UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

A Knowledge Management System for Horticulture Farming in Kenya

BY

Mayaka Purity Kemunto

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Supervisor

Dr Robert Oboko

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Declaration

The project presented in this report is my original work and to the best of my knowledge has not been presented for a degree in any other university.

Purity Kemunto Mayaka

P58/65122/2011

Signed.....

Date.....

This project has been submitted as part fulfillment of requirements for the award of Masters of Science in Computer Science of the School of Computing and Informatics of the University of Nairobi, with my approval as the University Supervisor.

Dr. Robert Oboko

Signed.....

Date.....

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Dedication

For Tata, Mama, Tonina and for Ivayo.

Abstract

Globally, the importance of knowledge as a means to gain or sustain competitive advantage is increasingly being recognized. Knowledge has become a vital resource. Consequently, there is a growing call for knowledge management (KM).

Human capital, which is defined by Wikipedia as the stock of competencies, knowledge, social and personality attributes, including creativity, embodied in the ability to perform labor so as to produce economic value has to be preserved and leveraged to allow for continual learning and improvement. A large number of problems in consulting, advertisement, media, high-tech, pharmaceutical, law, software development, and other human-capital based organizations are attributed to un-captured and un-shared knowledge, the need to know 'who-knows-what', the need for distance collaboration, and the need to capture lessons learned and best practices.

In Kenya, agri-business is attracting a growing class of 'peri-urban' farmers and investors who buy or rent land and plant high-yielding crops especially horticultural crops. These emerging farmers need adequate access to knowledge and information in areas of new agricultural technologies, early warning systems (drought, pests, diseases), improved seedlings, fertilizer, credit and market prices.

This project outlines the development of a knowledge management system for the upcoming enterprising farmers. The project was geared towards horticultural farmers specifically watermelon, strawberry and mushroom farmers. The knowledge management system developed using Structured System Analysis and Design methodology enables capturing of information from expert farmers through videos, pictures, documents and notes. The knowledge captured was then codified, tagged and categorized in a knowledge base before being disseminated to other farmers through web pages, video recordings and a simple mobile interface. From the pilot data analysis, the solution showed that if adopted, knowledge capture, storage, dissemination and sharing would be scaled up to real-time to the farmers who need it.

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List of Acronyms and Abbreviations

AFAAS	African Forum for Agricultural Advisory Services
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CIP	International Potato Center
CYMMIT	International Maize and Wheat Improvement Center
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
ICIPE	International Centre of Insect Physiology and Ecology
ICRAFT	International Center for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IDS	Internet Database System
IITA	International Institute of Tropical Agriculture
KACE	Kenyan Agricultural Commodity Exchange
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspectorate Services
MILS	Marketing Information and Linkage System
MRC	Marketing Resource Center

Glossary

Data

Data are the raw, isolated facts, figures, images and sounds that have little or no meaning. They have little or no meaning because they lack a context for evaluation.

Information

Information is data that is summarized or presented in a useful or meaningful way.

Knowledge

Knowledge refers to information combined with experience, context, interpretation and reflection.

Knowledge Base

A knowledge base is a common repository of knowledge that is made available to a group of knowledge consumers.

Knowledge Acquisition

Knowledge acquisition, also referred to as knowledge creation, refers to the process through which knowledge is added to a knowledge base in a knowledge system.

Knowledge Management

Knowledge management can be defined as the fact or condition of knowing something with a considerable degree of familiarity acquired through experience, association or contact.

Knowledge Management System

A knowledge management system is defined as a system designed and developed to give decision makers/users in organizations the knowledge they need to make their decisions and perform their tasks.

Peri-urban Farming

Peri-urban farming, refers to farm units close to town which operate intensive semi- or fully commercial farms to grow vegetables and other horticulture, raise chickens and other livestock, and produce milk and eggs.

Agricultural Extension

Agricultural extension is a general term meaning the application of scientific research and new knowledge to agricultural practices through farmer education.

Imagine a world in which every single person on the planet is given free access to the sum of all human knowledge.

~Jimmy Wales, founder of Wikipedia

Chapter 1. Introduction

This section gives a brief overview of agriculture in Kenya, the horticulture sub-sector and knowledge management. The problem statement is outlined and the objectives of the project are clearly stated. This section further covers the rationale of this project, the scope of the project, any assumptions made and the limitations identified.

1.1 Background

Agriculture is the mainstay of the Kenyan economy and underpins its development process. It accounts for about 26 percent of Kenya's Gross Domestic Product (GDP), and 60 percent of the export earnings with an estimated 80 percent of the population relying on it directly and directly (Ministry of Agriculture, Kenya, 2010).

The horticulture sub-sector of agriculture contributes immensely to the Kenyan economy through wealth creation, poverty alleviation and gender equity especially in the rural areas. Over the last decade it has grown to become a major foreign exchange earner. In addition, it is currently the fastest growing agricultural sub-sector in the country, and is ranked third in terms of foreign exchange earnings from exports after tourism and tea. In addition it provides raw materials to the agro processing industry. Due to the tremendous growth experienced in this industry, new small-scale farmers are coming on board. These enterprising new farmers often lack sufficient training and knowledge.

Knowledge management systems have been around for decades, but have significantly changed over time in complexity and features with the evolution of information technology and the Internet. With the development of these new technologies, the concept of knowledge management has thrived and has had significant impact on the way in which knowledge is accumulated, stored and accessed (Anders Nattestad, 2012). MEDLINE is one example of an effective knowledge management system in health care, providing access to health care-related scientific literature, which is highly organized under the auspices of the United States National Library of Medicine. Another and very differently organized example of an effective knowledge management system is Wikipedia, which is a free, web-based, collaborative, multilingual encyclopedia project supported by a nonprofit foundation.

The development of new technologies and the Internet have changed the way in which information is developed and accessed. This project entails the development of a knowledge management system that facilitates the availability of appropriate knowledge and timely information to farmers especially small scale farmers.

1.2 Problem Statement

In Africa, the effectiveness of knowledge management in agriculture is hampered by a range of constraints such as inadequate mechanisms for capturing, systematizing and sharing available knowledge; inadequate analysis of agricultural sector communication stakeholders, their knowledge needs, attitudes and practices to knowledge management; use of less effective media and channels for communicating with different stakeholders; and weak monitoring and evaluation of knowledge management systems (ASARECA, 2010).

Millions of farmers in developing countries do not have a good resource and knowledge base, and this limits their capacity to reap huge benefits from agriculture (Yuan Zhou, April 2010). Most small-scale farmers often lack sufficient training and knowledge. Remote areas and poor producers are poorly served and yet not only do they require advice to increase farm productivity, but also advice on markets, value addition and diversified income opportunities.

Urban and peri-urban farmers have limited access to public agricultural extension services due to the fact that those extension officers mostly serve rural areas. To further compound the problem, private extension services are offered at a costly fee.

In order to harness the benefits of agricultural knowledge management, adequate mechanisms are needed for generating, capturing, and disseminating documented and undocumented knowledge and information. There is an inherent need to share knowledge of agricultural management experiences so that upcoming farmers can stay abreast with new farming technologies, new horticulture related products in the market, improved plant varieties, environmental issues, new markets among others.

