of the poultry farmers in Jos, Plateau State?
- What types of poultry are the farmers in Jos, Plateau State involved in?
- What are the information needs of the poultry farmers in Jos, Plateau State?
- What is their perception of the present level of support they receive from extension agencies?

The results of the survey will form one of the components; the other being the focus group discussion (FGD) undertaken to farmers in some farming communities in Jos South Local Government of Plateau State that will be used as a basis for the development and deployment of a low-tech web based solution for agricultural extension delivery to farmers in Jos, Plateau State.

5.2 Demographic characteristics of the poultry farmers in Jos, Plateau State

In developing solutions for farmers it is important to know the demographic characteristics of the farmers. Many interventions targeting farmers are non-inclusive of a large variety of farmers. This has led to the neglect of many farmers who would have otherwise benefited from such intervention. Particular attention needs to be paid to the contribution of women and young people in farming.

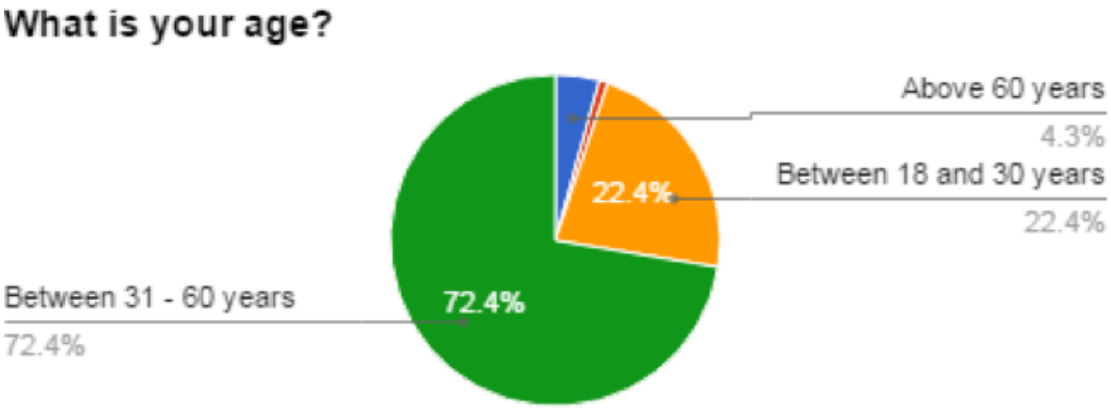

Figure 5.1: Age distribution of farmers

The survey we conducted of poultry farmers in Jos, Plateau State shows that most of the farmers (72.4%) are between the ages of 31 and 60 years and the second largest age bracket of farmers (22.4%) are between the ages of 18 and 30 years (Fig. 3.1).

Table 5.1: Crosstab between gender and age of respondents.

Age	**Female**	**Male**	**Total**
Above 60 years	2(3.8%)	3(4.8%)	5(4.2%)
Below 18 years	0(0%)	1(1.6%)	10(8%)
Between 18 and 30 years	9(17%)	17(27%)	26(22%)
Between 31 and 60 years	41(77.4%)	42(66.7%)	84(71.2%)

There is also a similar age distribution within the male and female farmers with 77.4% of female farmers and 66.7% of male farmers falling between the ages of 31 - 60 years (Table 3.1). This shows that most farmers whether they are male or female are within the active working age population. This has implications for any intervention for them. Intervention has to be gender inclusive especially to capture the working age female farmers.

It is also interesting to note that there is a higher proportion of male farmers (27%) within the younger population (18-30 years) than female farmers (17%) within the same age bracket (Table 3.1). This may not be unconnected to the fact that most rural women in Nigeria within that age bracket are heavily involved

in child care activities and spend most of the time supporting their husbands rather than taking the lead in farming activities. This is quite different from the proportion of female farmers (77.4%) which is higher than the proportion of male farmers (66.7%) (Table 3.1) that fall within the 31 -60 years age bracket. It can be assumed that most women of this older age bracket have less childcare activities as their children must have become older. They are therefore able to dedicate more time to their farming activities. It is therefore important that any intervention that will help small holder farmers has to take these gender and age demographics into consideration to be effective and sustainable.

Women make up over 50% (Ogunlela & Mukhtar, 2009) of smallholder farmers and therefore are a vital player in rural farming. They are a very important and vital part of the farming system in rural communities and participate actively in farming at this level. They have unfortunately being neglected when it comes to providing intervention for smallholder farmers.

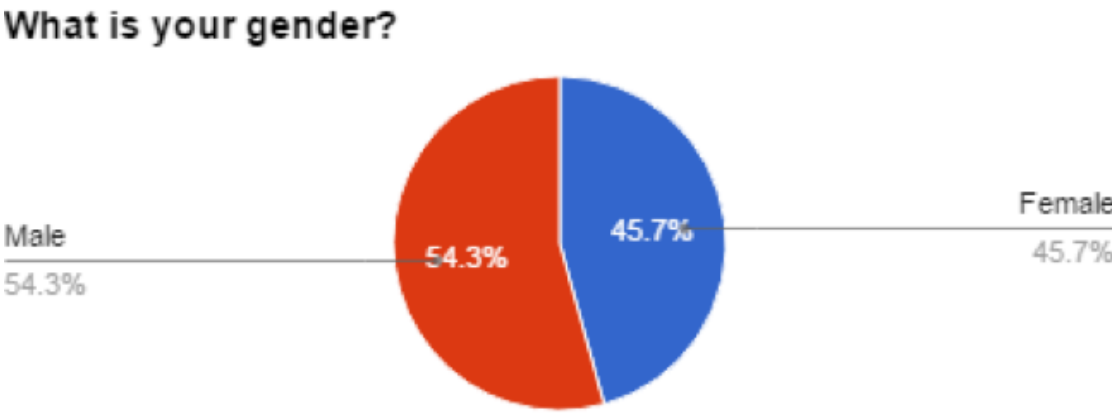

Figure 5.2: Gender of farmers

In our survey of poultry farmers in Jos, Plateau State we found out that there is an almost equal participation of women and men in poultry farming in Plateau State with 53.3% being male and 45.7% female (Fig. 3.2).

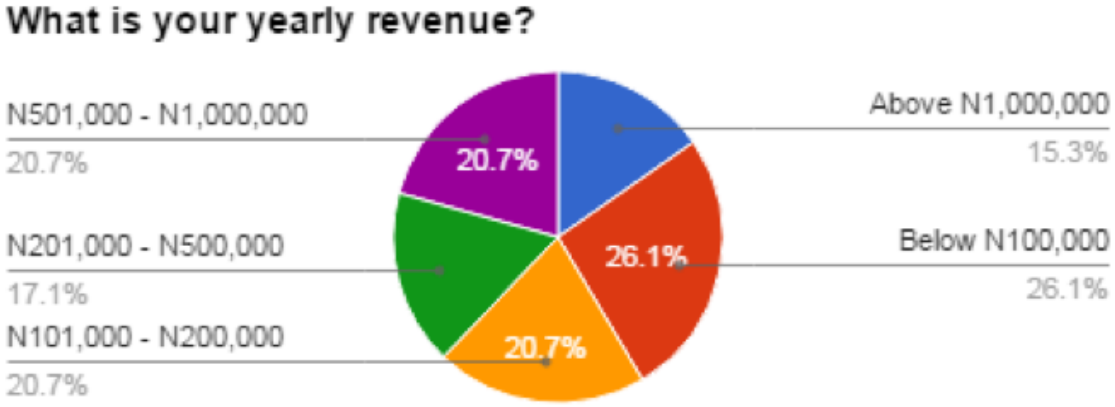

Figure 5.3: Yearly revenue of Farmers

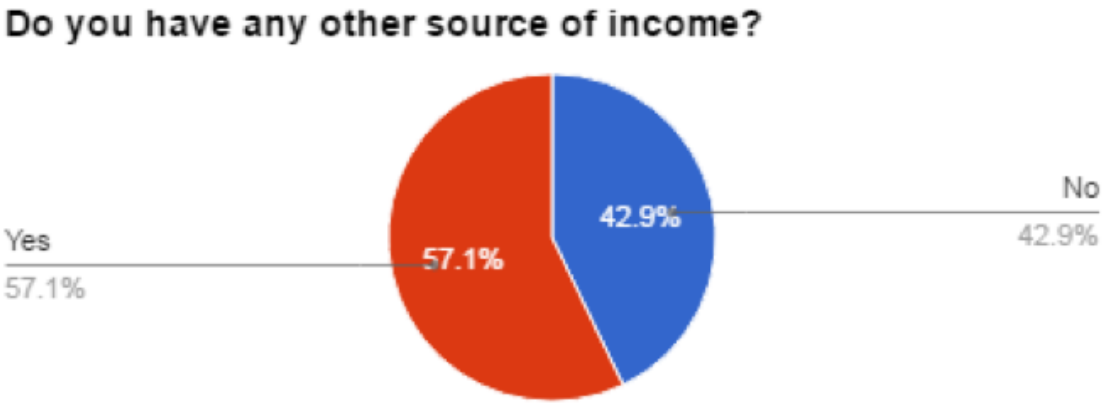

Figure 5.4: Other sources of income for Farmers

The yearly revenue of poultry farmers can be said to be evenly distributed. However many farmers (26.1%)(Fig.3.3) earn less than N100,000 ($500)per annum and about $1.36 dollars a day which is less than the $1.90 a day world poverty level (Newhouse *et al.*, 2016). There is therefore need to improve agricultural productivity and access to markets using technology. However, majority of the respondents have access to other sources of income (57.1%)(Fig.3.4), this may be because many of the farmers have a day job for which the poultry business is only a supplementary income.

Table 5.2: Crosstab between gender and income of respondents.

Income	**Female**	**Male**	**Total**
Above N1 million	5(9.5%)	12(19%)	17(14.5%)
N501,000 to N1 million	6(11.3%)	17(27%)	23(19.7%)
N201,000 to N501,000	7(13.2%)	11(17.5%)	19(16.2%)
N101,000 to N200,000	15(28.3%)	8(12.8%)	23(19.7%)
Below N100,000	15(28.3%)	14(22.2%)	29(24.8%)

Our survey also revealed that only 24.5% of the female farmers earned above N200,000 ($520) per annum from farming as compared to their male counterparts (44.5%) (Table 3.2). This shows a disproportionately large gap between the earnings of male and female smallholder farmers. This may not be unconnected to the earlier stated fact that many women smallholder farmers do not get as much support as their male counterparts get. Due to several socio cultural factors, women are not prioritized when it comes to provision of farming inputs like fertiliser, improved seedlings etc. They also do not have direct contact with extension agents' especially in very conservative parts of Nigeria and rely on second-hand information which may be late and inaccurate. It is very important that any intervention has to take this into consideration. In more conservative parts of Nigeria, female farmers are best reached by female extension workers who will gain more acceptance and be able to interact with and provide more support to those farmers.

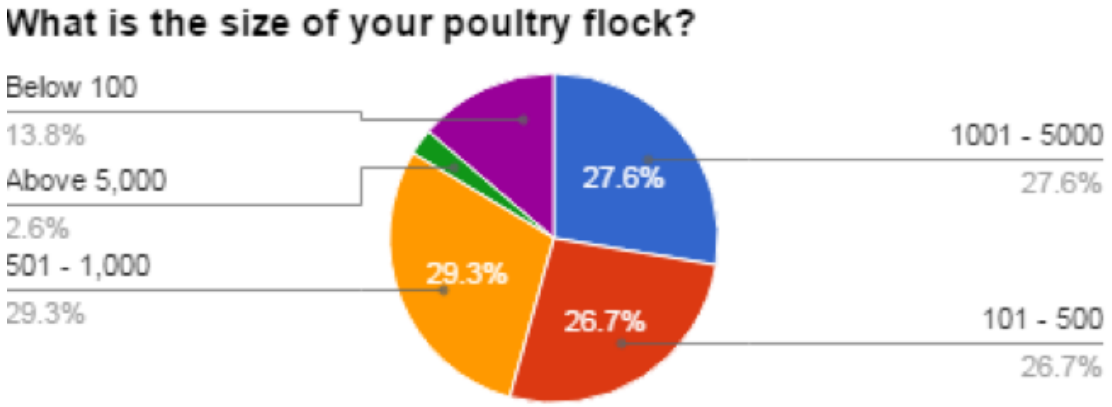

Figure 5.5: Poultry Flock size

Many farmers have medium sized farms with 29.3% having a flock size of 501 – 1,000(Fig.3.5). Very few farmers (2.6%) have a flock size larger than 5,000(Fig 3.5). This goes to show that most of the poultry farmers in Jos, Plateau state are small scale farmers. This is consistent with the view of (Mgbenka *et al.*, 2015) who said that most farmers (80%) in Nigeria are small holder farmers. This makes it more imperative to develop an easy to use solution for accessing farm extension information.

Table 5.3: Crosstab between gender and FarmSize of respondents.

FarmSize	**Female**	**Male**	**Total**
Above 5000	1(1.9%)	2(3.2%)	3(2.6%)
1001 to 5000	14(26.4%)	17(27%)	32(27.4%)
501 to 1000	16(30.2%)	18(28.6%)	34(29.1%)
101 to 500	15(28.3%)	16(25.4%)	31(26.5%)
Below 100	6(11.3%)	10(15.9%)	16(13.7%)

Table 5.4: Crosstab between gender and FarmStaff of respondents.

FarmStaff	**Female**	**Male**	**Total**
6 to 10	2(3.8%)	4(6.3%)	6(5.1%)
1 to 5	51(96.2%)	54(85.7%)	106(90.6%)

It is also interesting to note from the survey that although there is an almost equal representation of female (30.2%) and male (26.8%) (Table 3.3) farmers that have farms with over 500 to 1000 animals, a higher proportion of male farmers (6.3%) as against female farmers (3.8%) (Table 3.4) have more than 5 farm workers. This may be due to the fact that female smallholder farmers don't have as much financial resources as their male counterparts to employ more farmhands and this has an effect on their overall productivity.

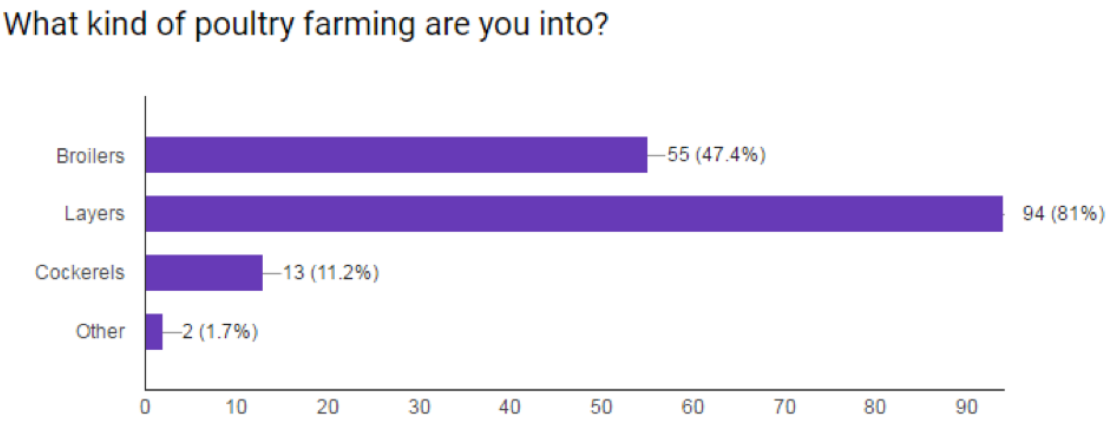

Figure 5.6: Poultry Farm type

Our survey revealed the types of poultry production farmers in Jos, Plateau State are involved in. This knowledge is important in developing the farm query system especially as it concerns poultry production. It will help to determine which information to prioritise when developing the farm query system. Presently 81%(Fig.3.6) of the poultry farmers rear layers. This means that information about layers has to the prioritised when developing a system for farm advisory.

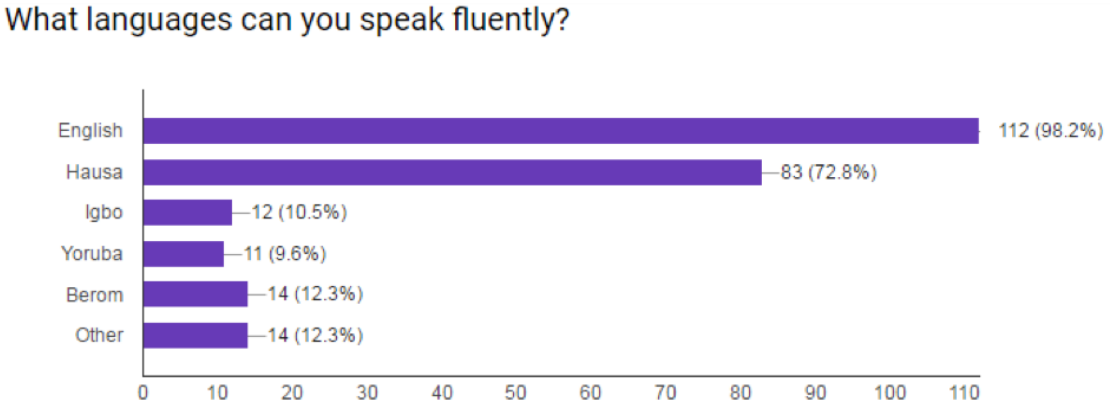

Figure 5.7: Languages spoken by farmers

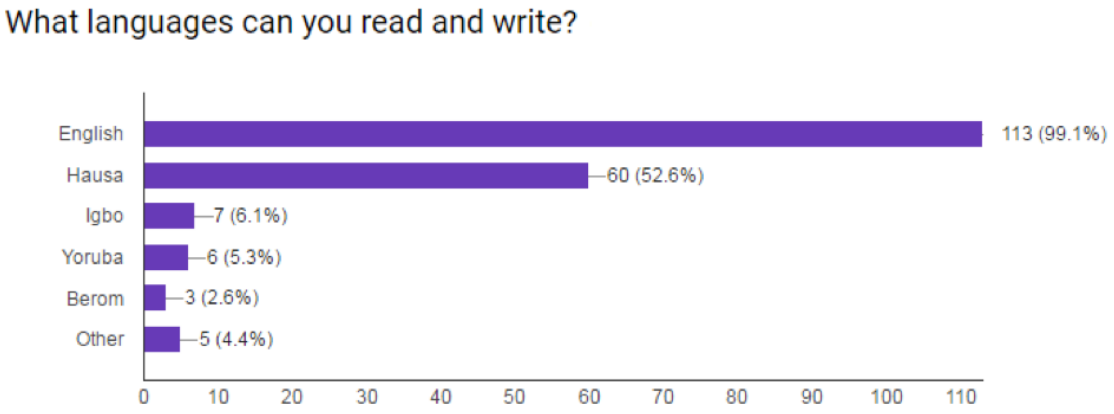

Figure 5.8: Languages farmers can read and write

Most of the farmers can speak English fluently (98.2%)(Fig.3.5) and can also read and write in English (99.1%)(Fig.3.6). Many of the farmers can also speak Hausa fluently (72.8%)(Fig.3.5) and read and write in Hausa (52.6%)(Fig.3.6). This can be attributed to the fact that Jos, Plateau state is in the Northern part of Nigeria where Hausa is the major language. This will guide the building of the cloud and mobile based platform and it is expected that information will be disseminated in at least these two major languages eventually.

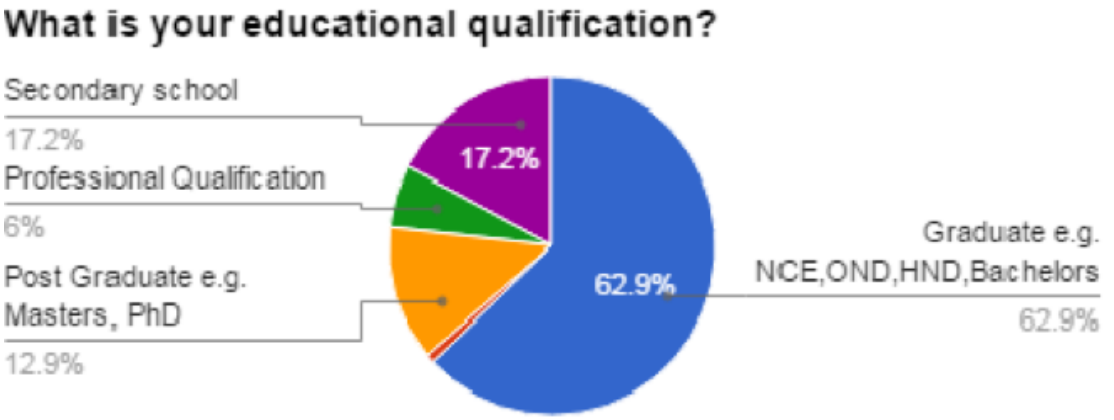

Figure 5.9: Educational qualification of Farmers

Most of the farmers are well educated (62.9% with post-secondary education, 12.9% with post graduate qualifications)(Fig.3.7). This could be attributed to the fact that many young educated people don't have access to jobs and have decided to go into poultry farming as a source of livelihood. An educated and young population of farmers would be very inclined towards accepting ICT tools in their farming practice. It would also be easy for them to use these ICT tools with relative ease and understanding.

5.3 Perception of the present level of support farmers receive from extension agencies

One of the main aims of the survey to poultry farmers in Jos, Plateau State was to assess the perception of the present level of support they receive from extension agencies. This was done to determine which sources the farmers mostly got their extension information from and the frequency of access to these farm extension information.

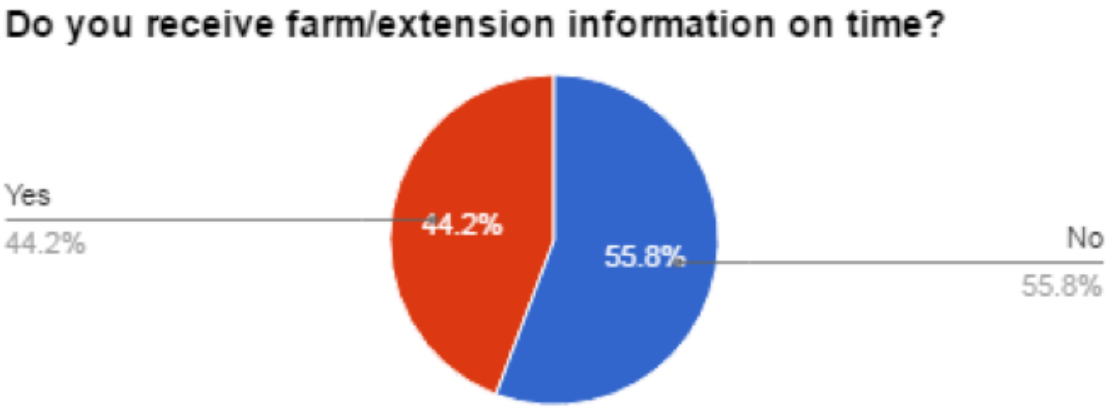

Figure 5.10: Frequency of access of farm extension information to farmers

Figure 3.10 shows that 55.8% of the respondents do not get access to farm/extension information on time while 44.2% of the respondents get farm/extension information on time.

This may be due to the inadequacies in the present extension delivery system that relies heavily on extension agents going to meet farmers on their farms. This method is still important especially in complex cases where farmers need to interact extensively with extension agents face-to-face. However, it is not effective due to earlier highlighted problems like bad roads, inadequate staff, and paucity of funds.

Table 5.5: Crosstab between gender and frequency of access to farm information

TimelyFarmInfo	**Female**	**Male**
No	30(56.6%)	32(50.8%)
Yes	21(39.6%)	29(40.6%)
FreqInfoAccess		
No	22(41.5%)	23(36.5%)
Yes	29(54.7%)	39(61.9%)

There is a slight difference in timely access to extension information between male and female respondents. More male respondents (40.6%) than female respondents (39.6%)(Table 3.5) said they received farm extension information on time. In a similar vein, more male respondents (61.9%) than female respondents (54.7%)

(Table 3.5) say they are satisfied with their frequency of access to farm extension information. This is consistent with the general lop-sidedness in access to farm extension information by female farmers in Nigeria. This makes it imperative to specially target female farmers when it comes to provision of farm extension information. In deploying the farm query application care will be taken to involve more female farmers than male farmers to help address this lop-sidedness in farm information access.

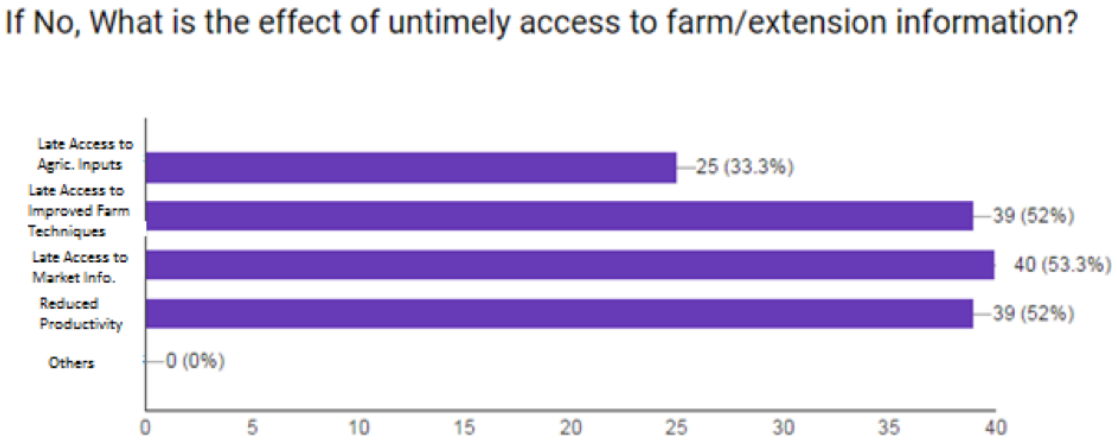

Figure 5.11: Consequences of untimely access to farm extension information

Many farmers have blamed the untimely access to farm/extension information for late access to market information (53.3%)(Fig.3.11), late access to improved farming techniques (52%)(Fig.3.11), reduced productivity (52%)(Fig.3.11) and to a lesser extent late access to agricultural inputs (33.3%)(Fig.3.11). The extension process can be enhanced with the introduction of a cloud and mobile based platform which will guarantee quick and regular access of farmers to farm/extension information. The information that will be contained in the farm query system will take into consideration these farm extension needs and provide answers to questions by farmers in these areas.