This project presents a system that will scale up knowledge to horticultural farmers in Kenya by providing a means for knowledge and information to be codified, made explicit and upgraded or modernized with research-based evidence.

1.3 Objectives

The objectives of this project are:

1. To develop a knowledge management system for horticultural farmers in Kenya
2. To create a knowledge repository for rare horticultural crops such as strawberries, mushrooms and tree tomatoes.
3. To create a web interface that will enable farmers to access the system.
4. To create a mobile web interface that will give farmers the flexibility of accessing the system via their mobile devices.

1.4 Research Questions

In order to achieve the objectives, the study was guided by the following research questions:

1) Which technologies have been developed in support of horticultural farming in Kenya?
2) Who is involved in technology dissemination, including public and private sector actors in Kenya?
3) What is the best way to document and disseminate information on the whole value chain of rare horticultural crops?

1.5 Rationale for the Project

This project will result in:

- The knowledge acquired from everyday work captured, maintained and shared.
- Farmers will be able to access appropriate information and share it with generations to come

This project is also geared towards creating a resource for assistance in other technology tasks, creating a base for further work, and contributing to the continuity in

the work being done by the School of Computing and Informatics in developing state of the art information systems.

1.6 Scope of the Project

The project content is restricted to horticulture farming especially crops not widely planted such as strawberries, mushrooms, tree tomato among others.

1.7 Assumptions

The assumptions made regarding this project is that the farmers are computer literate and well conversant with English.

1.8 Challenges/Limitations

The main challenge identified so far is availability of up-to-date information from credible institutions such as the Ministry of Agriculture.

Chapter 2. Literature Review

This chapter reviews central concepts pertaining to the project. It outlines farming in Kenya, the impact, the major subsectors and the key issues involved. The literature review section also explores the key issues on dissemination of agricultural knowledge in Kenya. Furthermore, the theoretical concepts underscoring knowledge management, knowledge management systems and agricultural extension services are also presented in this section. To wrap up the chapter, various applications in use for management and dissemination of agricultural knowledge are described.

2.1 Farming in Kenya

The key regional agricultural sub-sectors in Kenya include Pastoralism, Dairy, Fishing, Coffee, Tea, Sugar, Horticulture and Maize. The horticulture sub-sector has performed well surpassing both tea and coffee in terms of export earnings. It however has not kept pace with new developments and new technologies.

Wikipedia defines **horticulture** as the science, technology and business involved in intensive plant cultivation for human use. Kenya's history for growing horticultural crops for both domestic and export markets dates way back. The main horticultural crops grown in Kenya can be broadly grouped into **fruits, vegetables and cut flowers**. The major fruits grown in Kenya include avocado, bananas, mangoes, passion fruit, macadamia nuts, melon, strawberries, pawpaw, apricot and butternut, while the vegetables grown include chillies, french beans, okra, snow peas, brinjals, leeks, curry leaves, valore, bobby beans, guwar, karella, dudhi, asparagus, runner beans, spinach, tomatoes, cabbages, onions, among others and finally the flowers grown include roses, carnations, lillies, orchids, chrysanthemum, delphinium, allium among others.

Most of these crops are grown in green houses by large scale farmers. Due to the need to alleviate food insecurity, these horticultural crops are being introduced to a wider range of farmers most of who do not have access to relevant information. Extension officers serving various parts of the country have also proved to be inadequate.

Farmers need information on:

- Crop varieties with improved characteristics
- Agronomic or crop management technologies
- Appropriate and profitable crop protection technologies for the management of biotic factors, that is, diseases, pests and weeds
- Suitable and profitable post harvest technologies for horticultural crops
- Marketing information on horticultural crops

2.1.1 Peri-urban Farming in Kenya

Peri-urban agriculture, refers to farm units close to town which operate intensive semi- or fully commercial farms to grow vegetables and other horticulture, raise chickens and other livestock, and produce milk and eggs (Food and Agriculture Organization).

Peri-urban agriculture takes place in the urban periphery. Peri-urban areas tend to undergo dramatic changes over a given period of time, there is an influx of people from both rural and urban areas, population density increases, land prices tend to go up and multiple land use emerges. Such changes effect the agricultural production systems, which tend to become smaller scale with more intensive production.

Peri-urban farming is changing Kenyans fortune. From graduates to even those with basic education, people have taken into this type of farming with a boom as a source of employment and as a financial security. It is an activity that is aiding the country in attaining food sufficiency thereby playing part in solving persistent food problems.

"*The growth of urban agriculture has been buttressed by two important factors: the availability of non-built public land, even in central parts of the city, and the requests from people who want to use it to produce food*," Ms. Rey, advisor to the Mayor of La Habana

"*Good urban agriculture depends crucially on producers being granted proper agricultural extension and advice, including assistance for selecting crops*," Mayor Iga of Kampala

A new report published by the African Capacity Building Foundation (ACBF) quotes studies indicating that urban agriculture contributes substantially to food security and

safety for approximately 50 per cent of city dwellers worldwide, while about one-third of Nairobi households earn income related to urban farming.

Although farming is a well-known and widespread activity in the capital city Nairobi and other urban areas of Kenya, the Government provides limited extension services to urban farmers.

2.1.2 Agricultural Extension in Kenya

The term **extension** here means 'advisory and other services'. Agricultural extension services provide farmers with important information, such as patterns in crop prices, new seed varieties, crop management, and marketing. Exposure to such activities is intended to increase farmers' ability to optimize the use of their resources. Extension services, if properly designed and implemented, improve agricultural productivity. Most farmers rely on public extension workers for training and appropriate management advice (Muyanga M, 2006).

Agricultural extension in Kenya dates back to the early 1900s, but its only notable success was in the dissemination of hybrid maize technology in the late 1960s and early 1970s. The government through its Ministry of Agriculture provided the bulk of extension services to both small scale farmers and commercial producers. After the implementation of structural adjustment programs (SAPs) in the 1980s, the Kenyan government came under considerable pressure to scale down its dominant role in national economy (FAO 1997). Kenya's agricultural extension budget together with extension staff numbers has plummeted significantly. At the same time, the performance of the public agricultural extension service in Kenya was questioned and its effectiveness became a very controversial subject (Gautam and Anderson 1999). The traditional public extension system was perceived as outdated, top-down, paternalistic, uniform (one-size-fits-all), inflexible, subject to bureaucratic inefficiencies and therefore unable to cope with the dynamic demands of modern agriculture

Kenya's small scale farmers have traditionally benefited from these types of extension systems:

- Public Extension System

- Farmer Based Organizations and Cooperatives
- Private Extension System

Public Extension System

This system focuses mainly on food crops and livestock. The government has tried a number of extension models and styles, including the progressive (or model) farmer approach, integrated agricultural rural development approach, farm management, training and visit, attachment of officers to organizations, farming systems approaches and farmer field schools.

In Kenya, the public sector is represented by the Ministry of Agriculture (MOA) through the Direction of Extension, Research and Technical Training, the Ministry of Livestock and Fisheries Development (MLFD) through Kenya Marine and Fisheries Research Institute (KMFRI), Kenyata University, other universities and research institutions around the country. These institutions provide extension services through various departments and institutes some of which are listed below:

- Public Extension Institutions
    - Ministry of Agriculture (MOA)
        - Directorate of Extension, Research Liaison and Technical Training
            - Extension Services Division
            - Agricultural Sector Coordination Unit
            - Horticulture Crops Development Authority
    - Ministry of Livestock and Fisheries Development (MLFD)
        - Kenya Marine and Fisheries Research Institute (KMFRI)
- Public Research and Education Institutions
    - Kenya Agricultural Research Institute (KARI)

  - Kenya Sugar Research Foundation (KESREF)
  - Coffee Research Foundation (CRF)
  - Tea Research Foundation of Kenya (TRFK)
  - ASTI Agricultural Research and Development Investments and Capacity in Kenya
  - Kenyatta University
    - Center for Entrepreneurship and Enterprise Development
- International Organizations
  - International Livestock Research Institute (ILRI)
  - GIZ – Promotion of Private Sector Development

Farmer Based Organizations and Cooperatives

Farmers organize themselves at local level into membership-based entities (associations, cooperatives). In Kenya, farmers have organized themselves in groups to facilitate such ventures as the marketing of agricultural output, mutual help assistance and acquisition of agricultural credit. Community labor-sharing groups in Kenya are one of the successful farmers' based organizations providing supply of labor to farmers during critical periods of the cropping season. These groups allow the members to help each other to accomplish heavy farm tasks such as ploughing, planting, and harvesting.

Some development organizations try to build on these local institutions to carry out their agricultural extension work. The work groups are common in many parts of Kenya, and are known by several names, including *saga*, *ngwatio*, *bulala* and *m'wthya*. They are used by NGO and other partners to promote and share new farming and conservation practices.

Using community groups is a form of farmer-to-farmer extension, as farmers learn a particular innovation and share their knowledge and skills to other farmers. Farmers are

generally enthusiastic to share their skills with other farmers. Extension cannot be expected to reach every farmer - hence, the need for selectivity and reliance on farmer-to-farmer dissemination (World Bank, 1999).

The Kenya National Federation of Agricultural Producers (KNFAP) is the largest farmers union in Kenya. Other farmer organizations that provide some agricultural information and services to their members include: Fresh Produce Exporters Association of Kenya (FPEAK); Kenya Flower Council; Cereal Growers Association and Co-operative Societies.

Private Extension System

This comprises of private companies, non- governmental organizations (NGOs), community-based organizations (CBOs), and faith-based organizations. Most of them are promoting commercialization of small-scale agriculture , and provide training on marketing.

The majority of NGOs has extension staff trained in relevant agricultural disciplines. Most of these NGOs rely on the government research institution such as KARI for technology, and others have established links with private companies as well as international research centers (ICRAFT, ICIPE, CYMMIT, CIP ICRISAT and IITA). Following is a list of selected Kenyan NGOs involved in agricultural production and agribusiness supply chain development

- Care – Kenya
- Sacred Africa
- World Vision
- Catholic Relief Services
- Winrock International Institute for Agricultural Development

2.1.3 Challenges Related to Sharing, Exchanging and Disseminating Knowledge and Technologies in Kenya

There are prevailing challenges related to sharing, exchanging and disseminating knowledge and technologies. The first challenge is the **poor mechanisms and infrastructure for sharing** and exchanging agriculture knowledge generated from research at national and regional levels. Many research activities are repeated due to the lack of such mechanisms and infrastructure at the national level. Researchers can find research papers published in international journals and conferences more easily than finding research papers published nationally in local journals, conferences, theses and technical reports.

The second challenge is the **inefficient mechanisms and infrastructure for transferring** technologies produced as the result of research to growers either directly or through intermediaries such as extension officers. Knowledge and technologies fostering agricultural production and environment conservation are examples. Although many extension documents are produced by national agriculture research and extension systems to inform growers about the latest recommendations concerning different agricultural practices, these documents are not disseminated, updated or managed to respond to the needs of extension officers, advisers and farmers. This is also true for technical reports, books and research papers related to production.

The third challenge is **keeping the indigenous knowledge as a heritage** for new generations. It is available through experienced growers and specialists in different commodities. These inherited agricultural practices are rarely documented, but they embody a wealth of knowledge that researchers need to examine thoroughly.

The fourth challenge is **easily accessing and availing economic and social knowledge** to different stakeholders at operational, management and decision-making levels, so that those responsible will be able to make appropriate decisions regarding the profit making of certain technologies and their effect on resource-poor farmers.

2.2 Key Issues on Dissemination of Agricultural Knowledge in Kenya

New avenues and challenges in agricultural knowledge management are rapidly emerging. This is occasioned by the phenomenal growth in agricultural sciences, emergence of Information and Communication Technologies (ICTs) and rediscovery of indigenous knowledge system, globalization of economy, changing structure of economy and emerging problems such as climate change.

Three key issues put into consideration as regards the justification of this project include:

1. ICT for the Dissemination of Agricultural Knowledge and Information in Kenya
2. Production trends in the horticulture sub-sector
3. Access to ICT infrastructure and Services

2.2.1 ICT for the Dissemination of Agricultural Knowledge and Information in Kenya

Kenya has been making great strides in the agriculture industry thanks to the use of advanced technologies. Agricultural technical-knowhow and market information to some extent is available to support decision-making at the farm-level and along the value chain. The major challenge lies in transmitting this knowledge and information to farmers in a manner that they are able to assimilate the technology and use it to improve yields and livelihoods (United Nations Development Program, 2012).

ICT can play a crucial role in benefiting the resource-strapped farmers with up to date knowledge and information on agricultural technologies, best practices, markets, price trends, and weather conditions. The experiences of most countries indicate that rapid development of ICT, which facilitates the flow of data and information, has tremendously enhanced the knowledge management practice in agriculture (UNDP Ethiopia, 2012).

Smallholder farmers in Kenya as well as elsewhere in the developing world require up to date knowledge and information in order to effectively and efficiently perform their farming practices. The knowledge and information that farmers demand ranges from accessibility of new farming methods, availability of weather forecast and supply as well as price of inputs and outputs, among others. In Kenya, various institutions and organizations are engaged in the creation, collection, storing, and dissemination of

agricultural knowledge and information. The most notable ones, in terms of having direct linkage with the farmers, are institutes of agricultural research such as Kenya Agricultural Research Institute (KARI), Kenya Plant Health Inspectorate Services (KEPHIS) and the Ministry of Agriculture. Agricultural research institutes are the prime source for the creation of agricultural knowledge and information in the country.

The creation of information and knowledge management by these institutes begins with identification of information and knowledge needs or gaps, and the capturing, storage, and sharing/dissemination of the knowledge to the users. Identification of the demand for knowledge and information is conducted through a participatory approach with the involvement of stakeholders, namely: farmers, researchers, extension experts, among others (ASARECA, 2010).