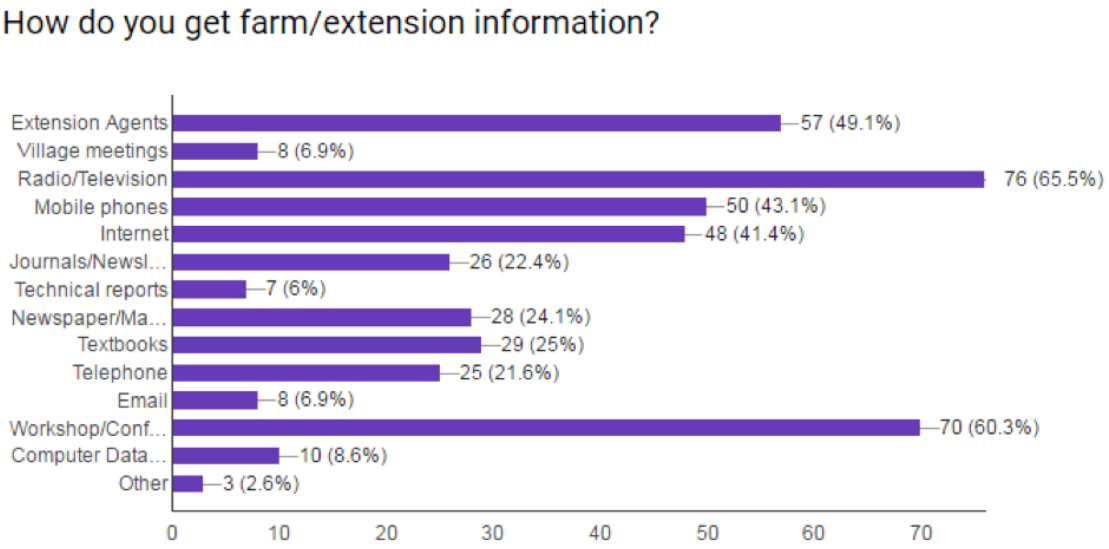

Figure 5.12: Source of farm extension information

Figure 3.12 shows that most of the respondents get farm/extension information through the radio/television (65.5%) and workshop/conferences (60.3%). Many respondents get farm/extension information from extension agents (49.1%), mobile phones (43.1%) and the Internet (41.4%). Some respondents get farm/extension information from textbooks (25%), newspapers/magazines (24.1%), journals /newsletters(22.4%) and telephone (21.6%). A few of the respondents get farm/ extension information from computer databases (8.6%), email (6.9%), village meetings (6.9%), technical reports (6%) and from other sources (2.6%).

Radio/Television remains the most popular channel of getting farm/extension information by farmers. This is so because of the widespread coverage of radio in rural areas. The cloud and mobile-based system will incorporate a forum that will be powered by online radio. Regular updates of relevant workshops/conferences would be accessible on the mobile "app" and would be sent as "push" messages to mobile phones of connected farmers. This will be done in response to the large percentage of farmers (60.3%)(Fig.3.12) who already get information from workshops/conferences. Many farmers already use their mobile phones (43.1%)(Fig.3.12) and the Internet (41.4%)(Fig.3.12) to get farm/extension information. The cloud and mobile based platform will leverage on these tools to improve access to information that would help the farmer to significantly improve productivity and income via access to markets.

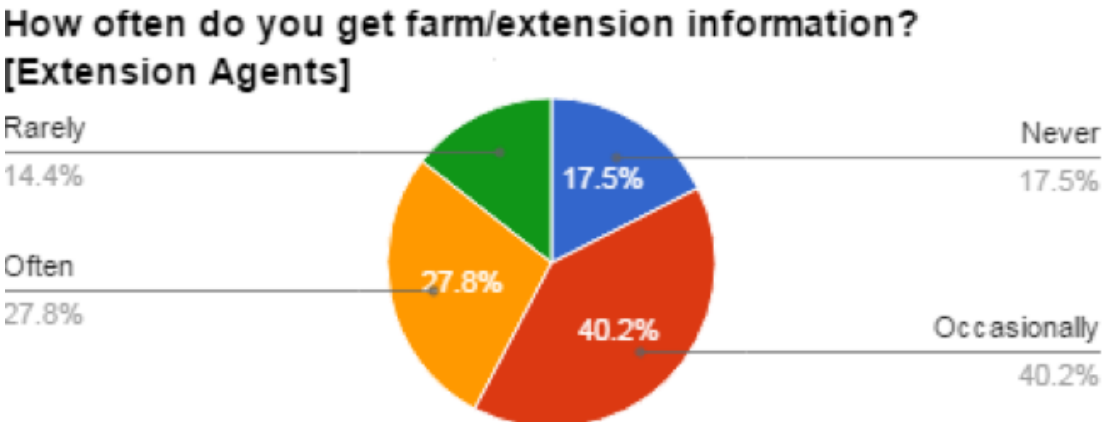

Figure 5.13: Farmers perception of farm extension information delivery from extension agents

A large percentage of respondents (40.2%)(Fig.3.13) get farm/extension information from extension agents occasionally. This low level of interaction between farmers and extension agents can be caused by many factors. Some of these factors include bad roads in rural areas, lack of trained extension agents and paucity of funds to send the extension agents to the field regularly.

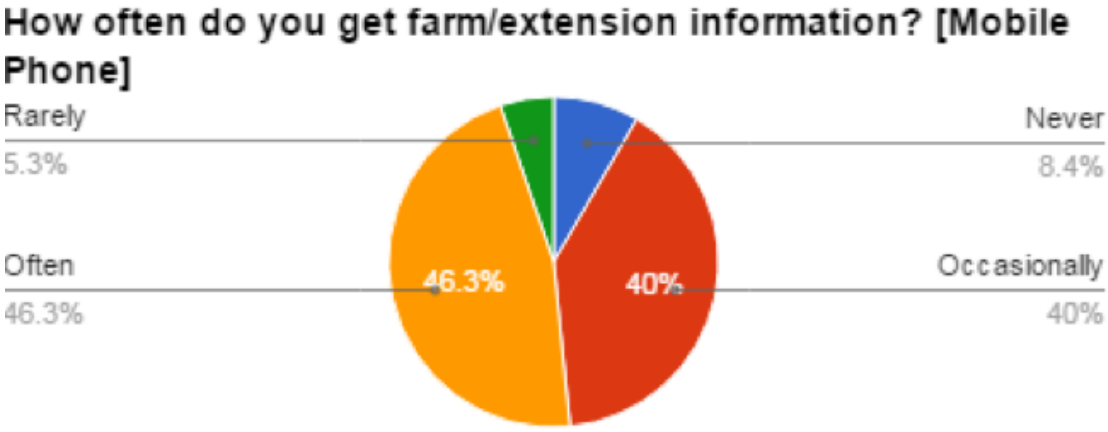

Figure 5.14: Farmers perception of farm extension information delivery via tmobile phones

However a large percentage of farmers (46.3%)(Fig.3.14) get farm/extension information via mobile phones very often which makes it imperative to take advantage of this tool to provide timely and regular access to farm/extension information to farmers.

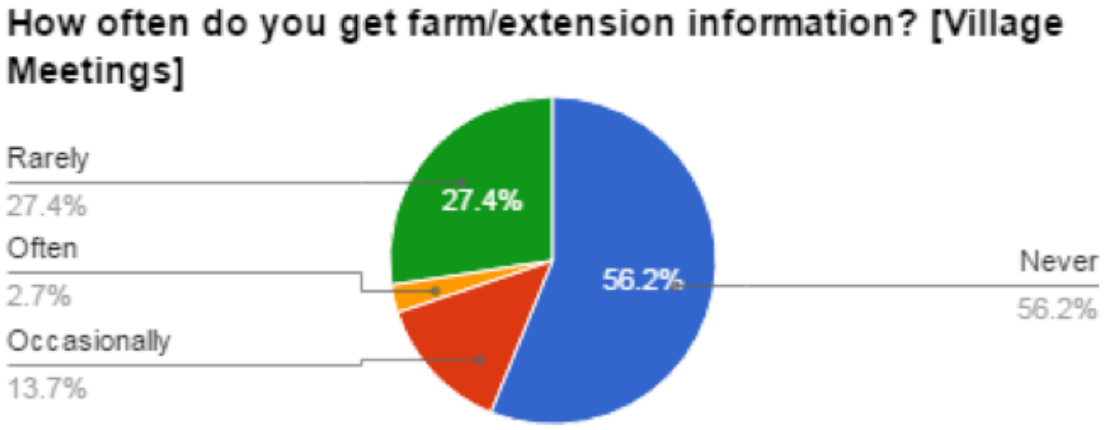

Figure 5.15: Farmers perception of farm extension information delivery via village meetings

Village meetings that should be a good forum to sensitize and educate farmers about new farming techniques and developments are not a popular source of farm/extension information. 56.2%(Fig.3.15) of farmers say they have never received such information from these village meetings. This low patronage of village meetings can be mitigated by setting up an online forum for farmer education, advisory services, and networking using their mobile phones. The farmer query system can be used as a tool to access a wider coverage of smallholder farmers who attend village meetings. An extension agent or experienced farmer who has full access to the query system can serve as a hub for other farmers to access information. The extension agent or farmer is fully connected to the farm query system and in turn passes the farm extension information to other farmers who may not have full access. This will enhance the usefulness of village meetings.

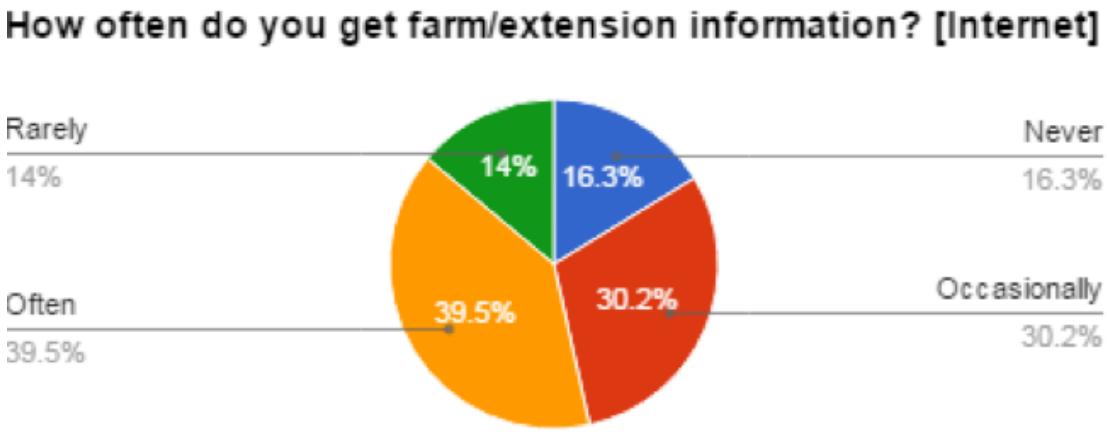

Figure 5.16: Farmers perception of farm extension information delivery via the Internet

The web based platform intends to take advantage of the good patronage of the Internet where 39.5%(Fig.3.16) of the farmers already say they access farm/extension information via the Internet on a regular basis. However, good access the internet cannot be generalised to all farmers in Plateau State, Nigeria.

The platform to be built will grant offline access of information to farmers because of the generally poor internet access in Nigeria especially in rural areas.

The extension process can be enhanced with the introduction of a cloud and mobile based platform which will guarantee quick and regular access of farmers to farm/extension information.

5.4 Farm extension information requirements of farmers

This survey has been able to highlight the information requirements of poultry farmers in Jos and by extension Plateau state. These requirements would also be similar to the requirements for poultry farmers all over Nigeria.

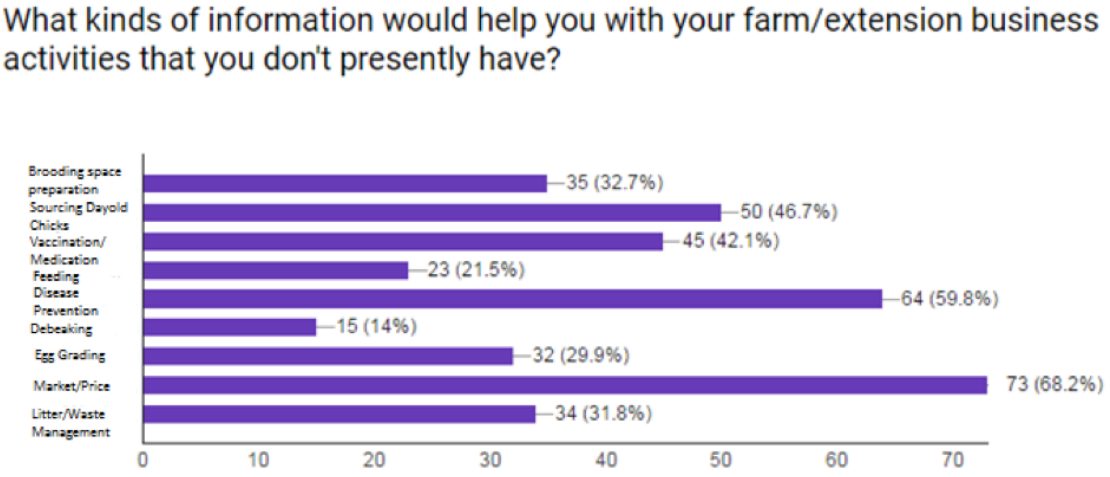

Figure 5.17: Farm extension information needs of farmers

Most farmers need access to marketing/pricing information (68.2%)(Fig.3.17), information about prevention of diseases(59.8%)(Fig.3.17), information about sourcing for day old chicks(46.7%)(Fig.3.17) and information about vaccination/medication (42.1%)(Fig.3.17).

In developing a farm query application for farmers, these concerns need to be adequately represented within the information database and made easily accessible to the farmers.

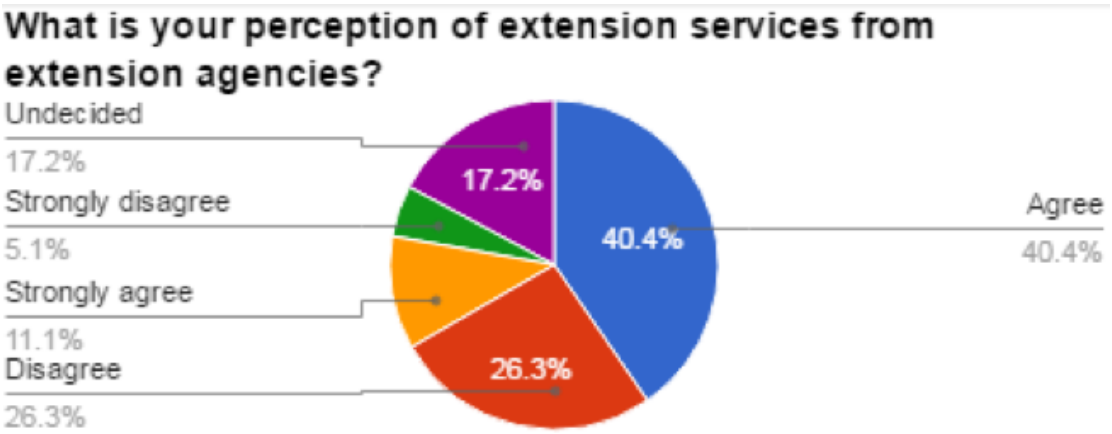

Figure 5.18: Farmers Perception of cost of access to farm extension information being too expensive

From the study many farmers agree (40.4%)(Fig.3.18) that access to extension service is too expensive. It is expected that with the introduction of the cloud and mobile based platform this expense would be reduced drastically.

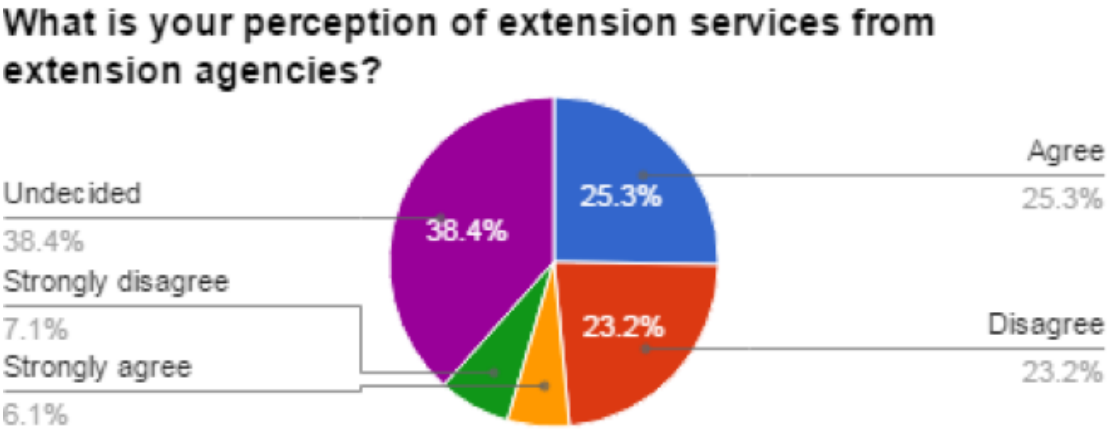

Figure 5.19: Farmers Perception of extension agency bureaucracy being too much

The bureaucracy associated with access to extension services and agents that many farmers agree is too much (25.3%)(Fig.3.19) can be reduced with the introduction of a cloud and mobile based system that reduces the bottlenecks between the farmer and farm/extension information. Farmers do not need to wait for extension agents to be deployed to the field when they have a need. Deployment of these extension agents can be delayed by bureaucratic bottlenecks as well as financial and logistics factors. Farmers would be able to access much needed information in a timely manner.

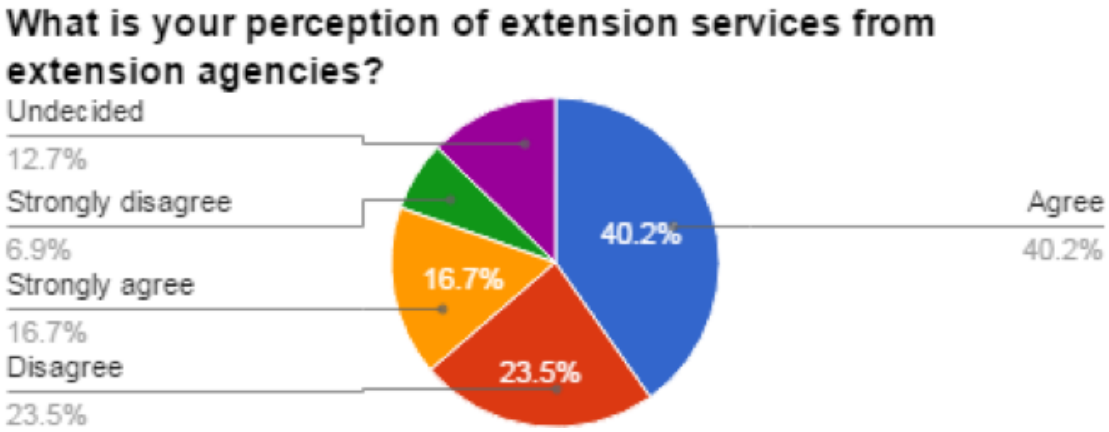

Figure 5.20: Farmers Perception of their inaccessibility to farm extension information

The problem of inaccessibility to extension agencies cited by 40.2%(Fig.3.20) of farmers can also be resolved with the introduction of farm query system. The proposed system will not be designed to totally replace the need for farm extension workers but will enhance their roles by providing them easily accessible information when they go on their farm visits. Extension agents will be able to use the farm query system to link up research agencies, agricultural experts, agricultural extension agencies and universities with the intention of sharing knowledge about farmers' problems.

Farmers can also use the farm query system for quick access to information while waiting for the extension agents to reach them with more elaboration and depth of information. This forum will go a long way in improving the knowledge base of extension agents who are perceived not to be knowledgeable enough by some farmers (16.8%)(Fig.3.21).

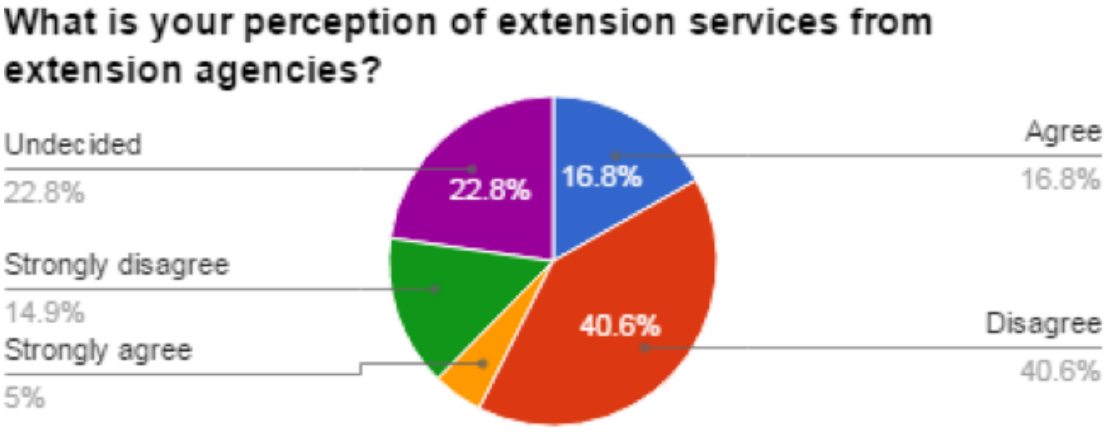

Figure 5.21: Farmers Perception that extension agents are not knowledgeable enough to solve their problems

Almost all the farmers not only have mobile phones (98.2%)(Fig.3.22) but have smart phones (81.2%)(Fig.3.23). It provides a very strong justification for

the development of a cloud and mobile computing platform for farm/extension information dissemination. However, it must be noted that these statistics may not be representative of all farmers in Plateau State due to the fact the this survey was conducted on poultry farmers who tend to be more educated and have greater access to extension information than most other farmers. It should also be noted that the farmers surveyed are well served by the ECWA extension system which is well developed and established. This may not be the case for other farmer's especially small holder crop farmers. It is therefore imperative to make the farm query system to be accessible to feature phones and to grant offline access to information.

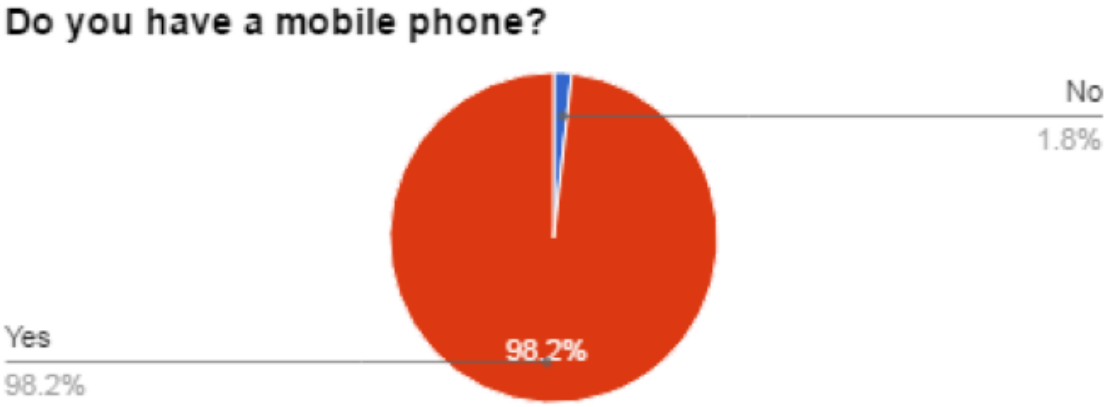

Figure 5.22: Farmers ownership of mobile phones

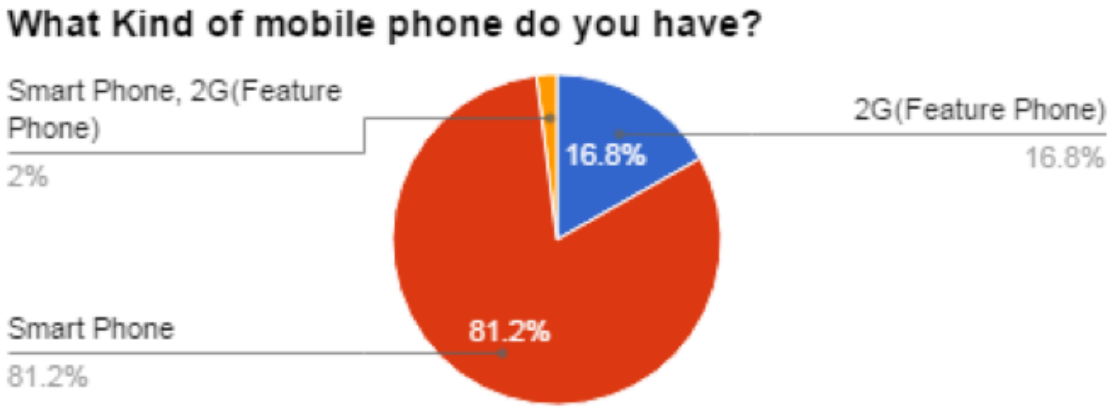

Figure 5.23: Type of mobile phones owned by farmers

5.5 Conclusion

The results of the survey tends to confirm the thinking of the researcher that agriculture information dissemination is presently inadequate in Nigeria. There is also a gender imbalance when it comes to access to farm extension information which puts female farmers at a disadvantage. The farm query system will go a long way in bridging this gender imbalance by granting female farmers easy access

to farm extension information especially in areas where access has been reduced due to socio-cultural and economic factors. Some of these factors which have been highlighted earlier include the fact that some cultures would not allow access to male extension agents by female farmers.

The development of the farm query system will take into consideration the information gathered from this survey. Many of the farmers (Fig 5.3) earn below N1,000,000 (£2,000) per annum so any intervention for them has to be affordable for it be sustained. Most of the farmers in the survey produce more than one type of poultry (Fig. 5.6). They also need information on a wide variety of farming activities (Fig. 5.17), therefore any intervention has to provide for a wide variety of help and support for different crops and animal types. Most of the farmers surveyed can speak more than one language (Fig. 5.7), so the query system has to be able to cater for their multilingual needs.

Most of the farmers surveyed (Fig. 5.22) have mobile phones, therefore a mobile phone based intervention will have the effect of granting most of them access to much needed locally relevant agricultural information. The deployment of the farm query system will go a long way in mitigating against the farm information access problems faced by smallholder farmers in Jos, Plateau State and by extension in developing countries due to paucity of extension workers, bad road networks and other factors. These challenges were attested to by the farmers surveyed who viewed their access to extension information has largely inadequate (Figs 5.13, 5.15, 5.18, 5.20).

There is also need to strengthen the linkages between agricultural innovators and extension agencies to better serve the needs of farmer's delivering to them the required information they need to improve productivity. The farm query system will serve as a veritable knowledge resource that links all these agencies together for information sharing and will further aid intervention and support to small holder farmers.

Chapter 6

Collection of Knowledge

6.1 Introduction

In order to address the issue of how to present agricultural information to make it easy for rural/small holder farmers to access this information, the researcher set about seeking to develop a mobile application that would be able to provide information to farmers using a simple interface. We decided to use Plateau State, Nigeria as a case study for the deployment of the application. A survey trip was organised in January 2017 to elicit this information from local farmers in that region. The efforts yielded some success as is discussed in the next section but did not provide enough questions and answers (Q/As) needed to populate the application before deployment to these farmers. Aberystwyth University Grand Challenges Research Fund (GCRF) Seed grant was sought and received to further improve knowledge collection and eventual deployment of the mobile application. Knowledge collection for the farming advice system involved several visits to Nigeria to interact with the farmers who are the end users of the system. Small holder farmers in Plateau State, Nigeria were visited between 2017 and 2019. During these visits surveys and focus group discussions (FGDs) were conducted with farmers in Jos South Local Government Area (LGA) of Plateau State, Nigeria.

6.2 January 2017 Survey Trip to Nigeria

The objectives of the visits were as follows:

1. To determine the kinds of help currently available to farmers in terms of access to farm information.

2. To find out the kinds of phones available to farmers and what kinds of farm information they use the phones for.

3. To find out what phone apps farmers are aware of and how they use those apps for sourcing various kinds of information.

4. To have a first-hand interaction with prospective farmers on the programme

as a means of ascertaining their current status on the use for ICT in agriculture.

6.2.1 West Africa Agricultural Productivity Programme (WAAPP)

The WAAPP programme is an intervention setup to address the issues of agricultural productivity in the West African sub region. The main focus of this intervention is in the provision of appropriate innovations and technologies. The main aim of the programme is to accelerate the adoption of these technologies in line with the specific needs of the region. The WAAPP 1B to which Nigeria belongs to started in 2009 and officially ended in 2012 (waapp-ppaao, 2015). FCAH&PT, Vom was one of the beneficiaries of the programme. The college setup the above-mentioned team to run the programme. The FCAH&PT WAAPP intervention included setting up of WAAPP Outreach centres in nearby villages. These outreach centres had the mandate to setup demonstration farms which were used to deploy new innovations and technologies as well as provide training on new techniques for the local farmers. It was therefore fitting for this team which had ongoing interactions with local farmers to be incorporated into the CIDRA program. The team alongside the researcher and Prof. Chris Price setup visits to Riyom and Ganawuri towns. These towns were chosen because they were one of the towns the WAAPP team had already setup outreach centres in and had significant links with the local farmers.

6.2.2 Riyom Village

A focus group discussion (FGD) was setup in the house of one of the farmers that had already received WAAPP intervention. This was done so has to build on the foundations of the WAAPP program already in-place in the town. The objectives and purpose of the visit was explained to the farmers after which an interaction was done with the farmers in line with the objectives set out. There were four farmer representatives at the interaction. The WAAPP team was led by Dr. Thomas Adisa who also coordinated the FGD. The farmers listed the following commonly grown crops in the region as: Maize, Millet, Sorghum, Irish potatoes, Sweet potatoes, Soy beans, Rice, Tamba and Vegetables (Assorted). The farmers also listed commonly kept livestock to include: Sheep and goats, Poultry, Pigs and Fish. It was noted that all the farmers are small holder farmers who cultivate more than one type of crop in addition to keeping different types of livestock. This is understandable because of the small income they get from farming and the seasonal nature of their farming activities which has made it imperative for them to practice multi-cropping/Livestock to make any economic gain from farming.

With respect to extension services available to them, they made the following comments:

- Most farmers have phones
- The community has access to a cyber café

The farmers complained that mobile data services were rather poor as a result of the topography of the community which makes it difficult for them to use mobile data services to access farm information. This comment is very understandable based on the fact that although there is a large mobile penetration in Nigeria, this penetration is mainly based in big cities and not in small towns or villages. The mobile coverage in most small towns and villages if available is rather inconsistent. The farmers also complained of inconsistent and limited extension coverage which the WAAPP program had been seeking to address. This had limited their access to much needed information about improved farming techniques, innovations, technologies etc.

Many of the farmers requested information about diseases diagnoses and treatment options. Many of them complained that they lacked timely information to resolve the issues of Pest and Diseases that had been plaguing their crops and livestock. They also requested for information about sources of quality fertiliser that they could use on their crops.

6.2.3 Ganawuri Village

The FGD for Ganawuri was held in a secondary school field. The attendance was very large which made the interactions very fruitful covering a wider scope of farmers and issues. The farmers expressed appreciation to the team from the College for all previous efforts via WAAPP and acknowledged great progress in their production activities. They have access to mobile phone networks but are limited in the kinds of phones they have. This is quite consistent with Riyom and in most rural farming communities in Nigeria. As was done in Riyom the purpose and objectives of the interaction were explained to the farmers and afterwards the interactions commenced. There were also students from the secondary school in attendance.

The comments that came from the interactions with the farmers were similar to those in Riyom town. Many of the farmers complained about lack of timely information and extension support to resolve issues of pest and diseases (P&D) to their crops and livestock. They were most concerned about P&D in crops like rice, Acha, cabbage, and sweet pepper (which are major crops produced in the area).They also complained about access to markets and customers of their products. They implicated this as the major problem affecting the commercial success of their farming activities. It was explained to them by the researcher that eventually the mobile application to be deployed will be able to ease this problem by linking them to both local and international market and customers for their farm produce. They welcomed the prospects of the app helping them to find ready markets, especially for a crop like coffee, which many of them are already dropping. The team however encouraged them to begin organising themselves into groups to take advantage of such larger markets. They indicated that they would need information on sources of better seeds to make production more profitable. The issue of access to improved seeds and other agricultural inputs is not only local to them but is a major problem for most small holder farmers in Nigeria.

In addition to the problem of access there is also have cash flow problems which

can hinder their purchase of these inputs even when they are available. For those involved in livestock farming access and sourcing for vaccines is a major problem. They currently have challenges in sourcing for vaccines for pigs and poultry and would appreciate information on that. Another major problem is the issue of actionable farm analytics such as local weather conditions etc. They would need information on weather in order help them plan their farm activities. The problem of timely extension support has caused many of the farmers to incur losses as result of wrong use of herbicides, especially as it affects type and dosage. Also, Weeds like the striga grass has been a source of challenge to rice and Acha farmers in the area. Citrus farmers also complained about being affected by Gummosis otherwise known as gumming diseases of citrus which is one of the major diseases that causes decline in citrus trees. They requested for appropriate information on handling the challenge. Access to good quality and appropriate fertilisers for their crops has also been an issue.

6.3 January 2019 Survey Trip to Nigeria

In January 2019 a follow-up survey trip was conducted with funding from the Aberystwyth University GCRF Seed grant. The main objective of the trip was to set up a team of agricultural experts who will engage with farmers in Plateau state, Nigeria with the view of soliciting appropriate questions and answers for a mobile application being built to assist them in information gathering. The team set up was an extension of the team from FCAH&PT, Vom who had earlier in 2017 conducted surveys to farmers in Jos South LGA, Plateau State, Nigeria. A visit was also conducted to the Agricultural Development Programme (ADP) Plateau State who have direct linkages to most small holder farmers in Plateau State.

6.3.1 Aberystwyth University GCRF Seed grant

A GCRF Seed grant was secured for the Automated Agricultural Analytics project. The main objective of the GCRF Seed grant is to provide farmers in Nigeria with mobile apps to assist them in improving their agricultural practices. It is the intention of the program to aggregate information crowd sourced from farmers about issues they are faced with e.g. sowing maize, or about specific poultry diseases to understand farmers' most pressing concerns, and to map disease occurrences across a region. This provides the potential to governments or companies of obtaining greater understanding of what is happening within a region without expensive surveying. That knowledge can be used as a basis for policy decisions or for commercial action. The seed grant activities are aimed at promoting widespread adoption of a fit for purpose mobile phone-based advice system to assist farmers. The project is led by Professor Chris Price and Professor Luis Mur in Aberystwyth. Both investigators have experience of working in Nigeria, and strong links with organisations there.

In order to achieve widespread adoption of the app in the region, a supported gradual roll-out of the app in the Plateau State region was adopted. Local support from FCAH&PT will achieve two goals. Firstly, it will meet with local groups

of farmers to encourage them to adopt the app in their groups. Secondly, it will provide secondary help to the app, to ensure that farmers' questions are answered. Where the app does not provide a suitable answer, the app will transmit the question to the FCAH&PT support, who will both answer the question for that farmer, and add the information to the app, enhancing its capability. The roll-out will be done in three stages, of firstly tens, then hundreds, then thousands of farmers being encouraged to take part. Lessons from the previous stage will be addressed before rolling out the next stage. All usage of the app will be anonymized, but will be recorded, so that it will be possible to perform data analysis on the data provided and extract trends and issues. The information crowd sourced from farmers as a result of the GCRF Seed grant will be used to develop the app based on the techniques researched in this thesis.

6.3.2 Setting up GCRF Seed grant Team

The researcher and Professor Chris Price held discussions with the management of FCAH&PT, Vom as well as the College's external linkages team to intimate them about the objectives of the GCRF Seed grant and to set out the terms for collaboration and the objectives of the program. Thereafter a meeting was setup with the 5 man team. The nucleus of this team was the WAAPP team that had been involved in the surveys in 2017. Professor Price explained the technical details and shed more light on the GCRF Seed grant. The Plateau State Agricultural Development Program (PLADP) was also visited by the team. They were informed of their role in the expansion of access of the mobile app to more farmers in the state.

6.3.3 Towards developing a Farmer Advice App

The GCRF seed grant has provided some resources to help develop an app for rural/small holder farmers in Plateau State, Nigeria. This app has helped to answer one of the research questions of this thesis which is to arrange agricultural information on mobile phones to make it easy for rural/small holder farmers to access information.

In developing the mobile app, the agricultural extension needs of rural/small holder farmers in Plateau State, Nigeria were taken into consideration. This was done by having focus group discussions(FGDs) with a cross section of them and conducting a survey of small holder farmers in Plateau State, Nigeria. Requirements for a mobile farm query system suitable for the farmers were developed based on the FGDs, survey and a review of relevant literature about providing extension services to rural/small holder farmers.

There has been a lot of work done in the area of using mobile telephony to help rural/small holder farmers especially in developing countries. These applications were looked into and studied to gain insight of how they have helped these farmers. Their limitations were also looked at in a bid to mitigate against them.

A solution which is based on arranging agricultural information on mobile phones to make it easy for rural/small holder farmers to access has been developed.

A review of related techniques on arranging information was done to determine the best combination of techniques to use in arranging information on mobile phones for easy access by small holder farmers.

A technique for arranging knowledge in a domain has been developed and tested against the requirements for a mobile farm query system.This technique has been used to arrange locally relevant agricultural information on mobile phones in such as way as to grant easy access to rural/small holder farmers in Plateau State, Nigeria.

As the app begins to be used, the Aberystwyth team will evaluate use of the app. Particular focus will be placed on how easy it is to get information from the app by farmers. Emphasis will also be placed on how farmers are able to send feedback in case they have issues using the app.

Chapter 7

Clarifying the application area

7.1 Needs of rural farmers

In the previous chapter we discussed some of the activities embarked upon in determining the needs of the farmers. One of these activities was to conduct a survey of rural/small holder farmers in Plateau State, Nigeria to determine their agricultural extension needs.

The purpose of the survey was to assess farmers' perception of the present level of interaction between them and extension agencies in Nigeria in relation to the level of support given to the farmers via farm/extension information delivery.

The results from the survey show an almost even gender distribution of poultry farmers in the Jos area with male (54.3%) and female (45.7%). Most of the farmers are within the age of 31 -60 years. This shows that most farmers are young and still within their most productive age. There is therefore the need to make farming much more attractive by the introduction of technology.

Most of the farmers can speak English fluently (98.2%) and can also read and write in English (99.1%). Many of the farmers can also speak Hausa fluently (72.8%) and read and write in Hausa (52.6%). This can be attributed to the fact that Jos, Plateau state is in the Northern part of Nigeria where Hausa is the major language. This will guide the building of a mobile based platform and it is expected that information will be disseminated in these two major languages.

Most of the farmers have some form of education; (62.9%) with post-secondary education, 12.9% with post graduate qualifications. This could be attributed to the fact that many young educated people don't have access to jobs and have decided to go into farming as a source of livelihood. An educated and young population of farmers would be very inclined towards accepting ICT tools in their farming practice. It would also be easy for them to use these ICT tools with relative ease and understanding.

Many farmers (26.1%) earn less than N100,000 ($500) per annum and about $1.36 a day which is less than the $2 a day world poverty level. There is therefore need to improve agricultural productivity and access to markets using technology.

A large percentage of respondents (40.2%) get farm/extension information from extension agents occasionally. This low level of interaction between farmers and extension agents can be caused by many factors. Some of these factors include

bad roads in rural areas, lack of trained extension agents and paucity of funds to send the extension agents to the field regularly. One of the ways to overcome these challenges to farm/extension information delivery is to use mobile phones. There is great potential for this since a large percentage of farmers (98.2%) have access to mobile phones. This makes it imperative to take advantage of this tool to provide timely and regular access to farm/extension information to farmers.

A majority of farmers (55.8%) do not receive farm/extension information on time. This may be due to the inadequacies in the present extension delivery system that relies heavily on extension agents going to meet farmers on their farms. This method is still important especially in complex cases but is not effective due to earlier highlighted problems like bad roads, inadequate staff, and paucity of funds. Many farmers have blamed the untimely access to farm/extension information for late access to market information (53.3%), late access to improved farming techniques (52%), reduced productivity (52%) and to a lesser extent late access to agricultural inputs like fertilizer, farm implements etc (33.3%). The extension process can be enhanced with the introduction of a mobile based platform which will guarantee quick and regular access of farmers to farm/extension information.

This survey has been able to highlight the information requirements of farmers in Jos and by extension Plateau state. These requirements would also be similar to the requirements for farmers all over Nigeria. Most farmers need access to marketing/pricing information (68.2%) and information about prevention of diseases (59.8%).

From the study many farmers agree (40.4%) that access to extension service is too expensive. It is expected that with the introduction of the mobile based platform this expense would be reduced drastically. The bureaucracy associated with access to extension services and agents that many farmers agree is too much (25.3%) can be reduced with the introduction of a mobile based system that reduces the bottlenecks between the farmer and farm/extension agent. The problem of inaccessibility to extension agencies cited by 40.2% of farmers can also be resolved.

Almost all the farmers not only have mobile phones (98.2%) but have smart phones (81.2%). A majority of farmers (83.8%) have access to the Internet and some even have access to the Internet on a daily basis (33.7%). It provides a very strong justification for the development of a mobile computing platform for farm/extension information dissemination.

The survey visit was an eye opener and tends to confirm the thinking of the researcher that agriculture information dissemination is presently inadequate in Nigeria. There is also a large mobile coverage for Nigerian farmers that can be taken advantage of by deploying mobile computing platforms for extension information delivery and gathering. There is also need to strengthen the linkages between agricultural innovators and extension agencies to better serve the needs of farmers, delivering to them the required information they need to improve productivity.

The convergence of a young farming population, challenges with agricultural extension delivery due to insufficient agricultural extension workers, bad roads in rural areas, lack of funds to send extension workers regularly to farms and the

availability of mobile phones to rural farmers has made it imperative to introduce a mobile query system to enable farmers easy access to much needed agricultural information via their mobile phones. This query system will provide simplified access to agricultural information based on the farmers' area of engagement. It is instructive to note that though this survey suggests an educated farming population, it is not representative of most rural farmers. It must be noted that all the farms surveyed were poultry farms and were located within the vicinity of the state capital, Jos. Generally small holder farmers tend to be less educated than what the survey suggests. Low level of education among most rural farmers suggests that traditional query methodologies like text-based search which is generally used by many online search engines may not suffice here. Also, mobile phones which are common among the farmers have limitations that may necessitate a more structured query system. Our mobile query system would enable farmers to streamline their search by narrowing down their search space based on which agricultural activity they are seeking information about and further narrowed down to the particular issue within that agricultural activity. For example, a maize crop farmer needing information about the best time to plant maize for a particular farming season will be able to traverse a search tree leading to the particular information as against been inundated by information on other crops and several agricultural issues not necessarily linked to planting maize. It is also important to note that may rural farmers do not understand the technical terminology used by agricultural experts who produce information for the farmers. The mobile query system is careful to take this into consideration by articulating the information within its database in simple everyday language used by farmers.

7.2 Requirements of mobile farm query systems

Query systems for farmers in rural areas have to take into consideration the limitations of these type of farmers. Most of these farmers are not well educated and live in rural areas with limited access to traditional ICT facilities and Internet coverage, they also require a wide range of advisories for a variety of agricultural concerns. Traditional ICT platforms don't seem to be able to overcome some of these limitations because they are expensive and not portable. Mobile platforms on the other hand are affordable, portable and can be used offline. Query systems that run on mobile platforms have different requirements from query systems that run on other ICT platforms like personal computers, laptops etc. Mobile systems have certain constraints that make it imperative to have these unique characteristics. Some of these constraints include much limited screen space for data entry and display. Designers of query systems for mobile platforms have to take these limitations into consideration. We here outline some requirements for effective mobile farm query systems.

1. As little input as possible by the user: The limited keyboard on a mobile means that it is more efficient to choose between options rather than type in data as much as possible. In the future, speech recognition might overcome this issue, although the minority languages spoken by many rural farmers

in Nigeria mean that speech recognition may never be practical for them. Intelligent Help Desk may be appropriate for the few farmers with access to a desktop computer – the user types in a query and it is matched with previous queries and likely matches are produced.

2. Limited data visible to the user: The small size of a mobile phone screen as compared with that of a PC or a laptop provides a unique challenge for displaying query results. Even if a Google search could be done without typing a query, the results are difficult to sort through on a small screen. For example, typing 'egg problems' into Google gives 144 million results. Mobile phone users accessing FAQs will have to grapple with the task of searching through a large corpus of Q/A pairs.

3. Usable when Internet is not available: While mobile phone use is widespread in Nigeria and as suggested from the survey amongst rural farmers, availability of data is much more limited. It might be possible to get data in the cities, and even in villages, but data service on farms is much rarer. This means that advice giving will also need to work stand-alone on the phone to be most effective.

4. Wide range of help for farmers: The aim would be to give the kind of help that extension workers provide when they are available. They are able to give advice on a wide range of farm related issues, from diagnostic advice on different crops and livestock, to plant care, breeding issues, storage and selling of crops.

5. Easy expansion of the system: Where the system is unable to help with a specific problem, it should be easy for non-technical people to extend the system with new advice. Although expert systems are highly structured, domain focused and highly targeted they are difficult to expand, they typically need technical staff to do the expansion.

6. Availability in minority languages: From the survey it is observed that most farmers can read and write in English and Hausa. It must be further stated that there are other minority languages in the area. Most farmers are much more comfortable in their local dialect although they can speak English. This is the general trend in Nigeria which is a multi-ethnic country. It is therefore imperative that the mobile farm query system should provide language support for these minority languages.

7. Sustainability within developing country budgets: There are many mobile based applications for small holder farmers in developing countries that are supported and sustained by funding from developed countries. This funding helps to subsidise the cost of these services to the farmers. However, many of these interventions would not be sustainable when funding sources seize. It is therefore important that any long-term solution to help small holder farmers in developing countries should be able to be sustained with the limited financial resources in developing countries.

7.3 Related application areas

There are other application areas which would benefit from an effective mobile query system. These areas have information stored in different formats and can be accessed through different platforms. Some of them like the Aberystwyth University Information Services (IS) provide FAQs which can be accessed by PCs, laptops and mobile platforms while others like FamilyDoctor provide offline question and answer support. These information sources are quite similar to providing information for farmers in that the users of these information sources would be best served by a mobile information retrieval system. The users of this systems may also not be Information Technology experts and would be best served by an easy to use system. Aberystwyth University IS FAQs can be accessed by mobile devices as a web page but the system suffers the same problem as a mobile query system as outlined above.

1. Aberystwyth University (AU) Information Services (IS) FAQs: This operates by matching questions (queries) with question and answer pairs already stored in a knowledge base. Once a question match is found, it's corresponding answer/s are returned. It is unstructured and domain focused. Little or no maintenance is done on the FAQ. There is a lot of redundant information in the FAQs as the same piece of information is categorised in many sub heads. A major challenge with viewing the FAQ using a mobile phone is the limited space available to display the result of a query. Users have to scroll through a large amount of information to get their required query result. The FAQ is domain focused and is therefore restricted to information within a particular context. AUIS FAQs (Aberystwyth, 2019) provide information on a wide range of areas that both staff and students of the University need to know about, there is therefore the need to streamline access to this information bearing in mind that returning lots of non-related information is possible and not helpful to users of the FAQs. Users of the system may also ask questions that may not have been answered by the FAQs and there is therefore need for the system to be easily updated to capture this situation. AUIS FAQs will therefore benefit from a mobile query system which meets the requirements outlined in section 2.2. However, users of the AUIS FAQs would probably have good access to the Internet and therefore the requirement for the system to work stand-alone may not be necessary. Also, most staff and students of AU understand English fluently and therefore minority language support with the exception of the need for language support in Welsh.

2. Personal health queries: FamilyDoctor is a self-help health information book developed by the British Medical Association (Smith, 2001). It provides first home health advice for a wide range of medical issues. Disease symptoms are presented and organized in age and gender categories. The four major categories are Children, General medical (Men and women), Special problems(men) and special problems (women). These categories are further subdivided. This provides a unique opportunity for implementing mobile

query systems as issues could be traversed from the general categories to subcategories thereby making searching much more structured. FamilyDoctor would benefit from a mobile query system because users of the system would need information to solve health problems as timely as possible which is best realised by mobile devices. The users of this system would not be medical experts and therefore will be best served by a system that helps them to navigate easily to their desired information need. The information contained in the FamilyDoctor database is diverse in nature and covers almost every aspect of medical health problems. It would therefore benefit from a system that would help users to target the particular area they need information about. They would also need a stand-alone system because medical problems can occur anytime and anywhere, and information could be needed critically out of internet coverage areas. Users of the system may also need information that is not presently in the database and the system would have to be able to expand its knowledge base. FamilyDoctor may not need minority language support because it is primarily for people in the United Kingdom where almost everybody can speak English. Although adding language support for Welsh would be helpful for native welsh speakers. Considering the fact that the information contained in the FamilyDoctor database is useful beyond the UK, it would be useful to provide language support in the event that it is to be used on multi-lingual countries.

7.4 Work already done in supporting rural farmers via mobile phones

A range of work has been done in the area of providing mobile phone support to farmers. A lot of this work has been focused on rural farmers in developing regions of the world with particular emphasis in disease diagnosis, information delivery and marketing support.

Examples of other work done include:

7.4.1 Farmer Query System (FQS)

This system developed by mPower Bangladesh is a mobile phone-based system that provides knowledge and information to farmers by linking them to local experts via SMS or phone call. Farmers are connected to these local experts and can ask questions using the mobile application. Their answers are thereafter sent to them via either SMS or by voice call. It also incorporates image capture of the farmers problem i.e. a farmer can also send the picture of their problems to assist the local experts in the diagnosis of their problems. The application is funded by USAID and is operational in many regions in Bangladesh. Over 47,000 farmers have been reached with over 82,000 services. Surveys conducted by farmers using the system have shown that 90% of the farmers using the mobile application have had their queries answered, 98% of the farmers have found the app to be a useful information source and about 99% of the farmers are willing to recommend the

mobile application to other farmers (Mpower, 2019).

There are clear benefits of the application to rural farmers as it delivers remote access for farmers to local experts to solve their problems especially considering the challenges, they have with face-to-face extension support. It also provides locally relevant and useful knowledge and information to the farmers. However, the system has its limitations. Farmers using the system have to depend on the availability of the local experts to read their SMS or answer their phone calls on time. Farming being a very time sensitive venture any delay in response to a query can have adverse effects on production. Local experts are also limited to the knowledge they have at any one time and they may not be able to meet the knowledge needs of farmers on time. Connectivity problems especially in rural areas may delay response to farmers' queries. Response to farmers' queries may also be experienced if too many farmers are trying to connect to the local experts at the same time. Presently the system is supported financially by USAID. This support from USAID subsidises the cost of the service to local farmers and therefore it is not a locally sustainable solution to assistance for rural farmers in developing countries.

7.4.2 Intelligent Advisory System for Farmers (IASF)

IASF is a mobile phone based intelligent advisory system that provides farm extension support to farmers. The system links the farmers to local extension support as well as providing advisory information locally on the mobile phone. This system presently domiciled in Northern India is focussed in areas that have a low extension worker to farmer ratio (CDAC, 2019). IASF automatically stores the farmers' queries and corresponding solution in a database. The database contains knowledge and information developed by local agricultural extension workers and experts. When a farmer types in a query the system automatically matches it unto an appropriate query solution pair using CASE based system for delivery to the farmer. The system is also expandable by acquiring new problems and solutions.

The system provides extension support to farmers in areas where the extension experts are not readily available. It also provides timely access to locally relevant knowledge and information to the farmers. In addition to connecting the farmers to local extension and expert help in real time it also provides off line extension support that farmers can access directly from their phones. However, farmers need to be able to construct long queries to elicit knowledge and information from the system. The query solution matched to a particular query may not be accurate to the farmer wants as this is dependent on the way the farmer formulates the query. Case based systems like this would normally return a number of matching cases to a query. This may be too much information displayed on a mobile screen and the user may find it difficult to sort through the matching cases to get an appropriate match. It would also be a challenge customising the system to be multi lingual as this will entail developing a large database of each case in several languages.