The major sources for capturing knowledge and information are publications, conferences, events (field day, exhibitions, visits, etc), and research reports. Whatever is obtained in this way is stored in various forms, including in publications, audio visuals, library services, and websites among others. The knowledge and information is then disseminated to researchers, extension experts, farmers, and the public at large through publications, mass media (radio and television), internet, field day, exhibitions, and interviews. In practice, however, field days, radio, and TV programs are the major tools usually used to share the knowledge and information to smallholder farmers while internet and other modern ICT tools are seldom used (EIAR, 2012). This is despite the fact that ICT and the Internet can facilitate cheaper methods for agricultural knowledge dissemination with a wider reach, especially among urban and peri-urban farmers.

2.2.2 Trends in Production

Horticulture records show an average growth of 15 to 20 percent per annum. In addition, approximately 4.5 million people countrywide are employed directly in production, processing and marketing while another 3.5 million people benefit indirectly through trade and other activities (Ministry of Agriculture, Kenya, 2010).

Figure 1 shows that between the year 2008 and 2009, the value of horticultural exports dropped from Kshs 64 to Kshs 65 billion. After that there is a steady increase. Between

2009 and 2010 there was an increase of Kshs 7 billion. The figure further shows that the value of horticultural exports increased from Kshs 72 billion in 2010 to Kshs 83 billion in 2011.

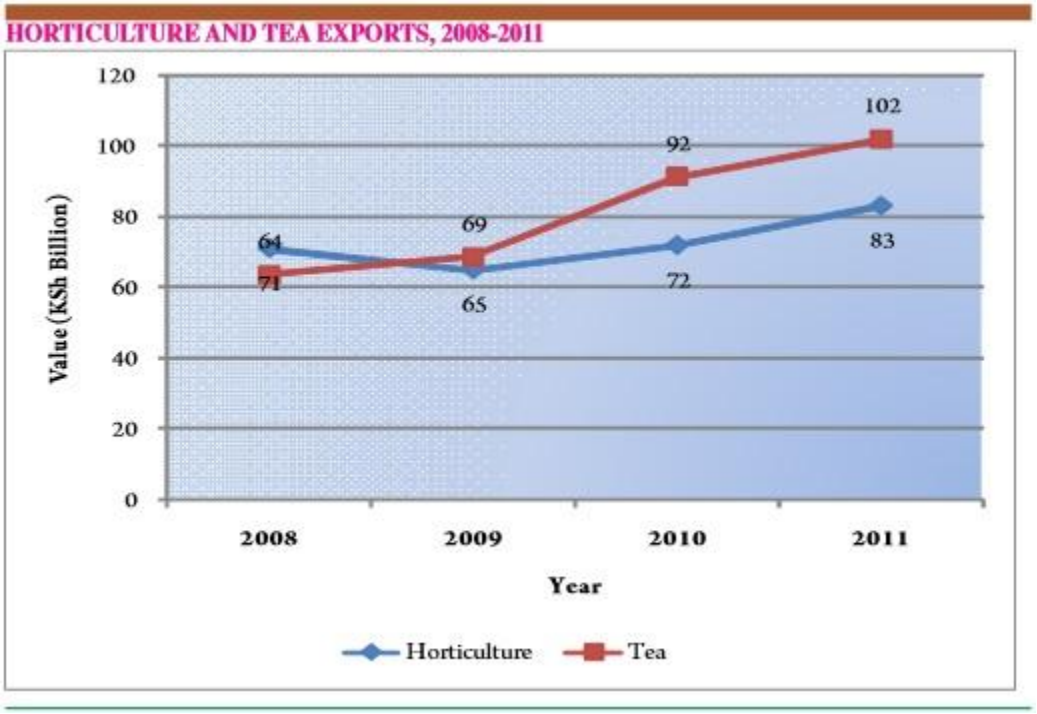

Figure 1: Horticulture and Tea Exports, 2008-2011

source: Kenya National Bureau of Statistics, Kenya Facts and Figures 2012

Figure 2 shows increase in the monthly exports of fresh horticultural produce in 2011 and 2012 for cut flowers, fruits and vegetables. Tremendous increase is shown for both quantity and value from the year 2011 to 2012. For example in the month of March in 2011 the quantity of vegetables exported was 6,854 metric tonnes amounting to Kshs 2,539 million. For the corresponding period in 2012, the quantity of vegetables exported was 6,972 metric tonnes amounting to Kshs 2,023 million.

Months	CUT FLOWERS				FRUITS				VEGETABLES			
	2011		2012*		2011		2012*		2011		2012*	
	QUANTITY (MT)	VALUE (KSh. Million)	QUANTITY (MT)	VALUE (KSh. Million)	QUANTITY (MT)	VALUE (KSh. Million)	QUANTITY (MT)	VALUE (KSh. Million)	QUANTITY (MT)	VALUE (KSh. Million)	QUANTITY (MT)	VALUE (KSh. Million)
January	8,607.2	4,894.3	9,172.8	7,245.6	1,330.3	191.8	1,728.7	227.2	6,293.5	2,384.3	5,255.9	1,549.7
February	9,516.1	5,218.4	10,189.7	5,368.2	2,024.6	351.0	2,515.0	275.3	5,990.4	1,798.9	4,482.5	1,368.6
March	9,608.3	4,468.3	10,246.3	4,697.8	4,823.8	539.3	3,627.2	343.7	6,854.5	2,539.9	6,972.4	2,023.2
April	11,742.1	4,462.0	9,137.6	4,226.5	3,973.4	436.3	2,833.4	300.7	7,732.4	2,260.2	6,510.6	2,087.3
May	10,066.7	4,940.7			4,298.8	412.3			7,473.9	2,961.6		
June	8,405.3	3,858.3			2,337.4	288.1			6,987.6	2,689.2		
July	7,987.9	3,482.1			2,197.6	308.6			5,234.2	1,740.2		
August	7,998.3	4,297.7			1,919.3	308.7			6,210.3	1,975.6		
September	8,103.7	4,786.8			965.4	157.2			6,588.6	1,800.4		
October	9,626.1	7,203.4			910.1	194.5			7,016.5	2,110.4		
November	9,533.5	4,382.5			1,036.9	168.5			6,706.8	2,095.6		
December	8,755.1	6,840.5			1,233.3	179.3			6,157.0	1,894.7		
Total	109,950.3	58,835.0			27,050.9	3,535.4			79,245.7	26,251.2		

Source: Horticultural Crops Development Authority

* Figures subject to revision

Figure 2: Monthly Exports of Fresh Horticultural Products

source: Kenya National Bureau of Statistics, April 2012

2.2.3 Access to ICT Infrastructure and Services

The role of ICT in enhancing food security and supporting rural livelihoods is increasingly being recognized and was officially endorsed at the World Summit on the Information Society (2005).

Several countries in Africa and Asia are now using ICT for the dissemination of agricultural knowledge and information and a number of success stories have been registered that can be replicated and scaled up in Kenya. In Philippines the Nutrient Manager for Rice Mobile program provides rice farmers with advice via their mobile phone on the optimal timing, amount, and type of fertilizer to apply to their rice crop to maximize production and profit, and reduce waste. In Ghana, Esoko, a local company, implemented Cocoalink, a pilot program that provides cocoa farmers with useful information about improving farming practices, farm safety, crop disease prevention, post-harvest production, and crop marketing. In India, farmers who subscribe to the Reuters Market Light (RML) system receive information about the weather, crops, current and projected commodity prices at different markets (Asenso-Okyere and Ayalew, 2011).