7.4.3 Esoko

Esoko is an agricultural information advisory service based in Uganda that provides farmers with information i.e weather forecasts, market prices etc . It is a communication tool that links farmers with government agencies, NGOs and other farming support agencies. Esoko is an offshoot of TradeNet which was formed in 2005 as a response to the need to give farmers access to market information that was being collected by the Ugandan government. It was formed out of the need to adapt technology to resolve communication gaps being experienced by farmers.

Esoko comprises 16 apps which are grouped into the following categories: Market apps, Monitoring apps, Advisory apps and Field services.

1. Market apps- These apps are used to send SMS messages that link farmers and sellers to each other and that provide for improved access by farmers to market information and prospective customers.

2. Monitoring apps– These apps provide survey information to both farmers and agricultural agencies throughout the entire agricultural value chain. This survey information can then be used to provide a clearer picture of what is happening throughout the agricultural value chain.

3. Advisory apps – Provides advisory services based on technical data-sets information and disease references. It also provides how-to manuals for the benefit of farmers. The main tool used by Esoko for advisory services is the Farmer Helpline. This service provides information on a variety of issues which include weather forecasts, extension services, agronomic tips etc via SMS. The service is coordinated by a manned centre that serves as its hub. The service provides for language support in 12 languages. Over the past 3 years the average number of farmers accessing the service is about 40,667 with a majority being men (81%) (Fugar, 2019). This is a pointer to the disproportionate distribution of mobile phone access between male and female farmers in Africa.

4. Field Services – Provides tools to support on-site training for farmers, extension agencies and also provides helplines and technical support via call-centre services.

Esoko presently has three major apps:

1. INYST - It is a mobile based data collection tool. Online forms are created on the INYST web platform and can be filled via mobile phones. The information is uploaded to the INSYT platform and can be used to generate analytics. Information entered offline is stored on the phone and synced to the online platform once the mobile phone is connected to the Internet. It also incorporates verification and agricultural payment solutions.

2. Information and communication services - This app provides for seamless communication between farmers and other agricultural stakeholders as well

as governments and NGOs for the purpose of farmer support. It provides marketing and announcements, market prices and weather forecasts, marketplace connections as well as call centre support. It combines mobile and web technologies to connect farmers to agricultural stakeholders and financial institutions.

3. Knowledge plus - This is an application that helps connect farmers to support from agricultural extension agencies. The tool can be used to enhance the agricultural extension service via an electronic platform. Traditional agricultural extension services like training and support can be offered electronically via this application. This application does not meet the requirement of providing wide range of help to farmers via the farmer mobile query system because it provides assistance to farmers through extension workers rather than the farmers directly. Extension workers can use this tool to conduct remote trainings and support on the farms. This can serve as a second level support to farmers who require such, but it does not replace the need to provide answers to farmer queries remotely, timely and directly to the farmers.

Esoko is an example of the use of mobile phones to provide comprehensive help to farmers in the entire agriculture value chain.

7.4.4 Ezaraat

Ezaraat is a Management Information System application that has both a web and a mobile interface. It is based on research which seeks to test the use of Information communication technologies especially mobile phones in providing extension support to rural farmers in Pakistan. It also supports help-line facilities. The Ezaraat project was developed by the Centre for Agriculture Bio-science International (CABI) with funding from the UK Department for International Development (DFID) to improve the reach of the extension service of Punjab district in Pakistan. The system comprises a mobile interface for farmers and extension agencies and a web-based interface for institutional users. The hub of the system is a communication centre which links the farmers and extension agencies via a mobile interface and the agricultural agencies and other institutions via a web-based interface. A farmer sends queries for weather information, fertilizer availability and other extension-based information. These queries are routed to the extension agents on the field via the information communication centre. Ezaraat has recorded some significant successes which include reaching out to 50,000 farmers which is about 19% of farmers in Vehari District, Punjab, Pakistan. Their services have also increased the profitability of what production by 2.02% in the district between 2011 and 2012 (Davison *et al.*, 2015)

The cost of reaching farmers has been greatly reduced because fewer extension workers per farmer is needed. However, Ezaraat takes for granted that there are available extension workers to answer calls and reply queries. In most developing countries this is not the case as extension workers are few, poorly trained and equipped. The whole essence of developing mobile applications for farmers in

developing countries is to mitigate the dire shortage of extension workers limited by bad logistics and infrastructure.

7.4.5 Tensor flow app for Cassava Disease Diagnosis

Pennsylvania State University in collaboration with the International Institute for Tropical Agriculture (IITA) developed a plant disease diagnostic application for cassava. The application was developed in response to several diseases affecting Cassava which include brown streak disease, cassava mosaic disease etc. The disease recognition application makes use of an image recognition model called convolutional neural network to identify up to five diseases that plague the cassava crop. A mobile device camera is used to deploy the system which runs entirely on the mobile device without need for wireless connection. It is also light weight and doesn't need large processing power.

The image recognition model was up to 98% accurate (Ramcharan *et al.*, 2017) for cassava crops on the field and was deployed offline thereby eliminating the need for small holder farmers in developing countries where access to the internet is erratic to access the Internet. The model was also trained on a desktop computer rather than a super computer thereby providing a light weight model that can easily be deployed on mobile phones.

Most small holder farmers need a wide range of advice and help which they would normally get from an extension worker visiting their farm. Specialized applications like Tensor flow cannot meet all their information needs and need to be integrated into a much more generalized application for farmers. Mobile applications that will be helpful for small holder farmers also need to take into consideration that most of them are multi-crop farmers and will need help in a variety of crops. Most small holder farmers also have limited knowledge of disease domains and will need assistance in interpreting and making sense out of the diagnostic information that they receive from many specialized applications.

7.5 Towards a solution

There is a lot of intervention that has taken advantage of the availability of mobile phones to small holder farmers in developing countries. Many of them have proven to be useful and have provided the necessary help to small holder farmers. They have also served to mitigate the paucity of resources available for agricultural extension service provision in developing countries. However, most of them do not meet all the requirements of mobile farm query systems.

Small holder farmers in Nigeria have a wide range of agricultural information needs but they are resource poor and do not have access to much needed information to improve their productivity. However, they have access to mobile phones though mobile coverage is not so good on their farms. All the services discussed above have utility for small holder farmers. They provide useful services to these farmers, however access to some of their services especially advisory services can be enhanced via mobile phones. Providing these services via mobile phones presents

the challenge of arranging the information in a format that will be easy and functional for small holder farmers to access. Any mobile query system that would be useful to them has to meet the requirements outlined in 2.2 which include as little input as possible by the user, Limited data visible to the user, provision for restricted access to the Internet, providing wide range of help to farmers, easy expansion of the system and multi-language availability. It is imperative that we need to give farmers access to a wide range of knowledge and experience, within the limitations of the mobile phone interface.

Chapter 8

Review of related techniques

8.1 Introduction

Mobile search is becoming very popular majorly due the fact that mobile devices are cheap and easily accessible. Also mobile search is convenient, timely and can be done from anywhere. However, developing mobile search interfaces must take into consideration the motivation, specific information needs and demographics of the users (Church & Oliver, 2011). Searching for computer-based resources requires knowledge and utilisation of search techniques that will optimise your search and give you appropriate query results. Searching using mobile devices is quite different from searching using PCs. As earlier highlighted mobile phones have a limited screen for inputting queries and for displaying query results. This is corroborated by (Church & Smyth, 2008) who added that these factors intensify the problems of modern web search. According to (Church & Smyth, 2009) other changing features like time, location, which activity the mobile search is addressing and even social interactions have implications on the type of search techniques should also be taken into consideration. This has serious consequences on the search techniques that can be implemented on them to optimise search. There are several search techniques that have been implemented successfully on PCs but to a lesser extent on mobile devices. We here review some of these techniques and look at their suitability or otherwise for mobile search.

8.2 Text-based matching/Approximate string matching

This involves searching an entire document with the intent of matching search criteria e.g a word. Text-based matching is composed to two major steps which are (1) locating approximate substrings within a given string and (2) Locating dictionary strings that approximately fit the pattern. The proximity of the match is measured by the number of primitive steps taken to locate an exact match to a string (Baeza-Yates & Navarro, 1998). This is measured as the edit distance between the pattern and the string. The major primitive operations are:

1. Insertion - This is when a character is added to the match string to convert it to the pattern
2. Deletion - When a character is deleted from the match string to convert it to the pattern
3. Substitution - when a character is the string is substituted by another character to convert it to the pattern
4. Transposition - the position of two letters in a string are swapped to convert it to the pattern

The determination of a match between a search string and the pattern depends on the constraints of the approximate matcher being used. If the number of primitive operations needed to convert a candidate match string to the pattern is one, then any candidate match string that needs more than one primitive operation to convert to the pattern will be discarded. For example, if the pattern is *kind* then a candidate match string like *blink* which need more than one primitive operation i.e. One insertion and two substitutions will be discarded while a search string like *king* which requires just one primitive operation i.e. one substitution will be accepted. From the above example it's obvious that the matching search string does not have any affiliation with the pattern from a semantic point of few. This is one of the many challenges of using Text-based matching. This is further exacerbated by the possibility of having several semantically incompatible match strings when searching. Searching for a phrase further amplifies this problem. This means that the precision of Text-based matching is low from a semantic context. Applying this technique in searching a database of question and answers will return several semantically incompatible matches. For example, typing "Aspire list" in the Aberystwyth University FAQs returns some semantically incompatible questions and answers like "Administering Sharepoint Task lists" , "Managing Email lists" , "Using Email Lists" and "Using Sharepoint Task Lists".These questions which do not address the issue of Aspire lists came up because of the matching word "lists" in the search phrase. Text-based matching also has the added challenge of returning a large number of matching strings/phrases. Text-based matching is therefore too broad because it retrieves every document that contains the word/s that match the search criteria. It is unstructured, not domain focused, targeted by word matching and requires automated maintenance. An example of this is Google Search. According to (Al-Khamaiseh & ALShagarin, 2014) string matching algorithms have wide applications ranging from computer networks, pattern recognition and even bioinformatics.

Stack overflow which is a platform that enables people to ask questions and provide answers about specific computer programming issues provides an avenue to better focus text-based matching. Members are able vote on the accuracy of answers either moving them up or down the stack of answers for a particular question. Forums which provide an avenue to ask questions and further discuss answers also help to better focus text-based search by providing more depth to question/answers pairs thereby making it easier for users to make an informed choice of particular Q/A pairs.

Text-based matching need a level of sophistication that farmers don't have because of the difficulty of sifting through contradictory answers and many possible matches. For example, typing "informed context" on the Google Search bar produces 155,000,000 results. This may not be a problem on PCs and for people who have advanced knowledge of the domain but will pose a serious problem on a mobile phone and also for people who are not well educated. There is an assumption that the farmer has expert knowledge of the domain which is not usually the case. Aligned to this problem is the limited amount of data that can be displayed on the mobile phone screen at any one time because of its limited screen space. This will make it difficult for a farmer to sort through and locate an appropriate matching query from a long list of retrieved matches. It therefore does not meet the requirement of having limited data visible to the user.

Text-based matching also does not meet the least possible input criterion of a farm query system because of the long queries that may have to be constructed in eliciting knowledge and information using these types of systems. Many farmers in Nigeria due to limitations of illiteracy may find it difficult to construct these long queries and even if they can it would be difficult for them to do so using mobile phones due to their limited keyboard as compared to personal computers.

The multi-ethnic nature of Nigeria with its numerous languages poses a major challenge to text-based search. This can be mitigated by language support which can constitute another level of complexity because many farmers may not be able to construct sentences in their native languages. It therefore does not meet the multi-language requirement of the farm query system.

8.3 Case based Reasoning

Case based reasoning (CBR) mimics the way humans solve problems by relying on the solution of previous similar problems to solve a new problem. According to (Becerra-Fernandez *et al.*, 2004) case based systems are particularly suited for domains that are difficult to implement using rule based reasoning. Rule based reasoning is anchored on the assumption that there is a universally accepted approach to solving a particular problem and this approach is known by most experts within a particular domain. However, this is not the case because these domains have very few experts and have a very diverse knowledge base thereby making it difficult to use rule based reasoning. An example is in the customer services domain where problems are very personal, and solutions are highly subjective. Rule based reasoning is also computationally expensive due to the fact the rules have to be applied in solving every problem.

Case-based systems try to mimic human-like intelligence by linking up new knowledge to existing knowledge in solving a problem. Case based systems can be described conceptually as a system that retrieves the most similar matching cases, reuses these cases to solve the problem and if these cases cannot solve the problem they are revised, and these revisions are retained in the CBR database (Althoff, 2001). The success of a case-based system is directly linked to how comprehensive the case library for that case-based system is. A case-based system

with a very comprehensive case library has a higher chance of having matches to new problems. An advantage of case-based systems is that new cases are updated regularly. Any new problem/solution pair is added to the case library and therefore makes future case matches possible. An example is Compaq case-based tool. Compaq introduced a tool called SMART(Support Management Automated Reasoning Technology) which retains solutions to previously solved knowledge and makes this available to support staff (Acorn & Walden, 1992). This seems to be an early version of case-based reasoning systems. They are much more targeted than text-based matching and require quite a lot of work to maintain. However, matching new cases with old cases within the database may not be straight forward within the context of providing farmers with solutions to their problems. Most farmers would use very simple everyday language in describing their information needs and this description would be influenced by their educational level, language skills and their environment. This makes it difficult to get exact matches to cases already existing in the database. For example, two farmers may describe the same problem in two different ways depending on the factors mentioned earlier and other factors. These two descriptions may even end up returning very divergent case sets. English language is not the first language for many Nigerians therefore many small holder farmers may be able to speak but may not able to construct words and sentences well in English language. There is therefore a high like hood of misspelled words and wrong use of tenses and other grammatically errors. These grammatical errors can totally change the meaning and the context of a problem description which will affect the accuracy of the retrieved matched cases. Multi-language support may not be able to solve this problem because most Nigerians who are fluent in their native language may not be able to write properly in these languages. Therefore, any online system that is designed to provide assistance to farmers has to take this into consideration. In addition to this, case-based systems still pose the problem of having to construct long and complex queries or cases, they therefore do not meet the requirements of little data input from the user. They also do not eliminate the issue of large number of possible case matches being displayed on a limited sized mobile phone screen therefore they do not meet the requirement that limited data be visible to the user.

8.4 Machine learning techniques

These techniques enable computers to learn rules from examples (data). Machine learning systems try to approximate a mapping function between input and output data. These approximate mapping functions are used as rules to predict possible matches. The accuracy of the mapping function heavily depends on how comprehensive the input and output data (training data) is and on the algorithm used. According to Google (Davies, 2019) machine learning techniques in search have been able to block 99.9% of spam with a false positive of .05% as against a 97% spam blocking rate when it was done programmatically. One of the earliest implementations of machine learning in search is RankBrain. It was created by Google and its main technique in search is to understand how entities are con-

nected in a query with the view of producing a set of accurate answers to the query. RankBrain was able to produce good answers to queries based on known and unknown entities. RankBrain has to some extent being able to understand the context of a search query within certain domains for example a google search "How do I fix my S7 screen" and "How do I replace my S7 Screen" will produce very similar results because within the context of the mobile phone industry "fix" and "replace" are very similar. However, machine learning techniques were not quite as successful in the automotive industry domain as seen in this example queries "How do I fix my car" and "How do I replace my car". They will give very different results because "fix" and "replace" are very different activities within the context of the automotive industry. They are well suited for non-diverse domains where patterns can be easily formed. However, they are not good for a farmer query system because of the diversity of the domain. One of the requirements for a farm query system is the ability to offer wide range of help for farmers. Most farmers in Nigeria are small holder multi crop farmers who rely on extension service personal for information and help for a large variety of agricultural products and issues. Training a machine learning system to provide this kind of help may be difficult because of the diversity of the domain involved. Even if this is possible farmers will still have to grapple with the challenge of constructing long queries to interrogate the system and this will be very difficult using a mobile phone. Machine learning techniques will therefore not meet the requirement of limited input by the user. Although machine learning systems develop rules based on data, these rules rather than the actual data are used for prediction. Using machine learning systems for a farm query system may pose the problem of many possible results that match the rule. For example, a farmer asking, "how can I store maize?" may get diverse answers which may include storing another cereal crop. Since many small holder farmers are illiterate and cannot read and write in English, the farmer may find it difficult to develop the appropriate query seeking help on storing maize. This will mean farmers using the system will have to sort through a lot of information within the limited screen space available on mobile phones and will make it difficult for systems using machine learning systems to meet the limited data visible to the user requirement of a farm query system.

8.5 Relevant knowledge acquisition techniques

Given the requirements enumerated in 2.2, what we need is a way of arranging agricultural information. So, we need to be able to categorise the information and that means having a way of structuring knowledge in such a way that users can easily navigate through the system to the specific question and answer pair they are looking for without having to type in long queries and sort through lots of similar information.

Structuring domain i.e. Card sort: Card sort was original designed to study how individuals classify knowledge (Wood & Wood, 2008). According to (Nurmuliani *et al.*, 2004) Card sort is a knowledge elicitation method for representing domain knowledge. In this method topics are organized into

different categories based on the way the participants understand the topics. It serves as a way people prompt themselves to partition a domain thereby giving them an idea of what categories should be in the domain. The participants may also be required to name these categories. Card sort helps in getting an understanding of the expectations of the end users of the platform (Spencer & Warfel, 2004). According to (Faiks & Hyland, 2000) card sort has proven to be very useful in understanding users' perspective about a domain. The challenge in applying this technique in classifying agricultural data for rural/small holder farmers is the lack of expertise of the farmers, their limited literacy and the diversity of the domain. The reason this technique cannot be wholly applied in building the mobile query system is the fact that card sort is highly subjective, needs a high level of domain knowledge by the farmers and may therefore not be able to provide a standardized categorization of information.

Semantic web ontology: According to (Berners-Lee *et al.*, 2001) the Semantic Web improves the current web by attaching meaning to contents thereby enabling computers to intelligently handle data and information. The basic component of the Semantic Web is an ontology. According to (Guarino *et al.*, 2009) ontologies can be defined from two perspectives which are the philosophical perspective and the computational perspective. In simple terms an ontology is a document that defines how the contents of a domain are related. According to (Fensel, 2001) they provide a mechanism of structuring and sharing the information of a domain between people and computer systems. This role of structuring and enabling knowledge sharing within a domain was corroborated by (Chandrasekaran *et al.*, 1999). An ontology which defines classes of objects and their relationships is made up of a set inference rules and a taxonomy(Hakeem & Shah, 2004). A taxonomy which defines how a domain is organised is a graph-like structure that comprises of nodes and edges (relationships) that link the nodes together. The lowest node to which no other node is connected downwards is called the leaf node. The hierarchy of nodes is based on is-a relationships where a child node has all the characteristics of its immediate parent node but has distinct characteristics that distinguishes it from other child nodes that are part of the same parent node (Arp *et al.*, 2015). The is-a relationship structure of the semantic web does not actually do justice to the classification needs of the farm mobile query system. The focus of the farm mobile query system is to group items based on how the user i.e. farmer groups them rather than how closely they may be linked agriculturally which an is-a relationship would intend to do. For example, "How do I sow maize?" and "How do I sow yams?" will not be categorised together although they have the same root characteristic of "sowing" but would rather be categorised under the sowing subcategory of their respective crops. Most farmers would usually be searching for information for a particular agricultural product rather than for an issue over a range of products. This makes it very difficult to adhere to all the principles of the semantic web. Rather the semantic web

serves as an inspiration and a guidance in partitioning the farming domain. It serves as a structured way people would prompt themselves to partition the domain. The main aim of semantic web ontology is to categorize terms for the purpose of identifying them within a domain and for easy and seamless inter-domain interoperability. This is however not the main aim of the mobile query system which is to provide easy navigation for Q/A pairs for rural farmers. Semantic ontology however provides a template for dividing a domain into relevant sub-domains such that we can home in on the area of interest.

Bringing together certain aspects of card sorting and semantic ontology has the potential of providing adequate categorisation of farming terms which will have a structure that is relevant to small holder farmers.

Chapter 9

Techniques for arranging knowledge in a domain

9.1 Accessing wide range of knowledge

Inspired by Card Sorting we have chosen to investigate arranging knowledge by semantically driven categorisation using sets of categories that would be familiar to farmers. Obvious categories include: Farming activity, crop type, type of animal etc. These categories are not exhaustive because more detailed categories would be added when the question and answer (Q/A) pairs become large. This is in line with the requirement that the farm query system should be easily expandable.

The idea is that farmers will come to the farm query application to have specific questions answered. Farmers have thousands of questions covering a broad range of farming areas that need answering and this is the kind of support they get from extension workers on the field. These farmers may not be able to construct long queries and may find it difficult to peruse through lots of information displayed on the small screen of a mobile phone. They also need to be able to get to their desired question as simply and as quickly as possible. Most farmers in Nigeria live in rural areas and do not have regular access to Internet services. They would therefore require a system that can be consulted even when they are out of Internet coverage area. Another requirement of a suitable system will be the need to incorporate multi-language support in view of the multi-lingual nature of Nigeria.

9.2 General technique

Repeatedly partition the domain so that the user can select the appropriate partition at any level, and gradually home in on the desired answer. The partitioning of the domain is inspired by card sort which seeks to represent the domain in a way that the user understands the domain. Specifically, we will apply our technique to arrange farming questions and answers for rural farmers. It seeks to represent different crops, animals and the issues or concerns farmers have with farming them. Some of these farm produce like maize have a wider spread throughout Nigeria while some of them like potatoes have a more limited spread in North Central

Nigeria. These partitions are based on the premise that the information system being designed is a question and answer system for rural farmers. It would therefore follow that the partitions for this domain will be based on the way a rural uneducated farmer will seek information about his/her farm produce. The major partitions includes:

1. the type of Farming/Farming Activity the farmer is engaged in i.e. Crop farming, Livestock farming, General Farm Management etc.

2. the farm produce for example Cassava, Maize, Poultry, cattle etc

3. the types of farming issues of concern to farmers. For example, farm diseases, making money from farming, planting, storing my farm produce, handling weeds, rearing etc. The labels for the agricultural issues have to reflect the simple everyday language of the rural farmers

9.2.1 How do we order those characteristics?

The ordering of these characteristics is based on the fact that farmers usually focus on one or a group of farm produce depending on where their farm is located among many other factors. Their agricultural information seeking behaviour will likewise be largely influenced by the farm produce they are largely involved with. They will tend to seek information concerning that farm produce or group of produce. Hence the most important characteristic for a farmer seeking information is the type of farm produce he/she produces. The farmer will also be concerned about agricultural issues affecting that particular farm produce. These activities may also span a number of farm produce. For example, farmers involved in most farm produce will be concerned about profits and diseases while Crop farmers like cassava and maize farmers will be specifically concerned about sowing, storage and weeds. Therefore, the agricultural concerns/issues will depend on the farm produce a farmer produces. These considerations will determine the ordering and splitting of the domain.

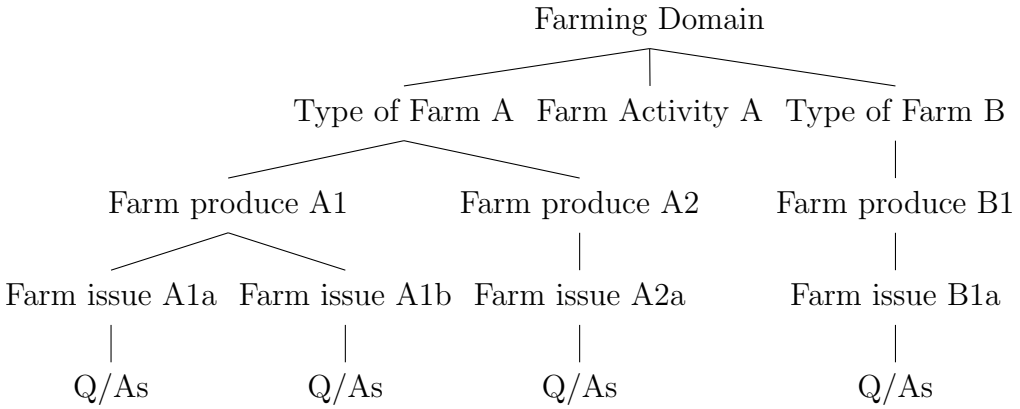

Figure 9.1: Knowledge tree showing ordering of the Farming Domain

9.2.2 How do we decide what is a good split?

In a bid to fulfil the requirement of limited data visible to the user, each category will need to be split if they exceed a number of terms that can be accommodated within one page of the mobile phone screen. Splitting of a category should be inspired by how the user of the domain will categorise the terms and also based on ontological closeness of the terms within each category. For example if a new crop is added to the system which causes the crop category to exceed the number of crops that can be displayed on the mobile phone screen then a splitting of the crop category will be necessary. Crops that have ontological similarity e.g rice, maize, millet (all grains) will be categorised together. It is important that users of the application do not need to scroll beyond one screen page on their mobile phones when searching within a category. According to Neil Patel (Patel, 2019) 75% of Google users don't scroll beyond the first page of their search screen. This makes it imperative to keep each split within one page. This is done to make sure that the users are not overloaded with too much information when searching within a category.

9.2.3 How do we insert a new item into the domain?

Inserting a new item may be as simple as inserting a term within a certain category or as complex as creating an entirely new category within the domain. At a conceptual level the domain is based on a tree like structure inspired by a taxonomy. At the top level the tree has a single node which is the root node. This root node is labelled by the name of the domain. The root node is further split into several children nodes which can also be further split into children nodes. The splitting of each node is inspired by card sorting and based on the ontological closeness of the terms. As much as possible categories should be based on how users of the domain would best categorise terms. This consideration takes precedent over the ontological closeness of the terms.

- Locate the proposed parent category for the new term you want to insert.
- Insert the new term under the parent category.
- If the number of terms in the parent category exceeds the number of terms that can be accommodated on the mobile phone screen then split the parent category into sub categories.
- Insert the terms below those sub categories. The new sub categories now become the parent categories of the terms and also children nodes of the split parent category.

9.3 How does the system meet all the requirements

- As little input as possible by the user: the system is formatted in a tree like manner so that users can traverse the tree to get to a particular question

and answer pair. Users therefore do not have to type long queries to access information on the system.

- Limited data visible to the user: Each category is split so that it does not span more than one page of the mobile phone screen. This is done by grouping and regrouping several items within a group based on similar ontological characteristics. This guarantees that the user will not have to go beyond one page to access information on any category. Each question will have only one answer which may be supported by links to further information and pictures for better understanding.

- Restricted access to the internet: The database of question and answer pairs will be domiciled on the users' mobile phone. When within internet coverage area any new advice will be uploaded to their mobile phone which can be accessed even outside such coverage area.

- Wide range of help for farmers: the system incorporates the fifteen most common agricultural products in Plateau State, Nigeria. Agricultural experts and local extension workers have painstakingly documented many of the agricultural issues facing farmers who are involved with these agricultural products. These local experts are involved in providing wide ranging extension support to the local farmers already.

- Easy expansion of the system: Expansion of the system i.e. improving its knowledge base is a non-technical task and can be done by local agricultural extension workers who already interface with these farmers. They will have access to top level information about farmer usage of the application and will be able to support the system adequately.

- Availability in minority languages: local language support for the system can easily be incorporated due to the structured nature of the system. Each item in each category can have bi-lingual or even multi-lingual support.

9.4 Improving the Knowledge base

What happens when no satisfactory answer is found? There may be cases where the user of the application cannot find an answer to a question. This can be caused by many factors. It is possible that the question and answer pair is not included in the database. In some other cases the answer may be in the database but may be located in a category that the user was not expecting. When such situations occur, steps have to be taken to improve the knowledge base. Record what information was wanted, and how the user traversed the tree to try to find it. Use the traversal information to insert a new answer in the appropriate place in the tree. If a limb of the tree now has too many answers, split and reformat.

9.5 Partitioning the Farming Domain

Whole application is made up of "shards of knowledge". In the farming domain, this might be knowledge about planting, such as "the most effective time to plant maize is in April, when there has been rain within the previous eight hours." The challenge is to arrange these shards of knowledge in such a way that the user can be guided to the shard that helps them in their present situation. This will mean categorising the domain in such a way that the farmer can easily access the required Q/A pair with little effort. The farming domain is initially partitioned based on the type of farming and activities the farmers are involved in e.g. Crop farming, Animal farming, etc. This is done because a farmer would normally be involved in specific types of farming i.e. Crop, Animal. They may not be bothered about other types of farming, therefore making this the first level of partitioning will eliminate information that is unnecessary to the farmer. Thereafter partitioning is based on the farm produce they are involved with e.g. maize, cassava, yams, Potatoes, cattle, Sheep, poultry etc. This farm produce are further partitioned based on the farm issues of concern e.g. Disease, fertiliser, sowing, storing etc. Splitting of each of these categories is done in order to meet the requirements of not having too much information on the mobile phone screen. As a rule of thumb, it is important that grouping at any level is based on the way they would be grouped by the local farmers. For example, to the maize farmer de-husking and drying of the maize cobs is part of the storage process and can be grouped as storage.

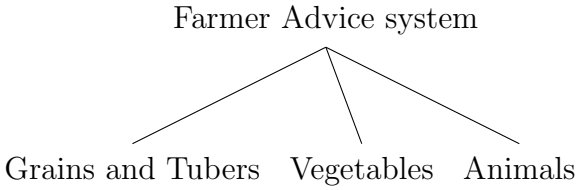

Figure 9.2: Knowledge tree showing levels one and two of Farming Advice system

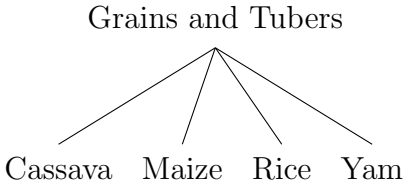

Figure 9.3: Knowledge tree showing partitioning of crops in Farming Advice system

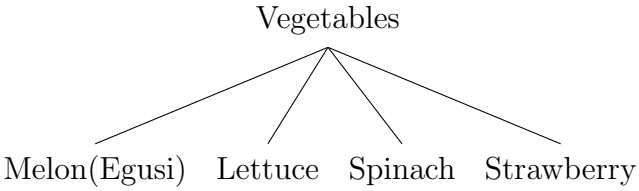

Figure 9.4: Knowledge tree showing partitioning of crops in Farming Advice system

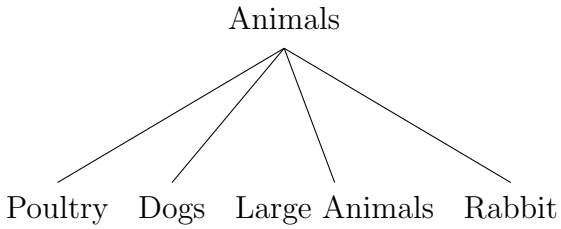

Figure 9.5: Knowledge tree showing partitioning of Animals in Farming Advice system

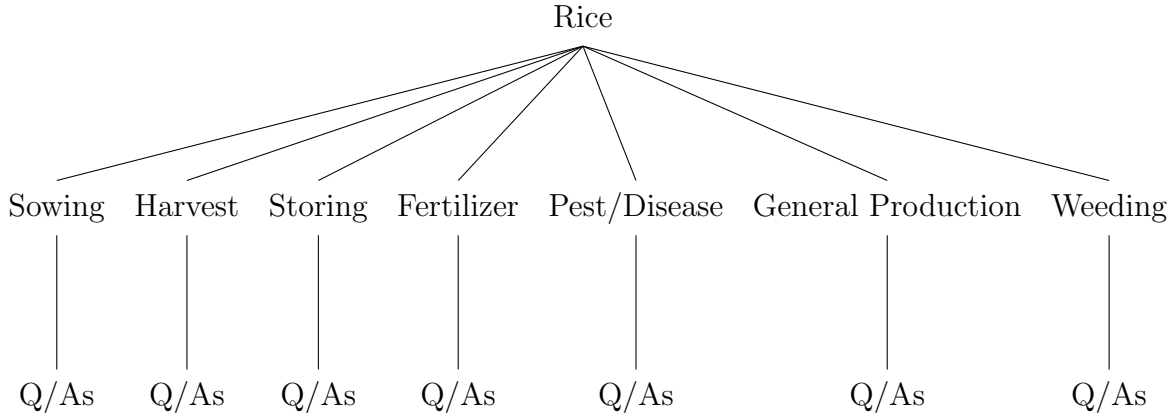

Figure 9.6: Knowledge tree showing partitioning of Rice by concerns in Farming Advice system

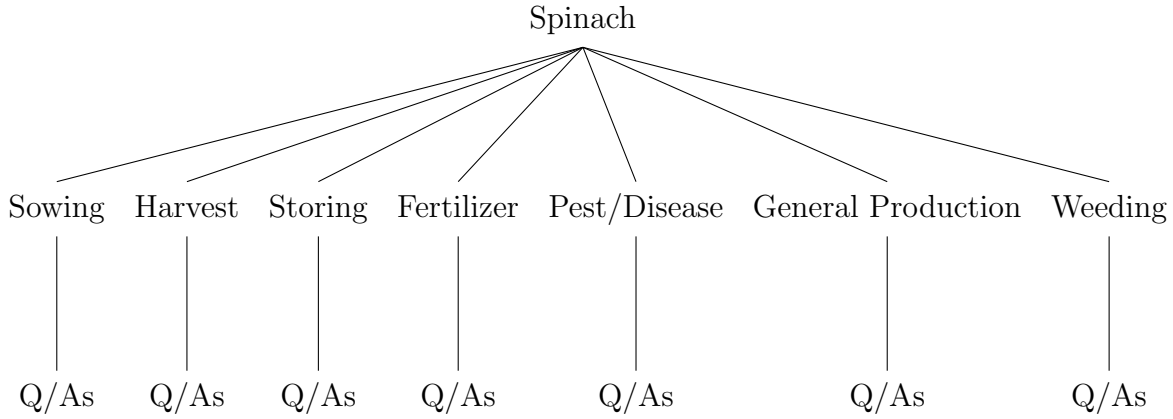

Figure 9.7: Knowledge tree showing partitioning of Rice by concerns in Farming Advice system

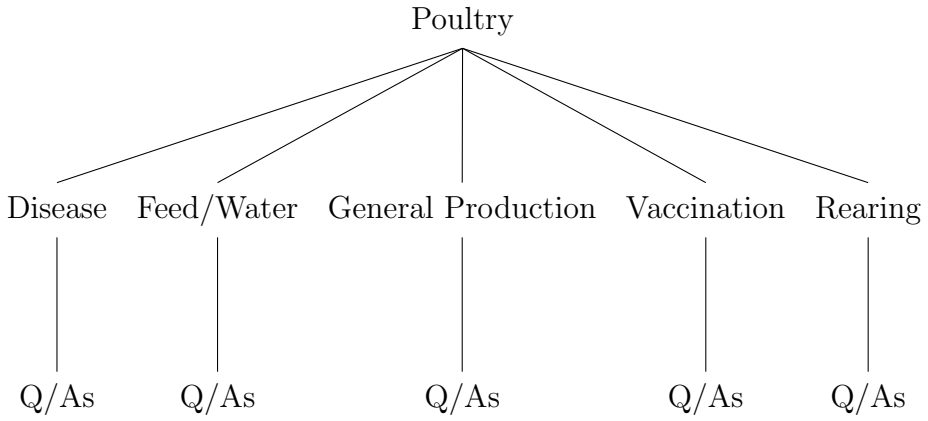

Figure 9.8: Knowledge tree showing partitioning of Poultry by concerns in Farming Advice system

At the level of the farming concerns it can be observed that the partitions have similar items for example all the crops have the similar concerns like harvest, storing, sowing, fertilizer, pest/disease and general production. Also, the animals have similar concerns which include Disease, feed/water, general production, vaccination and rearing. Therefore the system can be used as a checklist for farm produce being introduced into the system.

Chapter 10

Application to Advice for Rural Farmers

10.1 Introduction

A mobile application was developed to implement the technique for arranging farming questions and answers. The mobile application was built using the Android studio platform. A classifier was also built to arrange the knowledge that was collected from the field. The Farming Advice system is subdivided into either crops or animals. These groups are further divided into different types of crops and animals. When a new set of Q/A pairs are received they are placed within a crop or animal type.

10.2 Data entry and classification

The questions and answers crowd sourced from the farmers and edited by the team at FCAH&PT is then transmitted via email to the team at Aberystwyth University. The team in Aberystwyth University further edits the information for context and grammatical errors. The information is then classified using the iPad Classifier app based on the techniques which are enumerated in sections 4.2 and 4.5. Sections 4.2 and 4.5 explain how the Q/As are classified on the app. The Q/As are first classified into either crops or animals. This is the top level of the Farmer Advice system. The crops and animals are further subdivided into more closely related groupings i.e. poultry, large animals, maize, rice etc. They are then organised into concerns or issues e.g. pest/disease, storing, sowing etc. The classified information is then uploaded to the Farmer advice system. The process is repeated whenever any Q/A pair is received from the team in Nigeria. The farmer advice app is distributed to the farmers via the google app store. This gives access to farmers that have android phones. The team in Nigeria will assist the farmers in installing the application on their phones and also help them to use the app.

10.3 Adding a new item into the domain

As earlier discussed adding a new item to the domain could be done at any level of the knowledge tree. In order to add a new item into the domain the parent node should be first located and then the item could be added as a child node. Locating the parent node is inspired by card sort which aims to categorise items based on the users' preference.

10.3.1 Adding a new crop category

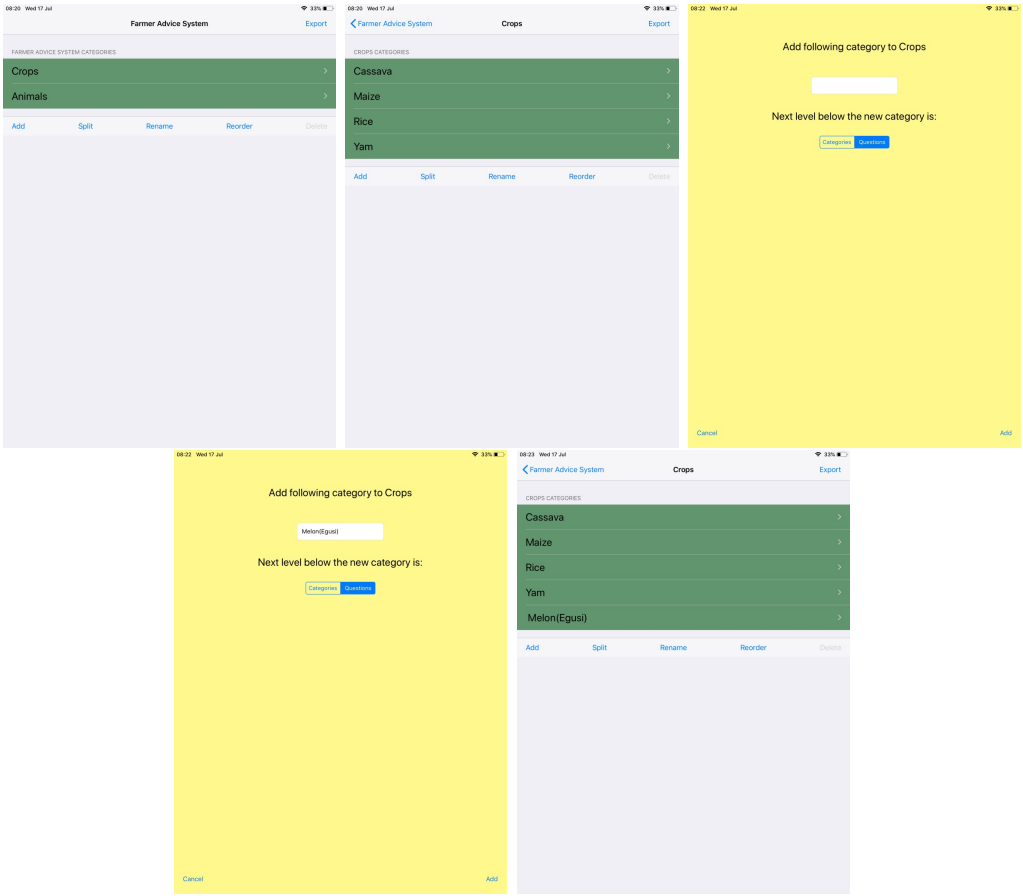

Figure 10.1: Adding Melon(Egusi) under the Crops group

For example to add Melon (Egusi) to the farming advice system the parent node is located. In this case the crop category is chosen as the parent node. This choice is inspired by the way farmers will normally categorise melon as a crop rather than as an animal. The crops category shows the crop types already within the system. The add button at the bottom right of this interface is then selected to reveal the interface to add a new category. The new category in this case Melon (Egusi) is keyed into the text box and the category select box is selected instead of the questions select box so that more categories can be added below the melon category i.e. concerns.

10.3.2 Adding a new concern/issue

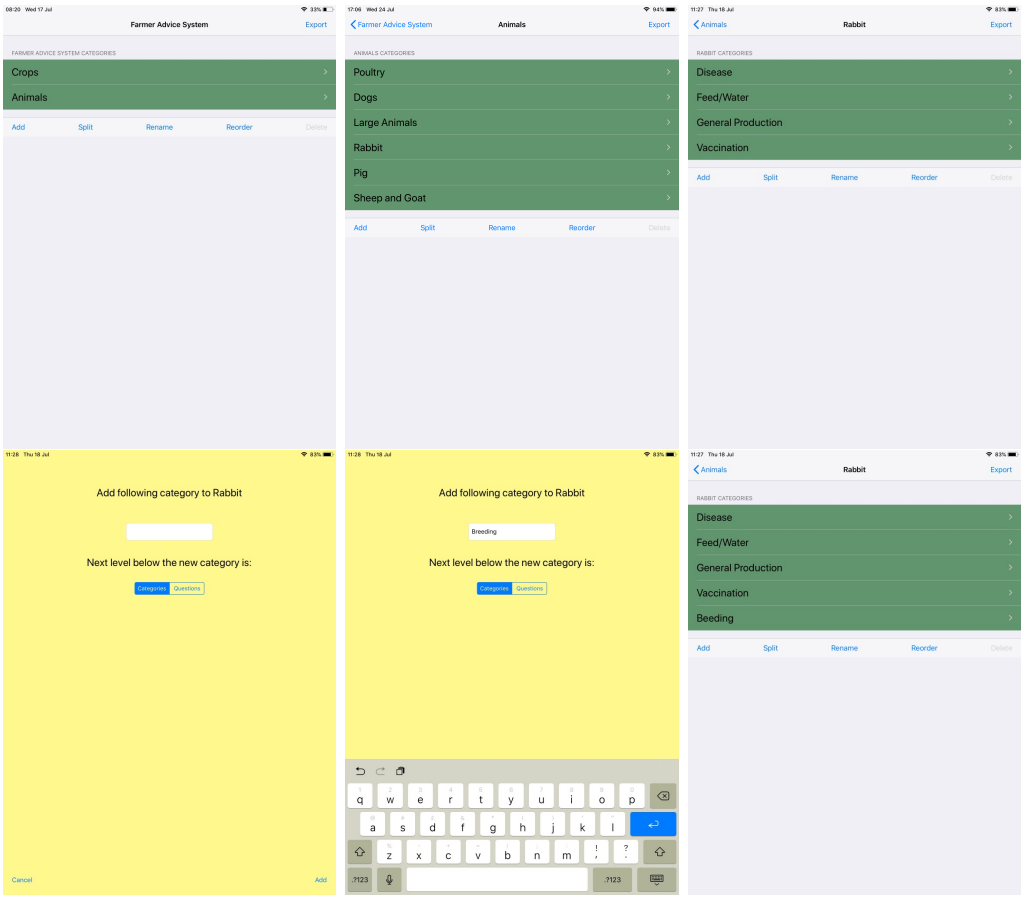

Figure 10.2: Adding Breeding under the Rabbit category

To add a new concern to the Rabbit category the interface that reveals all the concerns/issues presently under the rabbit category was selected. A new concern is added by selecting the add option which reveals the interface to add a new concern. The questions option is selected instead of the categories option so that Q/A pairs can be added under the new concern. The new concern in the case breeding typed into the text box and added.

10.3.3 Adding a new Q/A pair

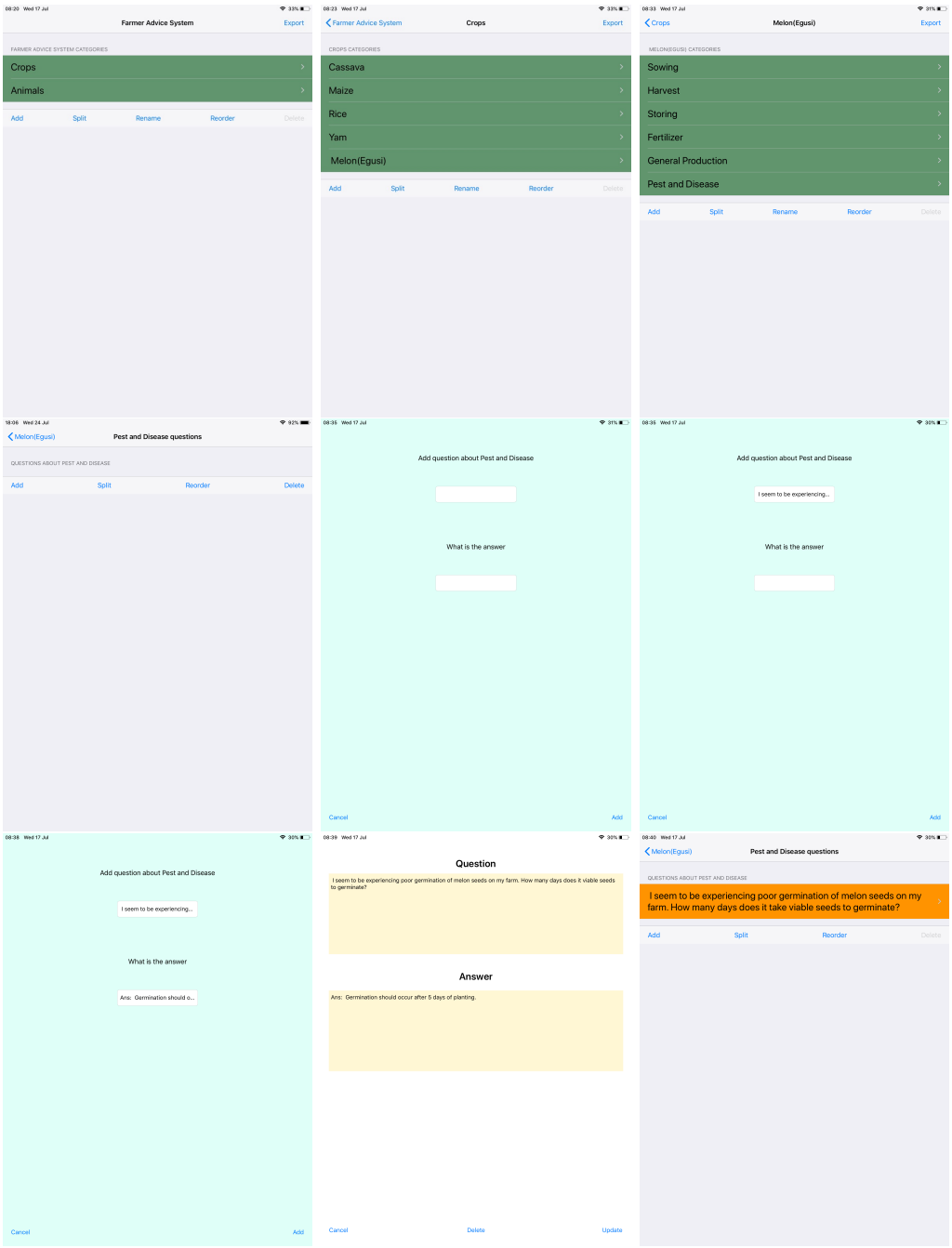

Figure 10.3: Adding a Q/A pair under the Pest and Disease concern of the Melon(Egusi) Category

To add a new Q/A pair to a concern in this case the Pest and Disease concern of the Melon(Egusi) category, the Pest and disease concern is navigated to and then shows the Q/A pairs presently available. In this case there is none. The add button is selected which reveals the interface to add a Q/A pair. The question and answer are keyed into separate text boxes and added.

10.4 Splitting a category

In a bid to fulfil the requirement of limited data visibility to the user splitting of a category may become necessary. Splitting a category adds children nodes to an existing node making that node a parent node. As earlier discussed, this splitting should be based on how the user will normally categorise the terms e.g crops or animals. In implementing this split for the farmer advice system, the classifier is used.

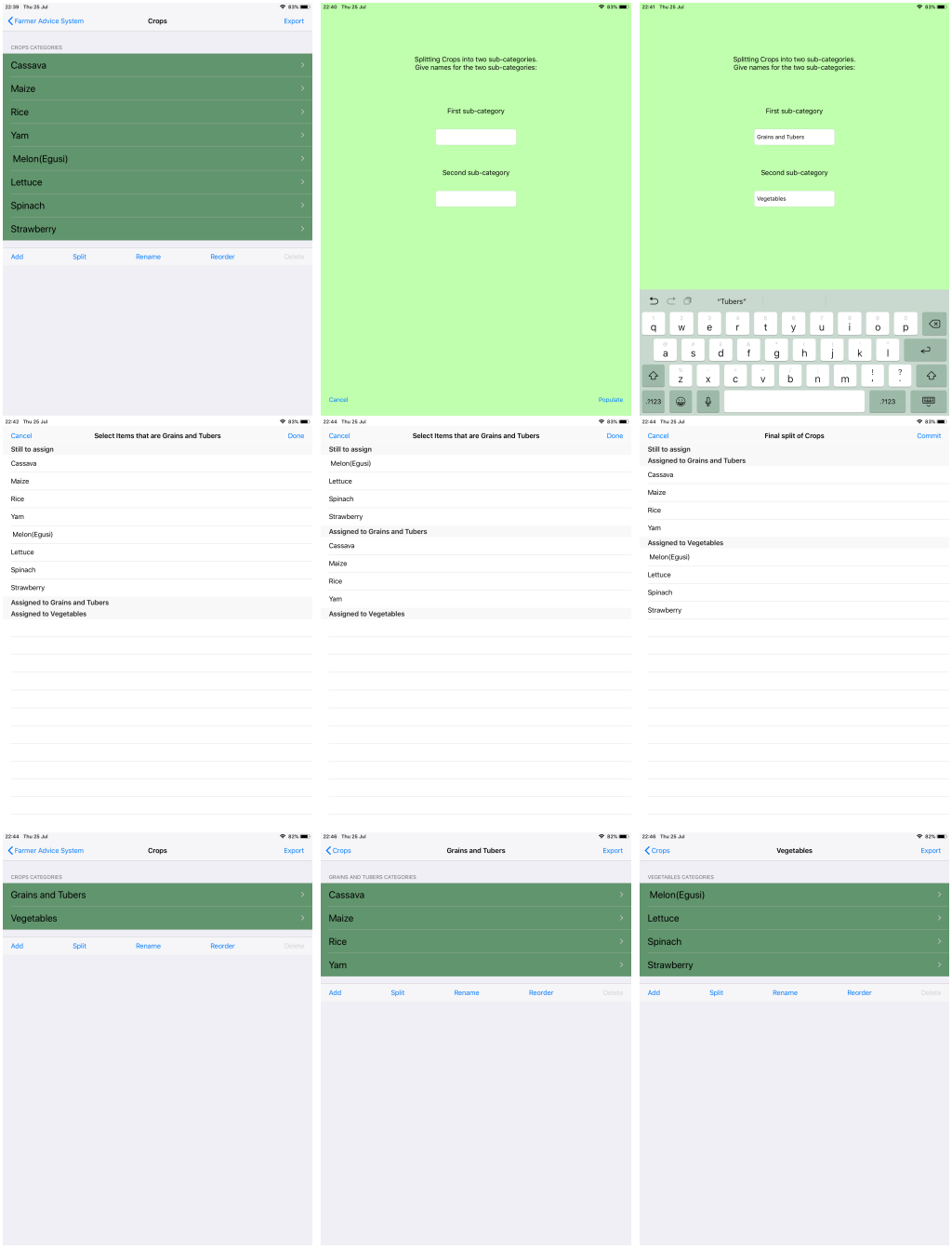

Figure 10.4: Splitting the crop category

In the example above the crop category is split into two categories namely Grains and Tubers in one category and vegetables in the other category. These categories can be further split if more items i.e. grains, tuber and vegetables are added to the system. In order to split the crop category using the classifier the split option is selected which reveals an interface where the new names of the two categories can be keyed into separate text boxes. Once the names are added an interface to assign the crops to each of the categories is revealed. The crops are assigned to each of the categories and committed.