In spite of being a necessary condition, access to ICT infrastructure by itself is not sufficient for the dissemination of knowledge and information to occur. Access to ICT infrastructure must be accompanied by access to ICT services. In this respect, the other challenge is how to make ICT services both affordable and available in venues or modes that are convenient to smallholder farmers. Furthermore, affordability poses a great challenge to accessibility of ICT service, especially among subsistent farmers (Adam, 2010).

The most notable opportunity in Kenya is the presence of ICT infrastructure boosted by the arrival of the fibre optic cables, that can be easily extended to reach most of the rural farmers and to further strengthen the research-extension officer-farmer linkage. Internet penetration in Kenya rose from 30.9 percent of the population recorded in June 2012 to 34.2 percent in September 2012. This represents an increase of 3.3 percent of the population that had access to internet during the period. Similarly, compared to the same period of the previous year, an increase of 19.5 percentage points was recorded. As shown in Figure 3, Internet penetration and number of Internet users have been on a growth trajectory from September 2011 to September 2012.

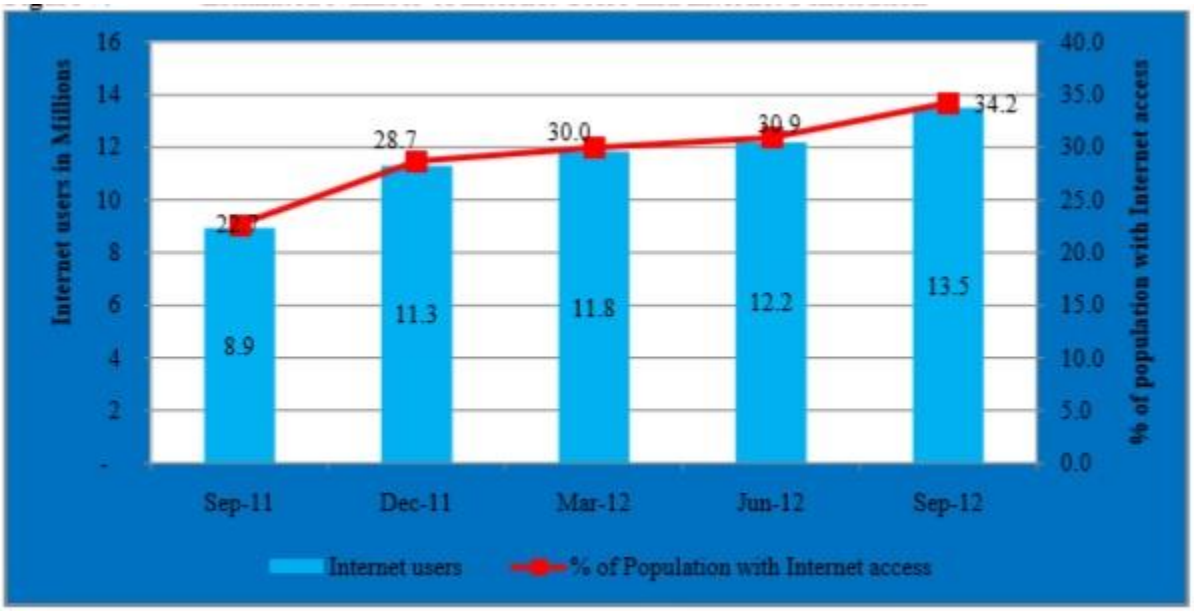

Figure 3: Estimated number of Internet users and Internet penetration

source: CCK, Quarterly Sector Statistics Report (July - September 2012)

2.3 Theoretical Framework

This section talks about knowledge, types of knowledge, knowledge management and knowledge management systems, knowledge management tools and generators, agricultural knowledge management and wraps up with the knowledge sharing and knowledge life cycle model by Nonaka nad Takeuchi.

2.3.1 Knowledge Management: Concepts, Processes and Tools

Knowledge

Knowledge is information combined with experience, context, interpretation and reflection (Davenport, 1998). Knowledge consists of the attitudes, cumulative experiences, and developed skills that enable a person to consistently, systematically and effectively perform a function (William and Michael, 2005). It is an integration of explicit and tacit knowledge.

Types of Knowledge

There are two basic types of human knowledge. *Explicit knowledge* refers to all aspects of formal, systematic, recorded, communicated and shared knowledge that is made accessible through a variety of information delivery systems. *Tacit knowledge* on the other hand is highly personal, created by doing, trial, error, reflection and revision. Tacit knowledge is extremely difficult to communicate directly. Knowledge systems deal in communicating both forms of knowledge, however the systems themselves deals exclusively with explicit knowledge. Common functional categories of knowledge include:

- Declarative/Descriptive: Knowledge describing what something is.
- Procedural: Knowledge describing how to accomplish a task.
- Causal: Knowledge that describes why something happens.

Knowledge Management

Knowledge management(KM) encompasses processes and practices concerned with the creation, acquisition, sharing and use of knowledge, skills and expertise and follow a

circular flow and a nonstop process that continuously updates itself as shown in Figure 4 (Quintas et al 1996).

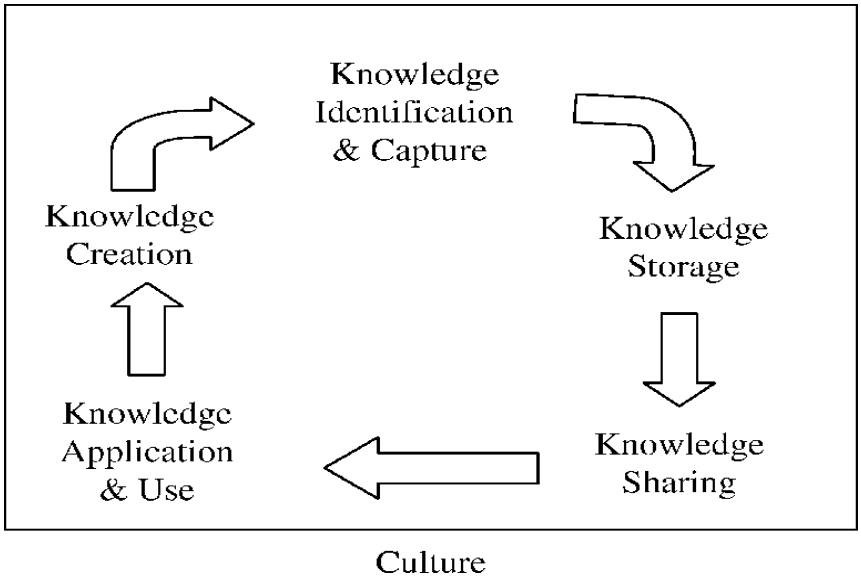

Figure 4: Knowledge Management Process

source: Adopted from Cong et al. (2007)

Another definition is that knowledge management refers to the set of business processes developed in an organization to create, gather, store, disseminate and apply knowledge. Knowledge management involves designing and maintaining knowledge systems that genuinely enhance organizational performance. KM increases the ability of an organization to learn from its environment and to incorporate knowledge into its business processes.