10.5 Other operations in farming advice system

10.5.1 Reordering a list of items

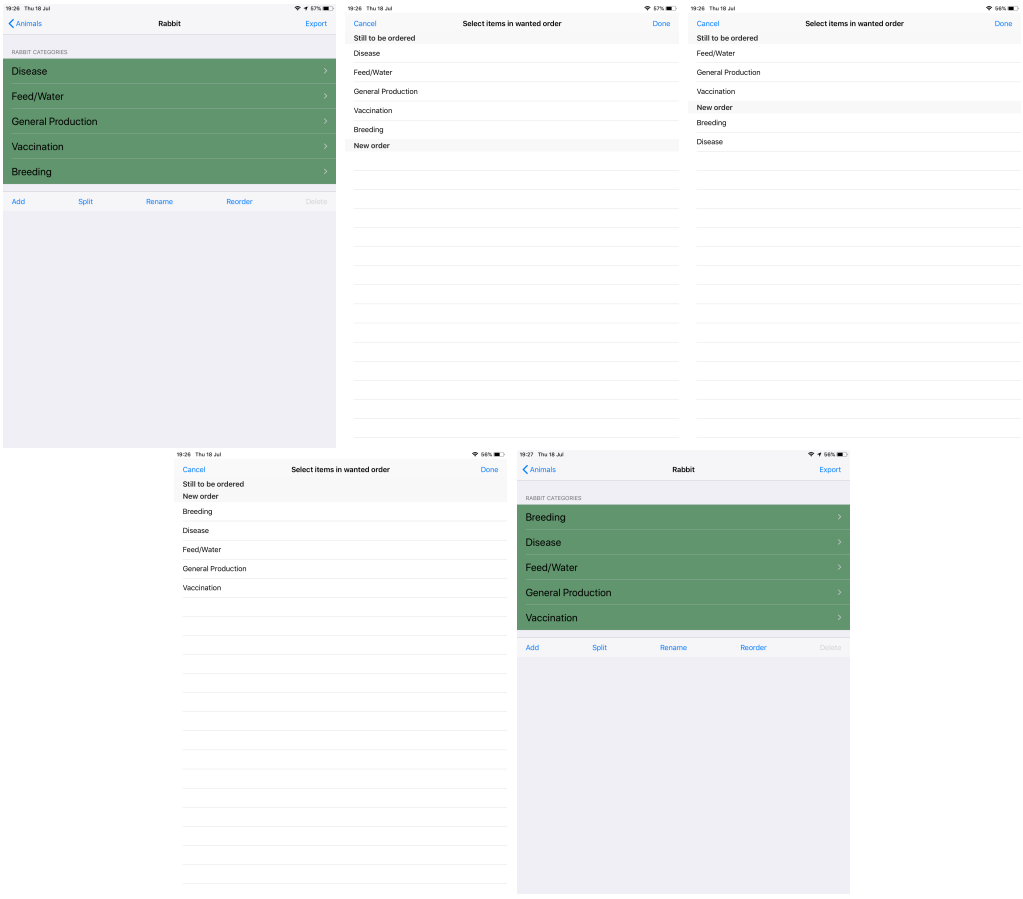

Figure 10.5: Reordering the concerns under the Rabbit category

It may become necessary to reorder a list of items for example a list of crops or animals or a list concerns under the crop or animal category. In the above example the list of concerns under the Rabbit category are reordered in alphabetical order. The Rabbit category was navigated to reveal its list of concerns. The reorder option was selected which in turn reveals the list under "still to be ordered" and an empty "New order" list. The concerns are moved from the "still to be ordered"

list in alphabetical order to the "New order" list. When this is done the concerns are then reordered in alphabetical order.

10.5.2 Exporting updates to the database

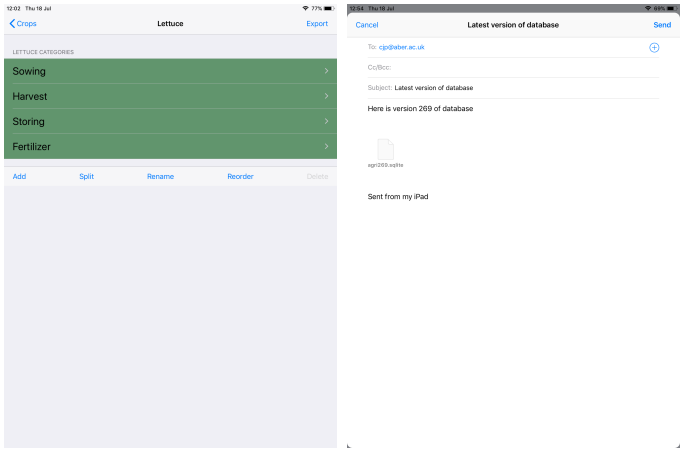

Figure 10.6: Updating the database

Whenever edits are made in the Classifier it is important to export the updates for use in the mobile app. This can be done from any screen. The export option is selected which then reveals the interface to enter the email to which the updates are exported to.

10.6 Evaluation of our technique for arranging knowledge

We have been able to implement our technique on the farming domain in Plateau State, Nigeria. We collected farming data from both locally based extension experts and farmers who are the end users of the system. The data was then curated by local extension experts with expertise in both animal and crop farming. The experts removed any duplicate entries and grammatical errors in the Q/A pairs. They also edited the Q/A pairs to make them easily understandably by the local farmers. The information was then sent to Aberystwyth University where the researcher further edited the Q/A pairs especially for grammatical errors. The Q/A pairs were then classified based on inspiration from card sort. The classification was done in collaboration with local extension workers in Plateau State. The general understanding of how local farmers and extension experts categorise both farm animals and crops were taken into consideration when classifying the domain. The classification was implemented using the IPad Classifier and then delivered on the Android operating system. Adding new knowledge to the farming domain is further aided by the fact that all the animals have the same set of concerns. This also applies for all Grains/Tubers and vegetables. This uniformity of concerns acts as a check when adding a new farm produce to the system. It

can also be used to further improve the information to be added to the domain. For example if a new vegetable to be added to the domain does not have questions on a particular concern that all other vegetables in the domain have then it would prompt the extension worker to seek out questions on that concern thereby improving the quality and quantity of Q/A pairs in the domain. Therefore, the ontology provides a framework for the domain. This may not be applicable to all the domains as can be seen in the AUIS and the Personal health domains where each item in a category may not necessarily have the same subgroups. There may be the tendency to repeat the same Q/A pair especially crops that have similar farming systems. For example, farm preparation may be similar to many grains. There is a trade-off here between streamlining the domain and making it easy for users to access information within the domain and in this case the later prevails.

10.7 Evaluation of the usefulness the system to farmers presently

The structure of the system is designed to make it easy and quick for users i.e. farmers to quickly go through different levels to reach a particular Q/A pair. The classification is consistent with how most farmers would categorise crops and animals in Plateau State, Nigeria. Most farmers in the area tend to have similar views as to how animals and crops are categorised and the extension experts who curated the Q/A pairs have been working closely with farmers in the area for a number of years and therefore have a general understanding of the classification of animals and crops in the area. However, some farmers may have different ideas on where to look for a particular Q/A pair within the domain. For example, a farmer may think a problem is about sowing when we have categorised the problem as a disease issue, this may prevent them from finding the particular Q/A pair to solve their problem. This can be mitigated by tracking what they looked at and allowing them to tell us when they don't find an answer, as we alter the tree or add duplicate questions to deal with this problem. Farming has a closely linked value chain and therefore some questions may span more than one concern.

Curating the knowledge that has been gotten from farmers and extension agents is very important. For example, one of the answers to a disease problem suggested that the animal be culled, this may be a dramatic response to a problem that may be better solved in another way. It is therefore important to thoroughly curate any Q/A pair before advice is inputted to the database of the knowledge system. This issue has more implications for advice to human beings like the personal health system.

We have been able to capture 15 crops and animals in our mobile application. This is still less than the 20 crops and animals that are intended for this work. Most small holder farmers in this region are multi-crop and animal farmers and any help that they will need will have to take this into consideration. We are presently executing the GCRF funded Automated Agricultural Analytical Project(3AP). The prototype has been deployed to farmers who participated in the FGDs and more crops/animals have been captured.

10.8 Evaluation of the usefulness the system to farmers in the future

In the future, evaluation of the usefulness of the application to the farmers will be assessed via deployment of the app to the field, assessment from local agricultural experts on the ground and most importantly feedback from the farmers who the app is intended for.The intention is to assess the farmers information needs, acquire Q/A pairs from the farmers to populate the app, deploy the app to the farmers and work alongside the farmers as they use the app within their local context. Evaluation of the app will be an ongoing exercise as the farmers begin to use the application. Farmers would be able to send feedback on the app. For example, if their questions are not captured in the apps database or they can't easily locate a particular Q/A pair. The feedback is facilitated by a question field in the app. These questions will be forwarded to the local agricultural experts who will answer them. The Q/A pair is then sent to the team in Aberystwyth University who will then update the app. Therefore, as usage of the app increases the database will be further updated to meet the unique needs of the local farmers. Also, the local agricultural experts will meet the farmers one-on-one and through FGDs to evaluate the usefulness of the app. The results of this evaluation will then be discussed with the Aberystwyth University team with the intention of improving the mobile app. Improvement of the system will be an ongoing process as farmers utilize the system. The idea here is to provide as much issues that the farmers have and provide solutions to them. The local agricultural expert team is therefore crucial in the process.

The mobile farm query system can only be installed on later versions of the Android operating system. This may limit the number of local farmers that can use the system. Many small holder farmers in the area have feature phones which run on older versions of the Android operating system. From a technical standpoint this problem can be solved by further customisation of the mobile farm query system to run on lower versions of the Android operating system. Farmers can also form groups to access information from farmers who have complaint mobile phones within their locality. This serves not only to provide access to more farmers but also to enable for more rigorous analysis of their farming problems and better understanding and uptake of the solutions provided in the mobile farm query system. Many extension agents may not have immediate answers to all farmers' queries when on the field and have to contact local agricultural experts. This system provides them more information to facilitate quick and timely resolution of farmers farming problems.

Chapter 11

Conclusion

11.1 Summary of work done

A review of the trends in mobile computing-based extension delivery in Nigeria was conducted. The review showed that there is a high penetration of mobile telephony in Nigeria although less so among rural farmers. However agricultural systems have not been adequately developed to take advantage of this mobile phone coverage. One of the major challenges identified after organising focus group discussions (FGDs) and one-to-one meetings with local farmers and surveys in Jos, Plateau State, Nigeria is that although farmers have access to mobile phones and the Internet, they find it difficult to access information easily and quickly to address their local farming needs. It therefore became imperative to look into effective ways at facilitating their access to locally relevant information.

Requirements for effective mobile farm query systems were developed and established. They include (1) As little input as possible by the user (2) Limited data visible to the user (3) Restricted access to the Internet (4) Wide range of help for farmers (5)Easy expansion of the system (6)Availability in minority languages (7) Sustainability within developing country budgets.

A mobile query technique that meets the requirements of providing access to information for rural farmers by ontology-based partitioning was developed. The technique requires the repeated partitioning of the domain so that the user can select the appropriate partition at any level, and gradually home in on the desired answer. This technique was used to develop a farming advice system for rural farmers in Jos, Plateau State, Nigeria. The farming advice system partitions the farming advice domain into three major groups i.e. Grains/tubers, Vegetables and Animals. These groups are further partitioned into smaller groups based on how local farmers group farming concerns and with some inspiration from case based reasoning.

Question and Answer (Q/A) pairs were collected from local small holder farmers with the active collaboration of local agricultural experts from the Federal College of Animal Health and Production Technology, (FCAH&PT), Vom, Plateau State, Nigeria. The local agricultural experts conducted FGDs, one-to-one meetings and questionnaire surveys with the local farmers. This information was curated, and the mobile query technique was used to arrange the Q/A pairs in the

farming advice system.

Farming advice for fifteen species of animals and crops were captured in the mobile farm query system. It was observed that within an ontological partition, similar sub-partitioning occurs e.g. for crops - sowing, harvest, storing, fertilizer, general production, pest/disease and weeding. Animals - Breeding, Disease, Feed/water, general production and vaccination. As more crops and animals are added to the system, the set of concerns can be used as a guide in the collection of Q/A pairs from local farmers and extension workers.

The application of the mobile query technique to other domains was explored by considering how it could be used for making FAQs about Aberystwyth University Information Services accessible. A third domain explored was the provision of personal health advice.

The three domains used in implementing the mobile query technique are very different but the developed principles for breaking down a domain have proven effective in each.

The mobile farm query systems developed using the technique is being trialled by small holder farmers in Plateau State, Nigeria. The system provides small holder farmers with an easy and timely way of accessing farm query information. This is very important to farmers because of the critical nature of timely information. The system provides extension agents who may not have immediate answers to all farmers' queries when on the field quick access to this information even in areas where there is no mobile signal or Internet access. It also provides a database of farmers' problems and concerns. As farmers use the system, the frequency of their consultation of Q/A pairs, the season when these Q/A pairs are consulted and the location from where they are consulted can be used to build a big picture of farming problems and concerns within an area. This information can be used to properly channel much needed help to small holder farmers.

11.2 Further work

11.2.1 Deploying mobile farm query system

The mobile farm query system is been deployed to farmers in Jos, Plateau State, Nigeria as part of the GCRF funded automated agricultural analytical project which is a pilot for a much larger effort to provide advice in an effective, efficient and timely manner to small holder farmers in Jos , Plateau State, Nigeria. The project is a collaboration between the Federal College of Animal Health and Production Technology (FCAH&PT), Vom, Plateau State and Aberystwyth University, UK. A five member team of agricultural experts from FCAH&PT, Vom who have been engaging with local farmers within Jos, Plateau State, Nigeria to determine their farming needs will deploy the mobile farm query system to farmers in two farming communities in Riyom Local Government of Plateau State, Nigeria. The mobile farm query system app has been available on the Android play store from where it can be downloaded and installed on the mobile phones of local extension workers and farmers. Every member of the five man team have been given mobile phones on which the app can be installed.

When the members of the team have successfully installed the mobile app on their phones, they will then assist the farmers on installation of the mobile app on their phones. The extension agents will then assist the farmers on how to use the system to seek answers to the farming issues. The local team of agricultural experts will also serve as local support to the farmers using the system. Farmers can use the system to ask questions that they may not find in the mobile farm query system or questions with answers they are not satisfied with. These questions will be answered by the team and updated on the mobile farm query system.

11.2.2 Providing continuous support to farmers on the application

The local team will evaluate the usefulness of the mobile farm query app to the farmers through one-to-one discussion, FGDs and surveys with the farmers on their usage experience. The usage statistics from farmers i.e. location of access to the mobile app, frequency of consultation of Q/A pairs and the time of the year when particular Q/A pairs were consulted most can be used in combination with satellite based data to build a rich big picture of farming issues/concerns in that particular area. This information can be used to help government agencies, universities, agricultural research and extension agencies and NGOs properly provide help to farmers within the area.

As the usage of the system expands to more farmers direct assistance to use the app by the 3AP team may not be feasible. This will be mitigated by the development of a self-help manual that will be made available to users when they open the mobile app. Farmers will be given a quick work through of how to download and install the mobile app from the google play store. They will also be given a guide on how to optimise the use of the mobile app once it has been installed on their system. This will further augment one-to-one and group trainings on how to use the mobile app.

The mobile farm query system would be supported by FCAH&PT, Vom in collaboration with Aberystwyth University. The 3AP team from the FCAH&PT, Vom will be organising on an ongoing basis one-to-one training, workshops, conferences as well, radio and television trainings for farmers as the number of users increase. There is also a plan for multilingual support for the system to target farmers who are not fluent in the use of the English language.

11.2.3 Expanding the coverage and scope of the mobile farm query system

The mobile query system was developed using data from Plateau state, Nigeria. In the future it can be expanded to cover farmers in other parts of Nigeria and Africa. There are five agro-ecological zones in Nigeria with Plateau being one of them (Udoh *et al.*, 2000). These zones have different and intersecting agricultural products with very similar farmer demographics and practices. Adapting the mobile farm query application for small holder farmers in these zones will necessitate some modifications to the application. Fundamentally the app will maintain the

same structure because most small holder farmers in Nigeria have similar characteristics. However, agricultural products peculiar to a particular zone will need to be added to the applications database. This will mean liaising with local farmers and extension workers within that zone to build a database of Q/As from that particular area. The local extension workers in that zone will also have to be engaged to support local farmers in using the application.

Language support will also be helpful to further improve the acceptance and usability of the application. Nigeria is a multi-lingual country and many of the small holder farmers are more comfortable in communicating in their local languages. The mobile farm query system can easily be adapted to provide multi lingual support.

11.2.4 Further applications for mobile farm query systems

A bottom up approach in accessing farmers' needs within an area has many beneficial applications in viewing the overall picture of agricultural practice within an area, zone or country. Enquiries that individual farmers make about e.g. sowing maize, or about specific poultry diseases can be aggregated to understand farmers' most pressing concerns, and to map disease occurrences across a region. This information can be combined with satellite-based information, survey results, research study results, sensor-based information and other agriculture-based information to form a rich picture of the agricultural activity within a large area. This picture can serve both individual farmers needs and large groups of farmers. This provides the potential to governments or companies of obtaining greater understanding of what is happening within a region without expensive surveying. That knowledge can be used as a basis for policy decisions or for commercial action. It can also be used by governments, research agencies, NGOs and agriculture-based businesses to provide much needed support and intervention to small holder farmers.

The research is particularly timely because there have been successful deployments of mobile apps, but no-one has yet instrumented those apps so that usage can be recorded and aggregated. At the same time, the interest in Agricultural Analytics, and being able to get a high-level picture of what is happening in a region has grown rapidly, with that information being generated through expensive surveying of farmers. This work provides the potential of using information from mobile apps to provide automated agricultural analytics.

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Appendices

Appendix A

Tables showing classification of Domains

Table A.1: Classification of Farming Advise System domain

Domain Name	**Farming Activity**	**Farm Produce**
Farming Advice System	Grains and Tubers	Maize
		Cassava
		Rice
		Yam
	Vegetables	Melon (egusi)
		Lettuce
		Spinach
		Strawberry
	Animals	Poultry
		Dogs
		Large Animals
		Rabbit
		Pig
		Sheep and Goat

Table A.2: Classification of Grains and Tubers in Farming Advice System

Farming Activity	**Farm Produce**	**Concern**
Grains and Tubers	Maize	Sowing
		Harvest
		Storing
		Fertilizer
		Pest/disease
		General Production
		Weeding
	Cassava	Sowing
		Harvest
		Storing
		Fertilizer
		Pest/disease
		General Production
		Weeding
	Rice	Sowing
		Harvest
		Storing
		Fertilizer
		Pest/disease
		General Production
		Weeding
	Yam	Sowing
		Harvest
		Storing
		Fertilizer
		Pest/disease
		General Production
		Weeding

Table A.3: Classification of Vegetables in Farming Advice System

Farming Activity	**Farm Produce**	**Concern**
Vegetables	Melon (Egusi)	Sowing
		Harvest
		Storing
		Fertilizer
		Pest/disease
		General Production
		Weeding
	Lettuce	Sowing
		Harvest
		Storing
		Fertilizer
		Pest/disease
		General Production
		Weeding
	Spinach	Sowing
		Harvest
		Storing
		Fertilizer
		Pest/disease
		General Production
		Weeding
	Strawberry	Sowing
		Harvest
		Storing
		Fertilizer
		Pest/disease
		General Production
		Weeding

Table A.4: Classification of Animals in Farming Advice System

Farming Activity	**Farm Produce**	**Concern**
Animals	Large Animals	Disease
		Vaccination
		General Production
		Feed/Water
		Breeding
	Poultry	Disease
		Vaccination
		General Production
		Feed/Water
		Breeding
	Dogs	Disease
		Vaccination
		General Production
		Feed/Water
		Breeding
	Rabbit	Disease
		Vaccination
		General Production
		Feed/Water
		Breeding

Table A.5: Classification showing Personal Health System

Family Doctor	Children	Under one	Slow weight gain
			Waking at night
			Fever in babies
			Skin problems
			Excessive crying
			Feeding problems
			Vomiting in Babies
			Diarrhoea in Babies
		All Ages	General issues and mouth problems
			Weight and growth problems
			Sleeping, drowsiness and related problems
			Arm and leg problems
			Genital and swollen gland problems
			Coughing and Breathing problems
			Vomiting, Urinary and related problems
			Behavioural and related problems
			Hair, Spots, rashes and related problems
			Eye, Ear and nose problems
		Adolescents	Delayed puberty
			Adolescent behaviour problems
			Adolescent skin problems
			Adolescent weight problems
	Adults	General Medical	Fever, Headache and related problems
			Weight problems
			Depression, Anxiety and related problems
			Itching and related problems
			Eye problems
			Hair and skin problems
			Breathing and voice problems
			Ear, Nose and Mouth problems
			Abdominal and urinary problems
			Body pain
		Special Problems	Male
			Female

Table A.6: Classification of Adult General Medical issues in Personal Health System

General Medical	Fever, Headache and related problems	Feeling under the weather
		Tiredness
		Fever
		Excessive sweating
		Faintness and fainting
		Giddiness
		Headache
	Weight problems	Loss of weight
		Overweight
	Depression, Anxiety and related problems	Difficulty in sleeping
		Forgetfulness and confusion
		Difficulty in speaking
		Disturbed thoughts and feelings
		Depression
		Anxiety
	Itching and related problems	Itching
		Numbness and Tingling
		Twitching and trembling
	Eye problems	Painful or irritated eye
		Disturbed or impaired vision
	Hair and skin problems	Hair and Scalp problems
		Nail problems
		General skin problems
		Spots and rashes
		Raised spots & lumps on the skin
		Lumps
		Rash with fever
	Breathing and voice problems	Hoarseness or loss of voice
		Wheezing
		Coughing
		Difficulty in breathing
		Palpations
	Ear, Nose and Mouth problems	Earache
		Noises in the ear
		Deafness
		Runny nose
		Toothache
		Difficulty in swallowing
		Sore mouth or tongue
		Sore throat
	Abdominal and urinary problems	Wind
		Diarrhoea
		Constipation
		Vomiting
		Recurrent vomiting
		Abdominal pain
		Swollen abdomen
		Abnormal-looking faeces
		Anal problems
		General urinary problems

Table A.7: Classification of Special problems for Adults in Personal Health System

Special Problems	Male	Baldness
		Painful or swollen testicles
		Painful penis
		Painful urination
		Erection difficulties
		Premature ejaculation
		Delayed ejaculation
		Low sex drive
		Fertility problems
		Contraception
	Female	Periods
		Genital/Vaginal issues
		Bladder/Urination
		Sex issues
		Failure to conceive
		Pregnancy & Childbirth

Appendix B

Sample Frequently Asked Questions (FAQs) and Answers for Farmers in Plateau State, Nigeria

B.1 Maize

1. Que: What variety of maize would you advise me to sow in order to get higher yield?
   Ans: Summaz 14, 32, and other summaz varieties.

2. Que: What is the best time to sow my maize (if I am cultivating for grains)?
   Ans: Second week of June What fertilizer type would be best for my maize and at what rate do I apply it?

3. Que: Basal application NPK 15:15:15 at 300kg per hectare
   Ans: Top dress Urea at 100kg per hectare applied 3 times (splits)

4. Que: What is the preventive treatment against stalk borers?
   Ans: Apply Endosulfan 2litres/hectare 10 days after germination

5. Que: What is the curative treatment of stalk borers?
   Ans: Spray chlorpain at 2.5litres per hectare when case becomes apparent

6. Que: How do I control broadleaved weeds on my maize farm using chemicals (herbicides)?
   Ans: Use 2, 4-D amine at 3 litres per hectare. Spray at 4 -6 weeks after germination.

7. Que: What pre – emergence herbicides is best for my maize farm at Ganawuri and what rate of application?
   Ans:

   - Use the combination of Attraxin and Paraquate dichloride

- Attraxin – 5litre per acre or 5 kg /ha
- Paraquate – 2l/ha
- Spray before crop emergence

8. Que: I experienced wilting or dying of the maize leaves on my maize farm last season. How do I prevent that disease or control it?
   Ans:

   - Use resistant varieties (hybrids)
   - Spray foliar fungicides against blight e.g Dithane M 45
   - Sow early to prevent leave blight fungus

9. Que: How do I prevent army worm from my farm?
   Ans: Spray Dimethoate round the farm to prevent worm from creeping into your farm.

10. Que: Termites are endemic in my area. How do I prevent their attack on my maize farm?
    Ans: Dig out all termite hills around your farm apply chloprifos to destroy the termites

11. Que: What is the best spacing for high yield when using high yielding maize varieties as recommended?
    Ans; 2 seeds at 40cm x 60cm(intra x inter)

12. Que: What is the best depth for sowing?
    Ans: 3 – 5cm deep

13. Que: How many times can I grow maize on my piece of land in a year?
    Ans: You can conveniently grow and harvest maize crop 3 times in a year with good irrigation.

14. Que: When and how do I top dress with urea?
    Ans: 2 to 3 weeks after crop emergence (first dose) subsequently apply at an interval of 10 days.

15. Que: Some organism eat up my maize leaves leaving the stem and ribs what are they and how do I control them?
    Ans:

    - They are army worms or grasshopper
    - Spray 2% methyl parathion at 2kg/ha for eggs for nymphs and adult spray 0.04% carboxyl at 500-800 (diluted) litres/hectare

16. Que: Internodes at the base of maize stem becomes soft. What causes it and how can I control it?

    Ans:

- Cause: bacteria stalk rot
- Use bleaching power along rows at 20-25kg/ha

17. Que: When do I harvest my maize and how?
    Ans: Harvest when moisture content is between 17-19%. Cut the stalk and allow the cob on it to cure for 72 hours before removal.

18. Que: At what moisture level do store my maize?
    Ans: When moisture content is 13% and below, you can know by cracking and rattling.