Knowledge Management Systems

In general, a **system** is defined as a set of elements that interact to achieve some common goal (Webster's Dictionary, 1995). Systems are typically composed of people, technologies and data/information. **Knowledge Management Systems** (KMSs) are defined as systems designed and developed to give decision makers/users in organizations the knowledge they need to make their decisions and perform their tasks (Davenport, 1998). KMSs are the tools and techniques that support knowledge management practices in organizations. They are seen as the means to aid

organizations in creating, sharing and using knowledge. Firms have invested millions of dollars in these types of systems in order to create competitive value. The sustainable advantage that can be achieved by the effective and efficient generation, distribution and application of knowledge within an organization is not being lost on today's modern managers.

The major types of Knowledge Management Systems include:

- **Enterprise Knowledge Management Systems**

  General purpose, integrated, and firm-wide systems to collect, store and disseminate digital content and knowledge.

- **Knowledge Work Systems**

  Information systems that aid knowledge workers in the creation and integration of new knowledge in the organization.

- **Intelligent Techniques**

  Data mining and artificial intelligence technologies used for discovering, codifying, storing and extending knowledge.

Knowledge Management Tools and Generators

These are the technologies that are used to acquire, store, and distribute knowledge. These tools are capable of handling the richness, the content, and the context of the information and not just the information itself. There are a number of types of computer-based tools/technologies to support knowledge management in modern organizations some of which are shown in Table 1 along with the role they play.

Intranets	Private internet-based networks using Web-browsers to share knowledge
Information Retrieval Programs	Tools to search corporate knowledge/data bases as well as external knowledge sources to provide access to a wide variety of

	knowledge
Database Management Systems	Combine with intranets and information network tools to provide a platform to build specific knowledge management tools
Document Management Software	Provide the means for capturing, storing, and distributing knowledge in the form of documents as opposed to discrete data
Groupware	Software and hardware that enables workgroups to communicate and collaborate. Groupware tools typically have features that enable groups to perform such tasks as generating ideas (create new knowledge) and reaching consensus
Intelligent Agents	Software programs that can filter out the knowledge that the user really needs. This may be particularly important in knowledge-intensive situations where particular knowledge sources need to be monitored.
Knowledge-Based or Expert Systems	Store the knowledge of experts in the form of rules or cases and then provide that knowledge to novices or other experts.

Table 1: Tools to Support Knowledge Management Systems

2.3.2 Agricultural Knowledge Management

Agriculture knowledge management involves different players such as farmers, extension personnel, researchers, inputs suppliers, etc. Sources of agricultural knowledge include scientific research and indigenous knowledge.

The attainment of effective knowledge management in the agriculture sector requires the systematic and continuous interaction of stakeholders that include farmers, farmer organizations, research scientists, policy makers, extension officers and the private sector among others (ASARECA, 2010).

After the creation, sourcing or accumulation of knowledge, the knowledge has to be disseminated to users to support the innovation process. ICT can play a critical role in facilitating rapid, efficient, and cost effective knowledge management.

Knowledge is considered as the fourth production factor after labor, land and capital (AFAAS, 2011) and is particularly critical in the agricultural sector. Making relevant knowledge accessible to the farming community helps improve production, productivity and brings higher returns. Agricultural practice of smallholders must be backed up by modern agricultural knowledge and information.

Various entities are engaged in the creation and development of information and knowledge. Likewise, several repositories and intermediaries play their role to bring the information and knowledge to the ultimate users.

Effective knowledge management is achieved when the right knowledge and information is delivered to the right person at the right time in a user friendly and accessible manner that helps the recipients to perform their jobs efficiently (Islam 2010). The outcome of effective knowledge management includes improved productivity and performance of the agricultural sector.

The major processes involved in agricultural knowledge management include:

- **Knowledge Creation**

  Modern knowledge is created through scientific research (and therefore it is explicit knowledge) by universities and research institutes. Indigenous knowledge or tacit knowledge, on the other hand, refers to traditional knowledge, innovations and practices of local communities and is developed outside the formal education system.

- **Knowledge Storage**

  Agricultural information and knowledge created from these sources is stored in a database before it is disseminated for use. The repository of this knowledge includes knowledge bases, publications, audio visuals, and website.

- **Knowledge Dissemination**

The stored knowledge and information is disseminated to farmers, through intermediaries and in this case using modern forms of ICT (internet and mobile phone).

2.3.3 Knowledge Sharing and Knowledge Life Cycle Model

The knowledge-sharing model presented in Figure 5 is also called the tacit-explicit model (Nonaka, I. and Takeuchi, H., 1995). The conversion of knowledge from one form to another leads to creation of new knowledge. As shown in Figure 5 some of the common ways in which knowledge is converted include:

- **Explicit-explicit/Combination**

  This involves the reconfiguration of explicit knowledge through sorting, adding, combining and categorizing and leads to new knowledge.

- **Explicit-tacit/Internationalization**

  Internationalization involved the assimilation of knowledge acquired from knowledge items. It contributes to the user's tacit knowledge.

- **Tacit-explicit/Externalization**

  Externalization is the transformation of context-based facts into context-free knowledge with the help of analogies. Tacit knowledge has a contextual component since it is personal. Once explicit, the contextual information must somehow be retained in order for it to have value.

- **Tacit-tacit/Socialization**

  Socialization occurs by sharing experiences, working together in a team, and by direct exchange of knowledge

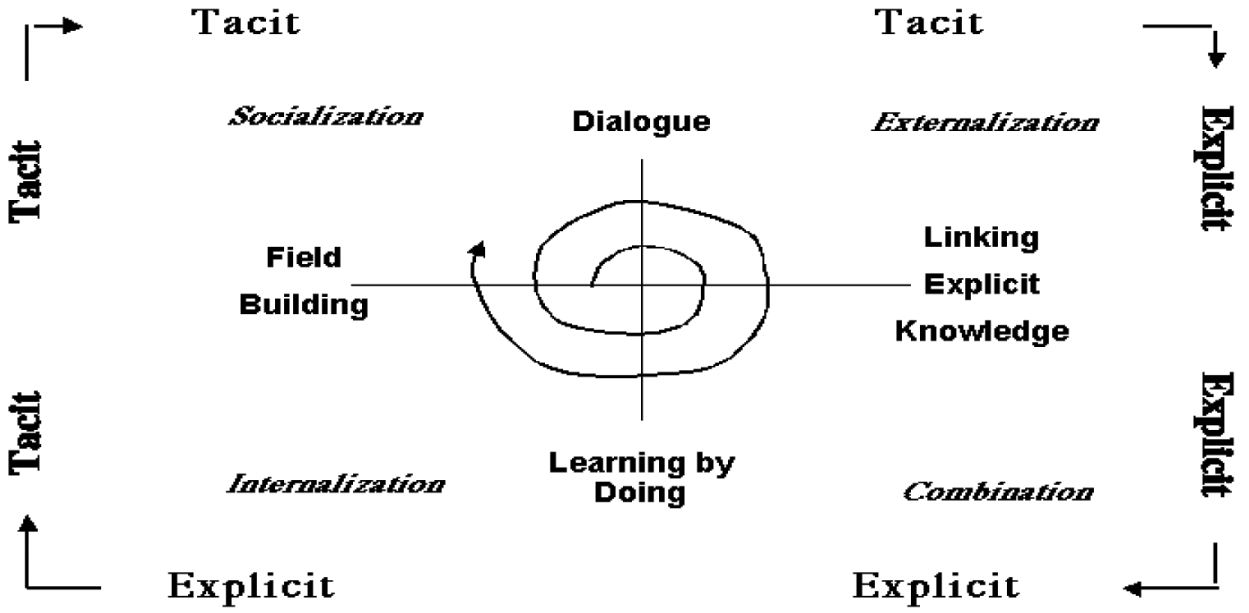

Figure 5: The Tacit-Explicit Model

source: (Nonaka, I. and Takeuchi, H., 1995)