19. Que: How do I control stored pests of maize?
    Ans:

    - Regular fumigation of the store with Gama Benzene Hydrochloride
    - Also dust with Lindane

20. Que: After fumigation or treating my store maize against pest, how long will it take against save use or else what do I do?
    Ans:

    - Safety period after fumigation is 60 days
    - Else spread under the sun for four hours before use

21. Que: What type of soil is suitable for maize production?
    Ans: Loamy soils are suitable but well drained fertile soils are ideal.

22. Que: What type of soil is suitable for maize production?
    Ans: Loamy soils are suitable but well drained fertile soils are ideal.

23. Que: What do I do when maize yield begins to reduce after some years of continuous cropping on same land?
    Ans:

    - practice crop rotation with legumes
    - line the soil to control pH level
    - Introduce organic fertilizer
    - Practice bush fallow if you have enough land

24. Que: My maize turns yellowish even after fertilizer application
    Ans:

    - Maize probably planted on waterlog soils
    - Deficiency of nitrogen, apply required nitrogen fertilizer

25. Que: Maize planted in Fadama shows sign of leave drying up and no cobing what is responsible?
    Ans: Don't apply nitrogen fertilizer (urea) on maize planted in Fadama. The reaction of area with water does not favour maize development in waterlog soils (Fadama)

26. Que: How is streak disease controlled in maize?
    Ans: Purchase good seeds from reputable seeds dealers

27. Que: Maize remains stunted even when recommended dosage of fertilizer is applied. What is the problem?
    Ans: The farm is probably infested with striga. Plant legumes for some time to control the striga before introducing maize

28. Que: Maize growing excessively tall with green leaves, but cobs formed is not encouraging. What is responsible?
    Ans:

    - It may be a local variety of maize
    - The soil is excessively fertile with high percentage of nitrogen
    - Plant improved variety of maize to utilize the abundant fertility of the area

29. Que: Often mix maize with other crops but yield from the other crop(s) turns out to be poor why?
    Ans: Maize plant grows tall and its leaves index covers a wider space, thereby denying the other crop(s) sunlight for growth and development which affects yield output.

30. Que: I brought maize seeds from a seed company; the maize matured early but the yield was not good enough why?
    Ans: Yes, the improved maize was not bred for high yields but to fight hunger, because of its early maturity. If has the advantage of being planted 3 times a year.

31. Que: Why is it that the local varieties of maize taste better than the improved varieties?
    Ans: Yes, because the local variety is already adaptable to the environment.

B.2 Poultry

1. Que: I have recorded low production and several mortalities in my last batch of layer flock due to some disease tumours on the comb. What could be the problem and what preventive measure(s) should I take now that I am bringing a new batch?
   Ans: It could be Newcastle disease tumour. There are no available drugs for the treatment of poultry viral diseases. There are vaccines available which

are for the prevention of the diseases. Ensure that you buy your birds from a reputable source. Before restocking, clean the poultry house and wash thoroughly. Fumigate the poultry house and allow for not less than three months. Ensure that you give the birds the recommended vaccines and observe strict biosecurity.

2. Que: At what age should I start vaccinating my poultry /birds?
   Ans: Consult with the nearest veterinary clinic or the hatchery for a vaccination schedule to follow. If you bought the birds at day old depending on your locality, your veterinary doctor will have a schedule that will show the age you are going to vaccinate for each disease. There are vaccines that are given right from hatchery. The first vaccine aside the one from the hatchery is given in the first week.

3. Que: My birds are 21 week old and are yet to start laying.
   Ans: Your layer birds should start laying eggs as from 18-20 weeks depending on the source and breed. If your birds had previous infection at early age, it may delay time of laying eggs. Infection such as intestinal worms, lice, mites, fowl typhoid, coccidiosis, mareks, newcastle diseases could affect production for all the birds' life. You must feed them well at early age for them to lay eggs at the appropriate time. Deficiencies in calcium, phosphorus in feed affects production. If they are not fed quality feed in the right quantity, you may have delay in production.

4. Que: When should I change from grower mash to layer mash?
   Ans: Between 0-9 weeks you should feed chick mash, above 9 weeks feed them grower mash until they reach point of lay and started laying up to 5% then change to layer mash.

5. Que: Where can I get a quality chickens for egg or for meat?
   Ans: Look for a reputable hatchery. You can ask those successful in the business for where they obtained their stock

6. Que: I am expecting a batch of day-old chicks in a few days what should I do?
   Ans: Ensure that the house is ready before their arrival. You need to have enough feeders and drinkers. Give vitamins and/or glucose. Observe to see those that are weak and isolate.

7. Que: My birds sometimes do not finish the feed and water I put for them. How do I know the quantity of feed and water they are supposed to take in a day?
   Ans: Birds consume much during cold weather and less during hot weather. More so, they tend to eat less when they are sick. It is better to feed just enough that they can consume. 200 birds can consume 1 bag i.e. 25kg of feed a day

8. Que: My birds are over 2 years old; at what age should I dispose of them?
   Ans: There is no actual age. Birds can lay eggs for more than 2 years.

However, if the production has dropped below 50% for a consecutive 4 weeks it will be better to sell them. Before making decision be sure that the low production was not because of poor- or low-quality feed and that there is no disease problem.

9. Que: If I skip a vaccine for my birds how do I start again?
   Ans: Make every effort to give the vaccines at the appropriate time. Usually there is a gap between one vaccination and the next. So, if it has not yet reached the next one, you can give the one you missed. However, consult with your veterinary doctor in the event you missed any.

10. Que: Some birds in the flock show signs twisting of neck and unable to walk while some show respiratory signs.
    Ans: The birds may have Newcastle disease. Isolate the sick ones then treat based on the signs, since there is no drug for the treatment of poultry viral diseases. Give multivitamins, antibiotics for secondary bacterial infection.
    Que: I observe my chicks crowding around the source of light.
    Ans: Your birds may be cold. It suggests lack of adequate source of light. When the light is too much birds move away from source and when not enough, they crowd around it to get warm. When the light is adequate, they will be evenly distributed

11. Que: What could be the cause of a sudden drop in egg production in my layer flock?
    Ans: Anything that constitutes stress to your birds such as sudden change of weather, feed, and change of litter and or infections can lead to sudden drop of egg production. If you have the record of activity and the level of production in the farm, then it's easier to trace the cause. For example; was it when you change their feed? Was there change of weather recently, was it after giving a particular drug? etc

12. Que: When should I change from grower mash to layer mash?
    Ans: When the birds start laying egg preferably when about 5% have started laying

13. Que: My birds just stopped feeding and taking water?
    Ans: your bird may be sick. However, sometimes birds may stop feeding or drinking water because of change of weather or change of feed.

14. Que: How do I prevent my birds from blood tinged watery stool?
    Ans: Ensure that the birds are not overcrowded and the house is well ventilated. Ensure that the litter is always dry (water should not be poured on the litter)

15. Que: My birds are passing out whitish and greenish stool?
    Ans: Depending on the age; change in colour of faeces may be due to infection which may be bacteria or viral; whitish diarrhoea in younger birds may be due to bacterial infection such as Pullorum disease while greenish diarrhoea could be fowl typhoid or Newcastle disease

16. Que: Can I give my broiler chicken the same type of feed I give my layer chickens?
    Ans: No! The nutrient requirement for broiler and layer chickens are not the same. Give broiler starter between 0-4 weeks and broiler finisher 5-8weeks

17. Que: How often should I de-worm laying birds?
    Ans: You can de-worm after every 3 months.

18. Que: What makes birds to peck each other?
    Ans: Pecking in poultry is often referred to as cannibalism. Pecking in poultry occurs due to overcrowding, mineral deficiency, overgrown beak etc.

19. Que: My birds curdle are sleepy, what is the cause and what should I do
    Ans: Your birds may be sick. Depending on other signs such as presence of blood tinged or whitish faeces, they may be having coccidiosis-Give amprolium in water. They may be having Gumboro disease. In Gumboro disease however, the birds may be dying much more than in coccidiosis and no treatment for Gumboro disease. Give them multivitamins.

20. Que: I observed sign of difficulty to stand and walk in my layer birds; what is the cause?
    Ans: Infection such as mareks disease affects the sciatic nerve leading to paralysis of the limbs. If you have mortality, take one or two for post-mortem for diagnosis. In calcium deficiency the limbs become de-mineralized and are weak leading to difficulty of the birds to walk. Isolate those showing signs and give all calcium supplements.

21. Que: I observed a small raised dried firm lesion on beak, shark, wattle and comb of my bird; how do I treat them
    Ans: your birds may be having fowl pox. The fowl pox is a viral disease and does not have treatment. It's recommended that you scrape the lesion and apply tincture iodine or gentian violet (GV).

22. Que: Can I keep, raise bird of different age in the same house
    Ans: It is always better to practice all in all out where you sell all birds of the same ages and bring in another batch of the same age.

23. Que: I sometimes pick whitish or small sized eggs in my layer farm?
    Ans: There are many causes of whitish or small sized eggs. Your birds may be under stress, may be getting old, and may be on certain drugs or having viral diseases such as Newcastle disease and Infectious bronchitis. In some cases, calcium deficiency may lead to whitish egg or even small size

B.3 Large Animals

1. Que: How do I know that my animal is/are sick?
   Ans: When you notice the following; your animal refuses to eat, abnormal

movement, lying down, watery stool, blood in urine and feces, vomiting, jaundice, emaciation, not growing properly and many abnormal signs.

2. Que: Can I get infection from animals?
   Ans: Yes. Disease such as rabies, salmonellosis, E. coli infection, anthrax, brucellosis, leptospirosis etc can be contracted from animals,

3. Que: What cause difficulty in birth?
   Ans: The mother may be weak mother and unable to push, her cervix may not open, the baby may not be in correct position, the baby in the womb may be dead and bloated, and the baby may be too big

4. Que: My cow is having difficulty standing after delivery
   Ans: It is possible that it is tired, may have damaged muscles or nerves, she may have low calcium in her blood. If after two weeks, the animal cannot stand it is advisable to slaughter it.

5. Que: Is it appropriate to breed animals from the same mother/parents since sometimes one may not have money to buy another male?
   Ans: No. Breeding animals from the same parent may lead to less healthy and less productive offspring

6. Que: How often should I use the male to breed?
   Ans: Depending on the specie of animal, for example Boar not more than once per day, Stallion not more than once every other day, Sheep and goats-one male for every 50 females, Buffalo bull not more than once per day. The reason for the number of breeding for each species is that beyond the required number it may result in semen with insufficient sperm in it.

7. Que: I sometimes mate my female animals, but they still come on heat not few days after?
   Ans: The fertility of the male should be questioned. Also, you might have missed the timing for mating. You will need to keep records of breeding date and ensure you use a good male.

8. Que: How can I improve my local animal without importing?
   Ans: By being careful in selecting young animals for breeding based on the performance of their parents. The only disadvantage is that improvement by selection is slower than by importing improved breeds. The risks are however less since the offspring are well adapted to the local condition

9. Que: I have an animal that has some good characteristic but with some defects. Should I use the animal for breeding purpose?
   Ans: No. It is advisable to castrate animals with defect before they reached maturity.

10. Que:My animal has stopped feeding well. What might be the problem?
    Ans: Your animal may be sick. It may also have any of the following: Sore mouth: foot and mouth disease, lumpy Jaw, wooden tongue or there may be pain in parts of the body

11. Que: My cow brings out too much saliva from the mouth
    Ans: your animal may have bad teeth, fever, wounds in the mouth, something might be choking it, presence of foreign body in the month. Grab the tongue, check for sores/wounds or if something is stock in the throat. Rinse the mouth with disinfectant if it's a sore. Administer antibiotic injection preferably Penstrep. Also give the animal some soft feed.

12. Que: What should I do if my animals eats too much of maize?
    Ans: Give magnesium sulfate to cause diarrhoea (250g for large animals and 25g for small). To prevent, always provide fresh drinking water.

13. Que: I have observed some occasion where too much gas collects in my cows stomach (bloating) leading to death:
    Ans: It might have eaten bad food, may be due to sudden change in diet, or have eaten poison.

14. Que: Sometimes my animal passes hard stool.
    Ans: It may be due to eating food without enough water or not eating enough roughage (Constipation)

15. Que: My animal has gone for more than two days without passing stool; what is the cause?
    Ans: If the animal has been eating check if it has eaten dry food without water. Give enough fresh water for animal to drink, give fresh green grass or other roughages cooking oil, mineral oil 1-4 litres of oil, Magnesium sulphate (MgSO4),

16. Que: My cow has stop eating its cut and is not eating properly
    Ans: This means that the cow has no good digestion. It may be due to feeding too many antibiotics. The cow may be having constipation. It may be due to "hardware disease" caused by ingestion of sharp object if you see that the animal is in pain and grunt. Use antibiotics, provide fresh green grass and give VitB inj. If there are no improvements consult your veterinary doctor for further examination.

17. Que: Sometimes I see one or two animals not eating, will be restless, rolling, kicking the belly, sweating, inability to pass stool and sitting like a dog.
    Ans: The animal may be in pain called colic. Give pain killers like aspirin, paracetamol or Novalgin. Give some oil or MgSO4 (Consult your vet if the condition persists)

18. Que: Animal passing loose/watery stool for more than 3 days
    Ans: The animal may have parasites in the stomach, have eaten bad food or water, or contacted viruses or bacteria. There may have been a sudden change in diet or have eaten poison or dangerous plants. Give a lot of water, give parasitic drugs and give antibiotics. If the animal looks sick and has fever, the diarrhoea is probably caused by bacteria or viruses. Call a veterinary doctor.

19. Que: Stool is red or black in colour but no diarrhoea
    Ans: There may be bleeding into the digestive tract. This may also be due to poison. If the animal is not sick and no fever the diarrhoea may be due to a change in feed or too much rich feed. Give plenty water, give small amounts of fluid frequently until the animal starts to urinate normally. Give kaolin and antibiotics (sulphadimidine) consult your vet if the condition persists.

B.4 Dogs

1. Que: My bitch is 9-month-old and I have started seeing signs of heat should I mate her?
   Ans: Female dogs reach maturity between 10 and 12 months. However, it is recommended that you do not mate her when she comes on heat the first time.

2. Que: I have mated my bitch for 3 consecutive times, and she has not conceived.
   Ans: The timing of the mating may be wrong. The bitch or the male may have problem of fertility. Next time you try a different male or change the timing of the mating. You can get a male dog to be in the house to solve the problem. Also take the dog for check-up

3. Que: Why is my bitch still discharging blood even though she was mated?
   Ans: It is possible you mated the dog too early. You may need to take the bitch for examination by a veterinarian

4. Que: I want to keep exotic dog but not sure the one appropriate for security purposes
   Ans: There are many of such dogs but those that are common and good for security purpose are: German shepherd, Caucasian and Rottweiler

5. Que: My bitch died a day after delivery, what should I do for the puppies to survive?
   Ans: Keep them in a warm place. If there is a bitch that just delivered, you can take them to her to get milk. You can use milk for babies and prepare with glucose for them.

6. Que: My dog has reached 61 days of pregnancy and there is no sign of delivery?
   Ans: When a dog gets pregnant, it will take 60 days for it to deliver. Sometimes it may take up to 65 days. If she is still eating well and active, then there's no problem. If she has stopped eating and is inactive for two days, then consult your vet doctor.

7. Que: For some days now, my dog has been scratching its body. I observed partial loss of hair and do not know what to do
   Ans: Presence of some parasites (mites, lice) on the body can cause itching and make an animal to scratch its body leading to loss of hair. Sometimes it

could be due to infection caused by bacteria. Also, when your dog reacts or is allergic to some materials it may cause itching and loss of hair. Consult with your vet doctor for treatment

8. Que: I usually see small raised areas on the body of my dogs and when pressed worms pop out; what causes it?
   Ans: This is caused by larva of some flies. If the place where your dog lives is always dirty (the faeces and urine) it attracts flies and the flies lay worms that enter the skin of the dog. Always keep the place where your dog stays clean.

Appendix C

Application to other domains i.e. FAQs for Information Services and Personal Health Data

C.1 Introduction

The mobile query technique has been implemented in two additional application areas. These application areas have been chosen because of the potential benefit an effective mobile query system will have on these datasets.

Aberystwyth University Information Services (AUIS) and Personal Health Data were chosen because of the importance of mobile information access to these databases. AUIS provides FAQs to staff and students of Aberystwyth University who need to access information services at the university. The present FAQ for AUIS can be accessed by both mobile and desktop computer systems. However, it is still challenging to access the FAQs via mobile phones. AUIS FAQs as presently constituted does not meet some of the criteria for an effective mobile information system. Presently users of the system have to scroll beyond one page on their mobile phones to access all the categories in the AUIS FAQs. This means that it does not meet the Limited data visible to user requirement for an effective mobile query system. AUIS FAQs cannot be accessed offline. This is not a major problem since staff and students have access to the Internet on campus and in most places in the United Kingdom. However, this may pose a challenge when they want to access the FAQs from an area with limited or no Internet access. The AUIS FAQs cannot be easily expanded by users. If a user is not satisfied with the answer to a query in the FAQs they will have to send an email or chat with a staff of the university Information services.

There are a number of Personal Health data services geared towards providing support to people. However many of these services do not meet the requirements for an effective mobile query system. The British Medical Association Family Doctor is an example. The information can be accessed via a book which limits the access to the information to only people who have access to the book. The FAQs provides a wide range of help for health issues to all categories of people. However, it does not meet any of the other criteria for a mobile query system. It

is imperative to implement a mobile query system for the Personal health data considering the importance of quick and timely access to Personal Health issues.

C.2 Data entry and classification for AUIS

The questions and answers for the AUIS were sourced from the AUIS website. The FAQs were downloaded from the website and stored in a MS Excel page. Each category was stored in a separate MS Excel sheet within the same MS Excel work book. The information was checked for any duplication which were deleted. The major classification of the AUIS FAQs on its website was used for the implementation of the mobile query system. These major categories are the Library services, IT services and Help/support. It was observed that the present categorisation does not meet some of the requirements for a mobile query system. Users of the system are required to formulate and type in queries to access information from the system. The limited keyboard on a mobile phone screen will make typing long queries a bit difficult for users of the system. There is also a lot of information that is displaced on the mobile phone screen when accessing the AUIS FAQ website. Further classification was therefore done by repeatedly partitioning the domain so that users can select the appropriate partition at any level. The partitions were inspired by card sorting with the intent of creating partitions that are closely related to how the users will group services together. The classification was implemented using the iPad classifier.

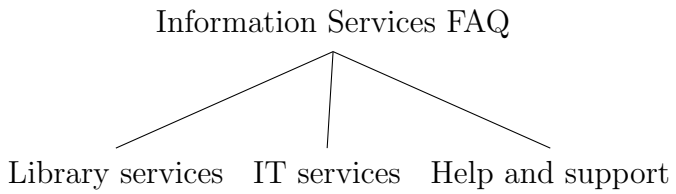

Figure C.1: Knowledge tree showing top level of the Information Services FAQ

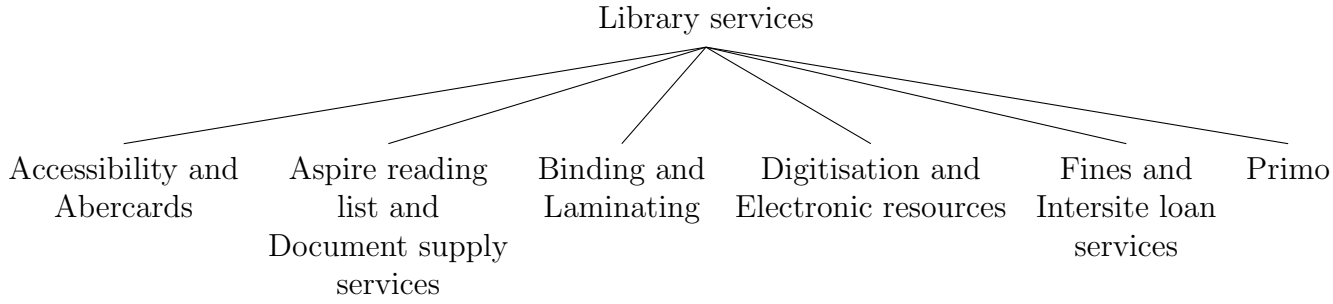

Figure C.2: Knowledge tree showing cross-section of AUIS Library Services

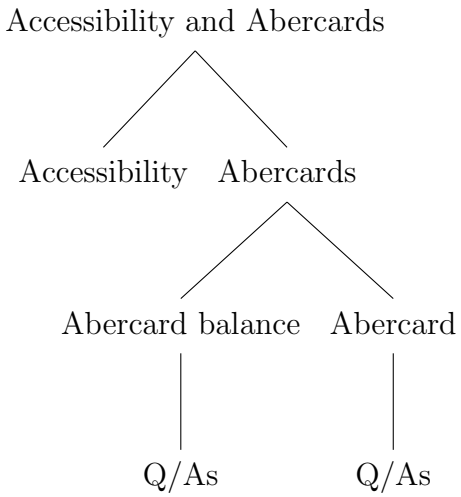

Figure C.3: Knowledge tree showing Accessibility and Abercards Library services

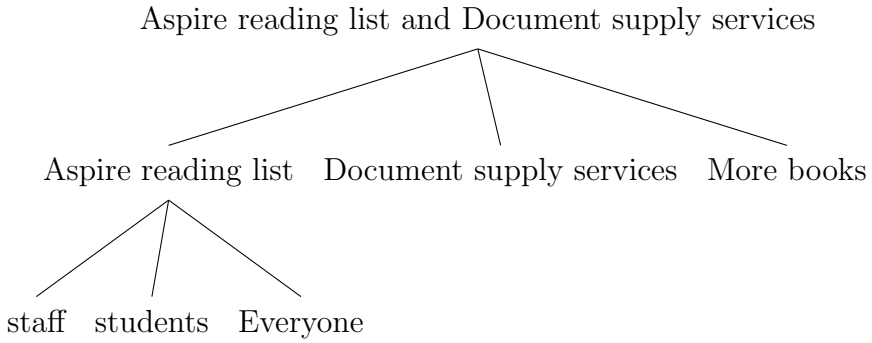

Figure C.4: Knowledge tree showing Aspire reading list and Document supply services Library services

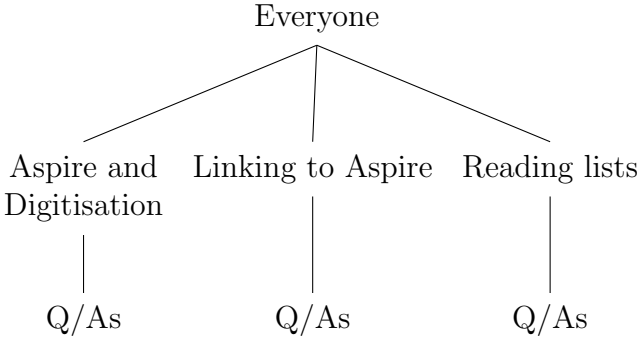

Figure C.5: Knowledge tree showing Aspire Reading list for everyone in the Library