The knowledge lifecycle takes the path of knowledge creation/acquisition, organization/storage, distribution, application/reuse and finally ends up in creation/acquisition again.

2.4 KMS Research Frameworks

A number of research frameworks have been proposed to guide research into knowledge management systems. These include:

2.4.1 General Systems Framework

This framework treats a knowledge management system as any other information system. These systems can be studied in terms of their inputs, processes and outputs. In other words, a systems approach can be used to provide a basis for research programs in KMS. The General systems framework is shown in Figure 6. The figure shows the three components of the framework, that is, inputs e.g. knowledge, people, tools, process and outputs.

The advantage of this framework is its simplicity and inclusiveness. All major components for KMS can be included in this model. The disadvantage is it does not highlight the importance of knowledge bases/repositories, or the critical nature of knowledge transfer between people.

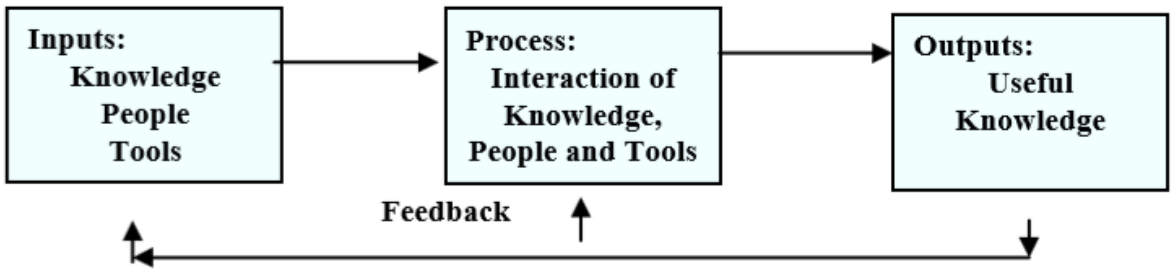

Figure 6: General Systems Framework for Knowledge Management Systems

source: www.business.queensu.ca/kbe

2.4.2 The Four Component Model of KMS

This framework is based on the model of Group Decision Support Systems developed by DeSanctis and Gallupe (1985). This model shows a KMS as being made up of four components: a knowledge base or repository subsystem, a user-interface subsystem, a group support or knowledge transfer subsystem, and the user/knowledge generators themselves. This model is shown in Figure 7.

The major advantage of this framework is that it shows the inter-relatedness of the main components of a KMS. This framework also highlights the importance of the user of a KMS both as a generator of knowledge and a user of knowledge.

The disadvantage of this framework is it may not be detailed enough to highlight the areas where research into KMS may be productive.

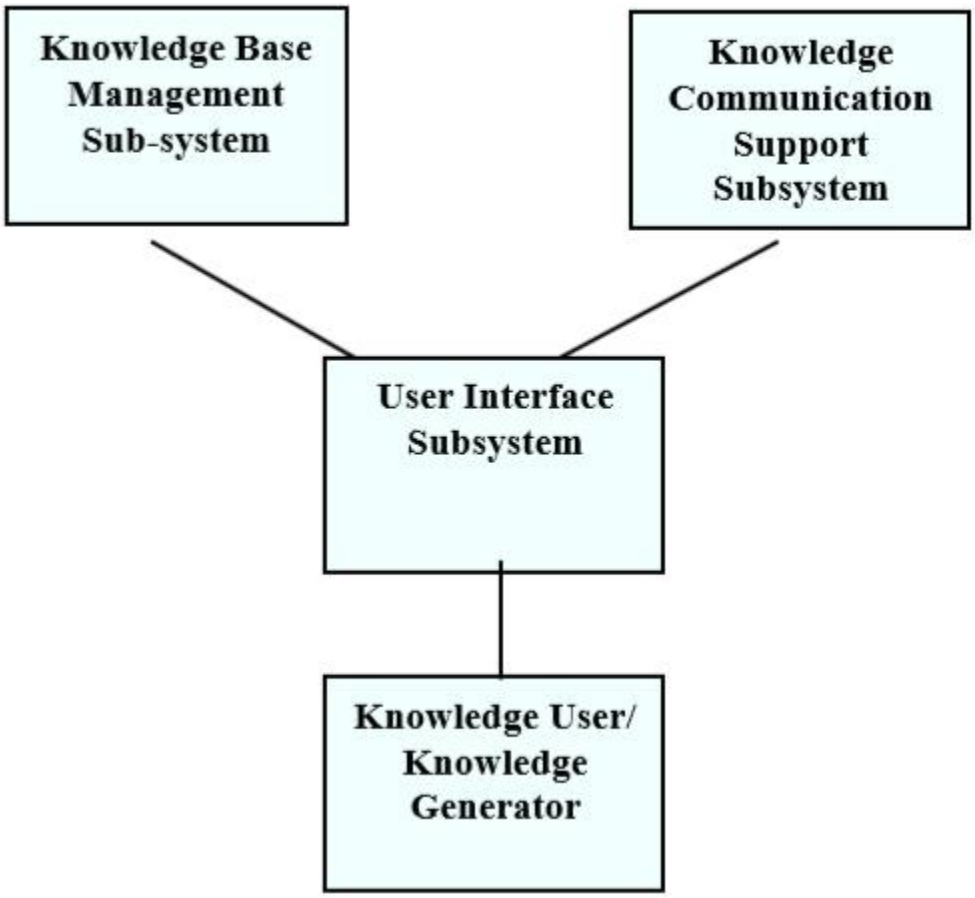

Figure 7: The Four Component Framework of Knowledge Management Systems

source: www.business.queensu.ca/kbe

2.4.3 The Knowledge Life Cycle Framework

This framework follows knowledge through the stages of its life cycle from creation to disposition (Ruggles, 1997; Liedner and Alavi, 1999). It is more knowledge-centric than the other frameworks. The stages are Knowledge Creation/Acquisition, Knowledge Codification and Storage, Knowledge Transfer/Dissemination and finally Knowledge

Use. At each stage, knowledge management systems can be created and studied to examine their impact on knowledge within each stage.