C.2.1 Adding a new category at the top level

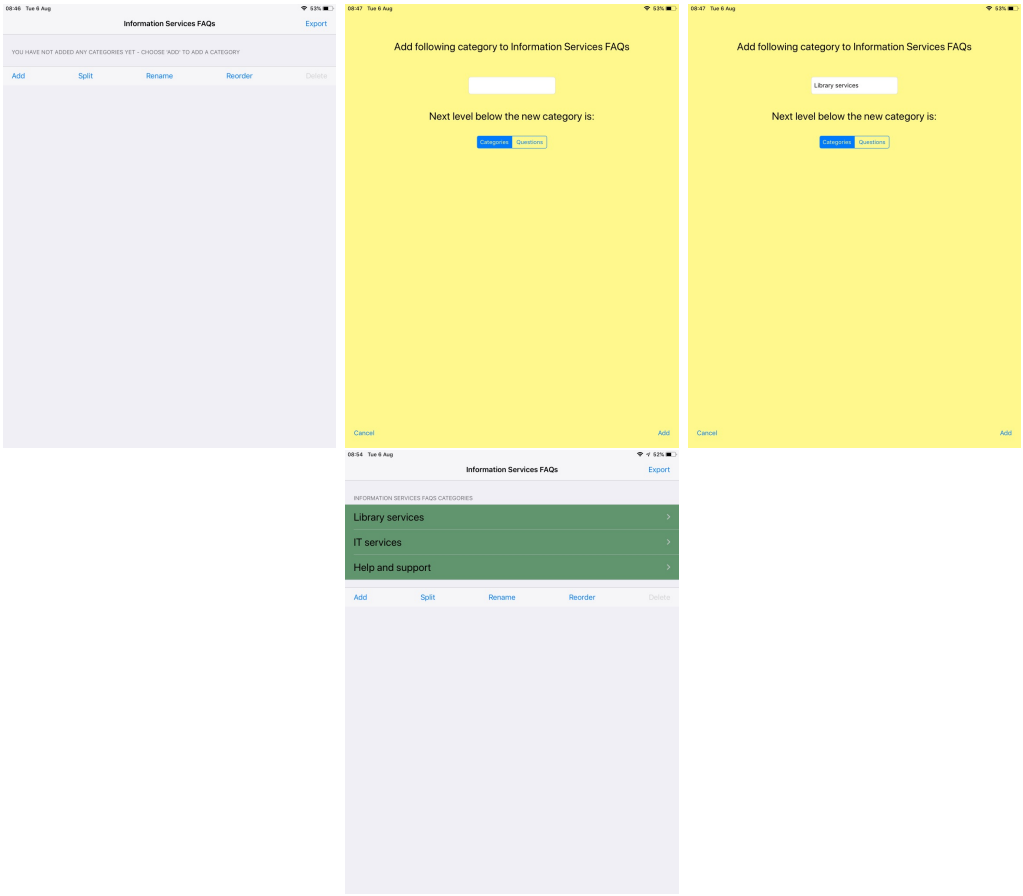

Figure C.6: Adding Library services category

C.2.2 Adding a new category under Library services

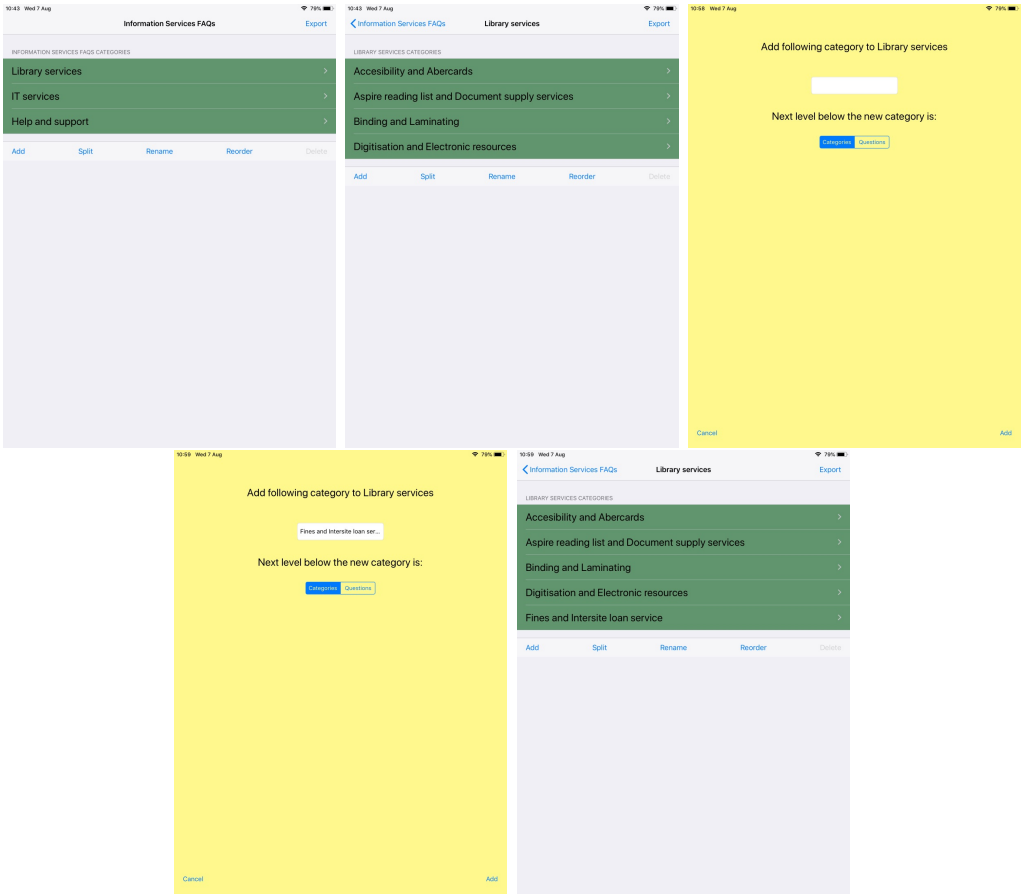

Figure C.7: Adding Fines and Intersite loans services category

C.2.3 Splitting a category

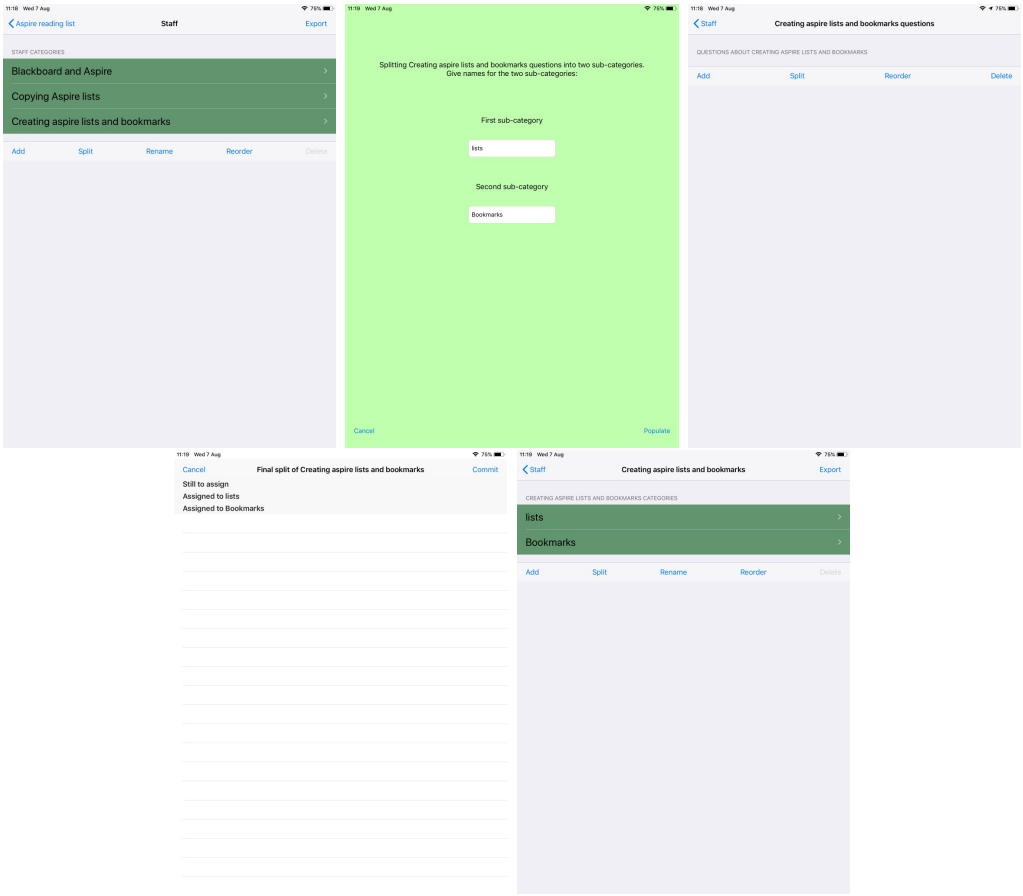

Figure C.8: Splitting the Creating Aspire lists and Bookmarks category

C.2.4 Adding question and answer pairs to a category

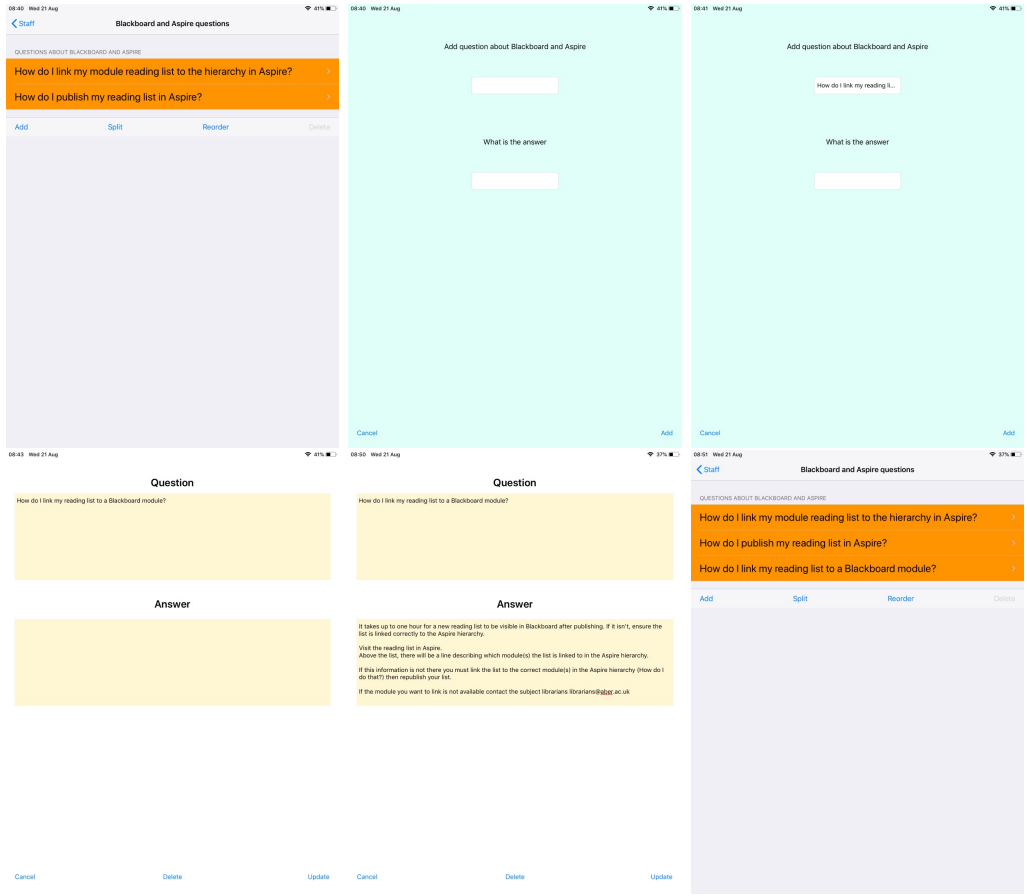

Figure C.9: Adding a question and answer pair to the Blackboard and Aspire category

C.3 Data entry and classification for Personal Health Data

The question and answers for the Personal Health data was sourced from the British Medical Association Family Doctor Home Adviser book (Smith, 2001). The book already categorises health issues based on age and gender. It further breaks the Adult category into special medical problems and general medical problems and also categorises the special problems by gender. It also partitions the children category by age. If the present categorisation is used to develop a mobile query system, it will not meet some of the requirements for an effective mobile query system. Some categories contain too many items which cannot be viewed on one page of a mobile phone. It will also be difficult to expand the system e.g. if a user does not find an appropriate answer to a question it will be difficult for the user to send feedback to the authors of the book. Further categorisation was done on the present structure of the book. This categorisation was inspired by card sorting whereby items that users would normally group together were put

within the same category. The general technique for arranging knowledge in a domain was applied for the categorisation. Inspired by card sorting the domain was repeatedly partition so that the user can select the appropriate partition at any level. The classification was implemented using the iPad classifier. This was done with the intention of fulfilling some requirements for a mobile query system. These requirements include the fact that the user to the system can choose between options rather than type in lots of information to query the system. The amount of data displayed on each screen of the mobile phone is also very limited. The information on the system is stored locally on the mobile phone so it can be accessed offline. Users of the system can also easily expand the system in cases where they do not get an appropriate answer on the system. Language support can also be added to the system in the future especially for use in Wales which is a bilingual part of the United Kingdom.

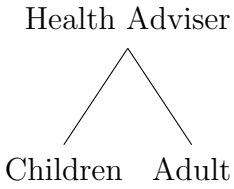

Figure C.10: Knowledge tree showing top level of the Personal Health FAQs

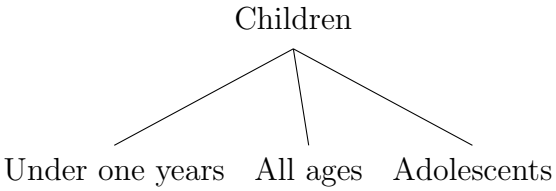

Figure C.11: Knowledge tree showing Children category of Personal Health FAQs

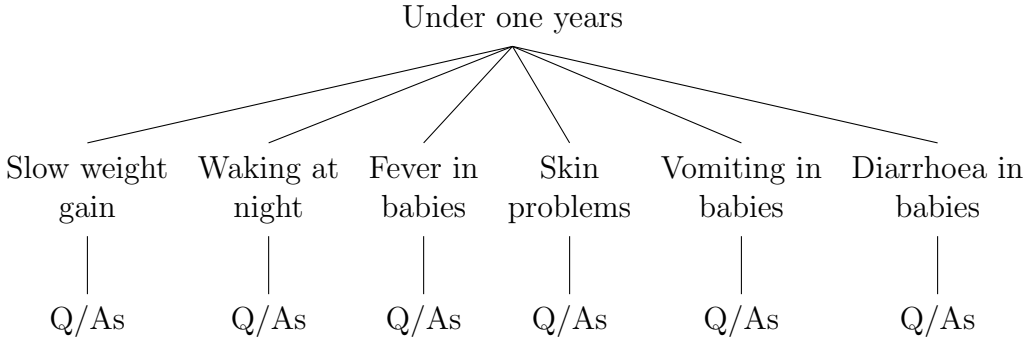

Figure C.12: Knowledge tree showing Children category of Personal Health FAQs

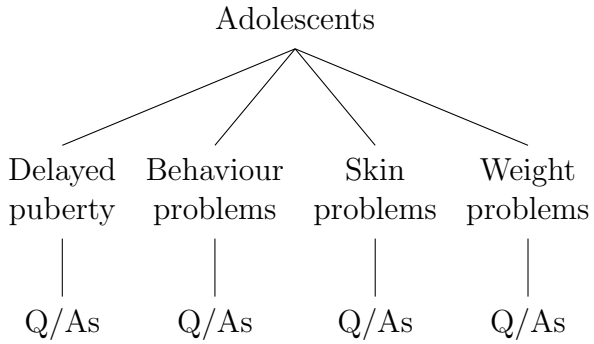

Figure C.13: Knowledge tree showing Adolescents category of Personal Health FAQs

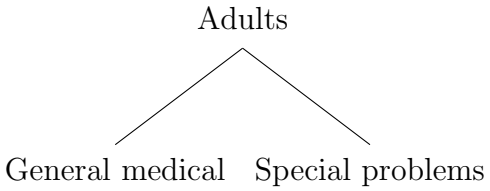

Figure C.14: Knowledge tree showing Adults category of Personal Health FAQs

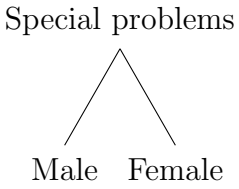

Figure C.15: Knowledge tree showing Adult Special problems category of Personal Health FAQs

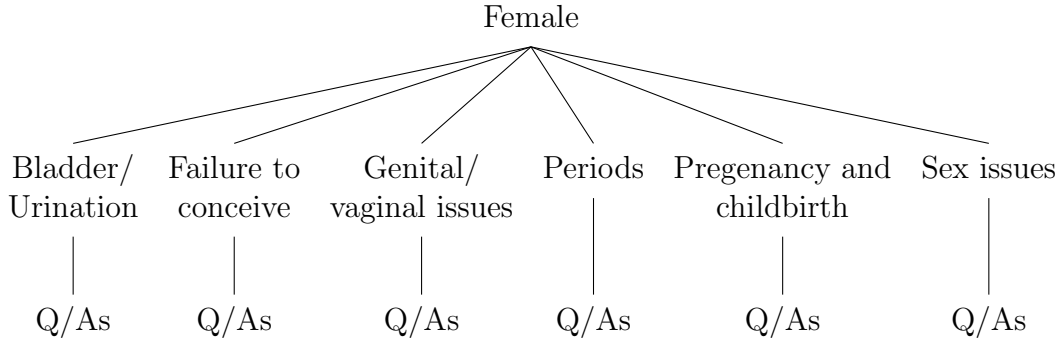

Figure C.16: Knowledge tree showing Female special problem category of Personal Health FAQs

C.3.1 Adding a new category to the Personal Health FAQs

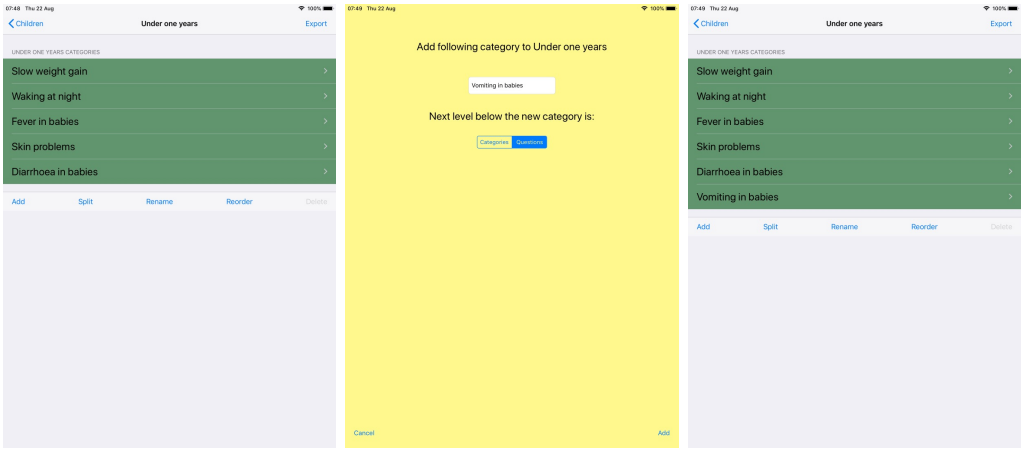

Figure C.17: Adding a new category to the under-one-years category for children of Personal Health FAQs

C.3.2 Adding a new Q/A pair to the Personal Health FAQs

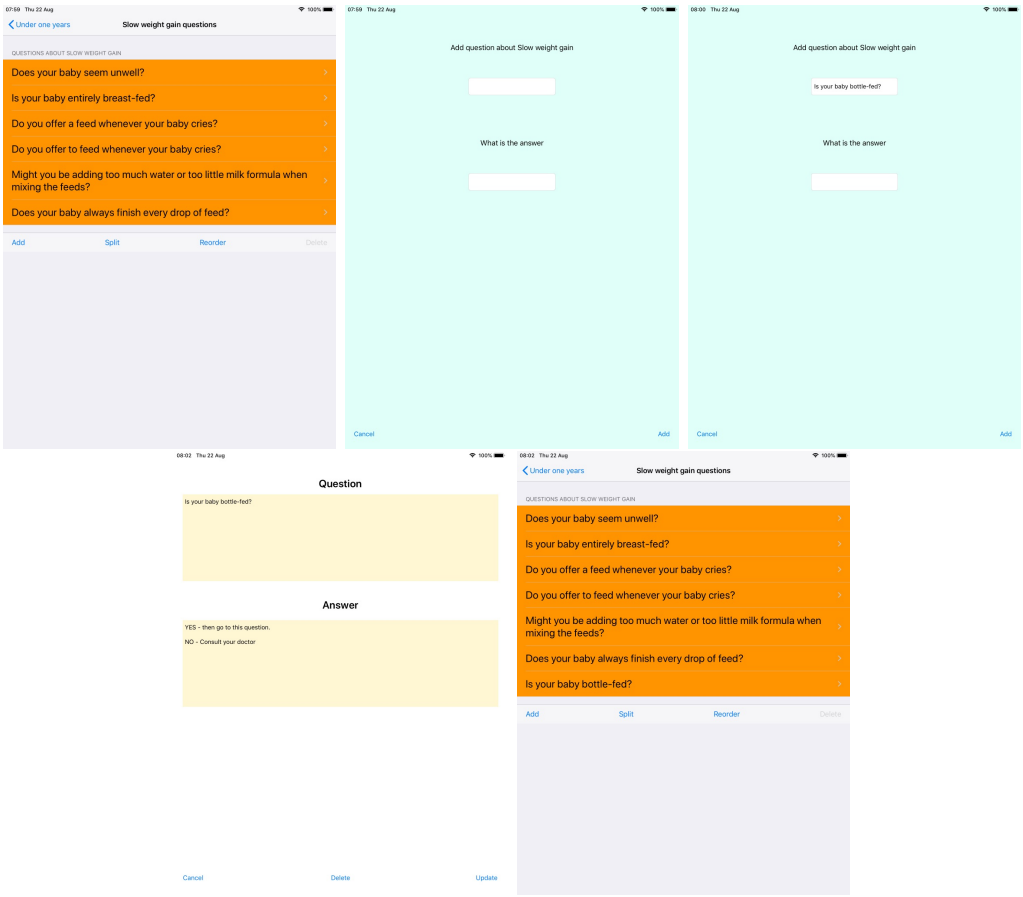

Figure C.18: Adding a new Q/A pair to the slow-weight-gain category for children under one years of Personal Health FAQs

C.3.3 Reordering Q/A pairs in the Personal Health FAQs

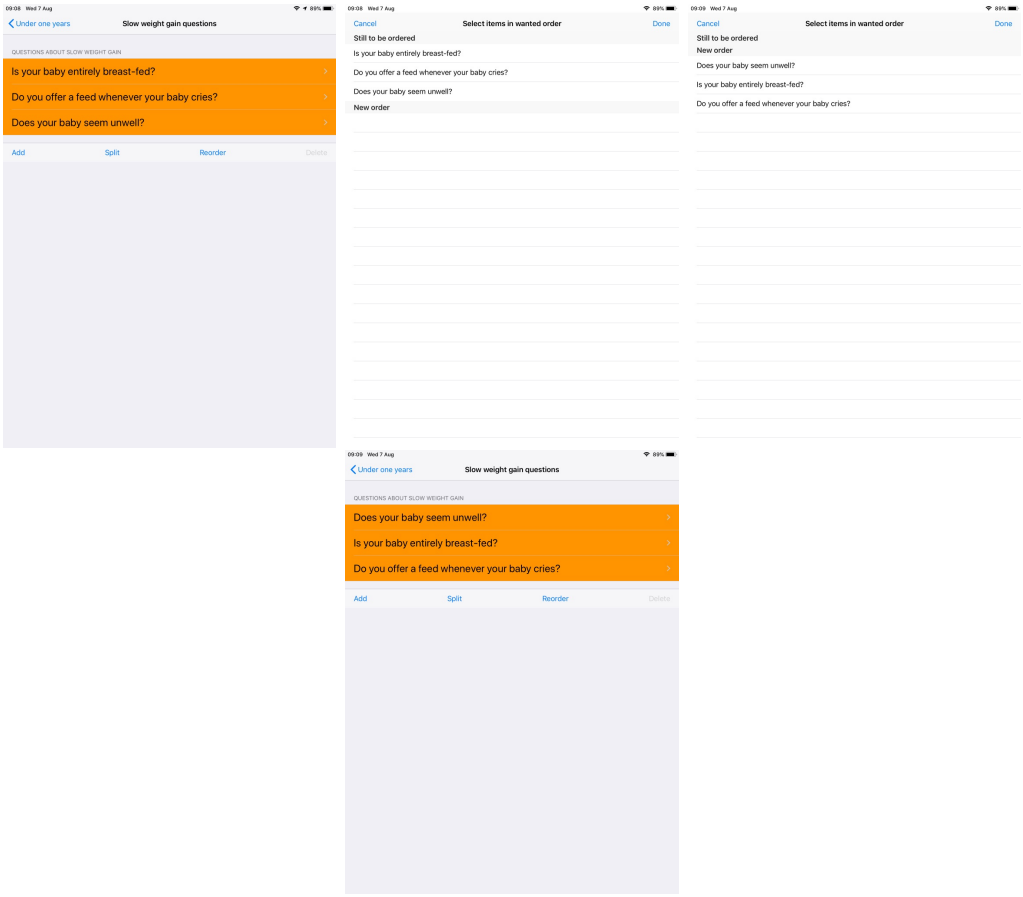

Figure C.19: Reordering the Q/A pairs in the slow-weight-gain category for children under one years of Personal Health FAQs

C.4 Evaluation of using the mobile query technique for arranging knowledge on the AUIS and Personal health FAQs

The main purpose for implementing the technique on both the AUIS and Personal Health FAQs was to see if the mobile query technique has wider applications beyond agricultural data, compare the implementation across multiple domains and test the mobile query requirements against other FAQs.

The mobile query technique has been successfully used to implement these two different domains. The AUIS and Personal health FAQs have less homogenous categories as compared with the farming domain. This makes it difficult to use the structure of these domains as a check when entering new knowledge.

The major operations for implementing the AUIS and the Personal Health FAQs using the iPad Classifier are similar. These operations include adding a new category, splitting a category, renaming a category, reordering a list of sub

categories, reordering a list of Q/A pairs, deleting a category, deleting a Q/A pair, adding a new Q/A pair, splitting a list of Q/A pairs and exporting the database to the mobile phone.

Most of the requirements for mobile query systems that were proposed in this thesis have applications for these two FAQs. The implementations of the AUIS and Personal Health FAQs have benefited from reduced input by the users of the systems. They are required to select choices to get their particular Q/A pair rather than typing lengthy queries. The information they also see on their mobile phone screens has also been greatly reduced and streamlined. Users of these two systems do not have to be within Internet connectivity to access knowledge. The two FAQs have wide ranging knowledge within their domains and the implementation provides utility for that. They can also be easily updated, and feedback is relatively easy. The implementation of the mobile query system on these two FAQs makes it easy for multilingual support to be implemented. However, the AUIS and Personal Health data do not have the budgetary limitations that the Farming Advise system has since they are domiciled in a developed country.

Appendix D

Ethical Clearance

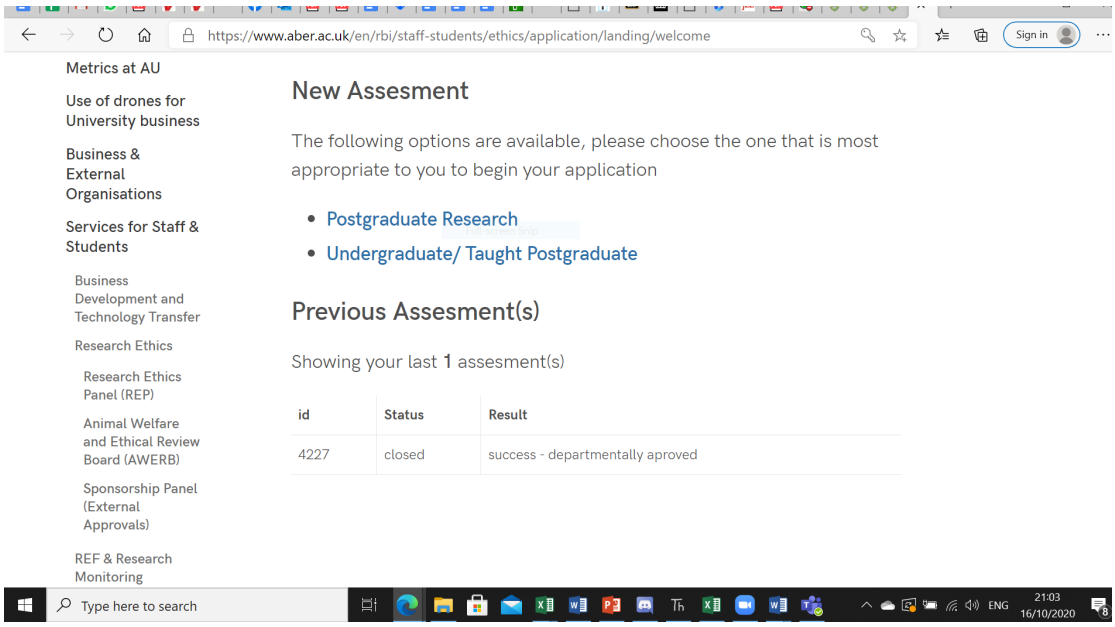

Figure D.1: University Ethical approval