The major advantage of this framework is that it is conceptually simple in that KMS can be categorized and studied through identifiable stages. The disadvantage of this framework is that it does not provide for the richness inherent in KMS and does not show where research might be lacking.

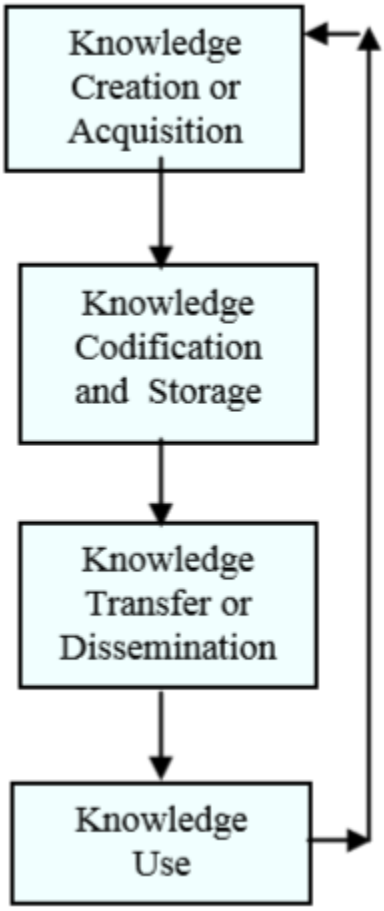

Figure 8: Knowledge Life Cycle Framework

source: www.business.queensu.ca/kbe

2.4.4 Knowledge Management Practices Framework

This framework is based on the work of Gray and Chan (1999) and it focuses on KMS to support knowledge management practices. The framework is shown in Figure 9. This framework treats what organizations actually do (their knowledge management practices) as central to the framework and highlights the type and form of KMS that can support that practice.

This framework incorporates the process in the "General Systems" model shown in Figure 6 and structures inherent in the "Four Components" model shown in Figure 7. In addition, it implicitly uses the "Knowledge Life Cycle Model" shown in Figure 8 to help categorize knowledge management practices and uses of KMS.

This framework examines knowledge management practices along two dimensions. The first dimension is the process to be supported (problem recognition or problem solving). The second dimension is the class of the problem being solved, that is, new or unique, previously solved. The integration of these dimensions results in four types of knowledge management practices that may be supported by KMS:

1) **Encouraging Serendipity**

   These knowledge practices seek to identify new problems by encouraging creativity and the generation of new knowledge e.g. talk rooms, chat rooms, brainstorming.

2) **Knowledge Creation**

   These are the knowledge practices that solve new problems by creating and storing knowledge related to these problems e.g. communities of practice, knowledge forums.

3) **Knowledge Acquisition**

   These are the knowledge practices that seek to use knowledge to address previously solved problems e.g. repositories, maps.

4) **Mentoring and Training**

These are the knowledge practices that involve transfer of knowledge to individuals to support problem recognition with pre-existing problems e.g. formal and informal training.

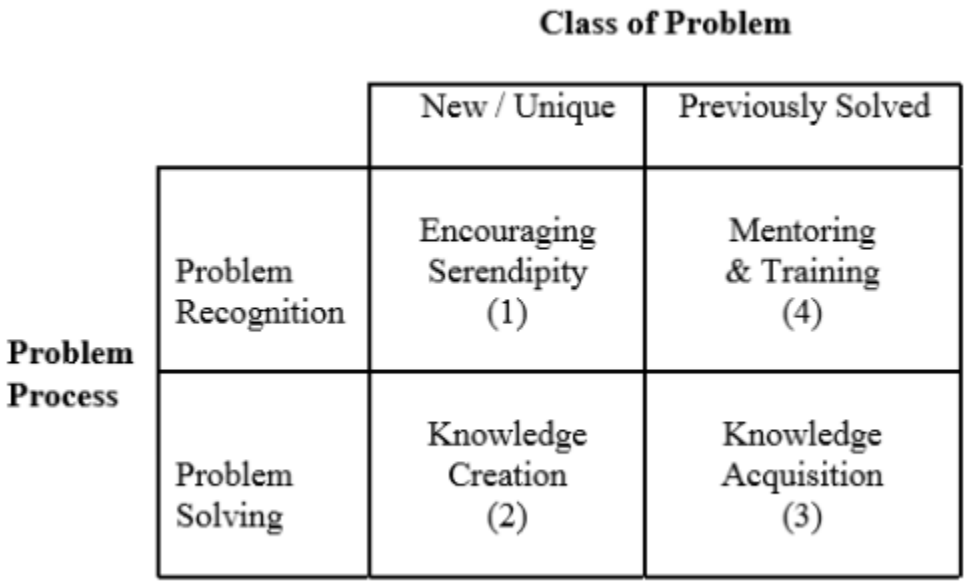

Figure 9: Knowledge Practices Framework for Knowledge Management Systems

source: www.business.queensu.ca/kbe

This model easily establishes boundaries around the phenomena being studied. The model also facilitates the identification of the main components or sub-factors so that relationships can be examined and new knowledge generated.

2.5 Developments in Use of ICT for Dissemination of Agricultural Knowledge and Information

A few of the ICT-based interventions are provided below to illustrate the extent of the progress that has been made in the agricultural sector in selected countries.

2.5.1 Nutrient Manager for Rice

Figure 10: Nutrient Manager for Rice

source: International Rice Research Institute (IRRI), irri.org

In Philippines the Nutrient Manager for Rice Mobile program provides rice farmers with advice via their mobile phone on the optimal timing, amount, and type of fertilizer to apply to their rice crop to maximize production and profit, and reduce waste. The farmers and extension officers are able to dial a toll-free number and hear a voice instruction in their preferred local language, which will prompt them to use their keypad to answer 12 to 15 questions about their rice crop. The main pitfall of this system is that due to the fact that most of the recommendations are provided by scientists and not other farmers, farmers express doubts about some of those recommendations.

2.5.2 Cocoalink

In Ghana, Esoko, a local company, implemented Cocoalink, a pilot program that provides cocoa farmers with useful information about improving farming practices, farm safety, crop disease prevention, post-harvest production, and crop marketing. In this

program farmers receive information and specific answers to questions at no charge through voice and Short Message Service (SMS) messages in their local language or English. In this system, there is no collaboration with farmers and extension officers to capture information. The farmers simply have to subscribe to listen to weekly SMSs which may or not be relevant to an individual.

2.5.3 Reuters Market Light (RML)

Figure 11: Reuters Market Light Demo

source: www.reutersmarketlight.com

In India, Reuters Market Light (RML) sends four SMS messages a day to its subscribers. Farmers who subscribe to the system receive information about the weather, crops, current and projected commodity prices at different markets. Farmers using this system complained about the high subscription charges involved and preferred the information to be disseminated through phone call rather than SMS.

2.5.4 Agricultural Marketing Service (SIMA)

In Mozambique, Agricultural Marketing Service (SIMA) collects and disseminates nation-wide and provincial data on market prices, product processing and availability through a variety of media including text messages, email, internet, national and rural radios, television and newspapers (Asenso-Okyere and Ayalew, 2011). This system does not cover the entire value chain of crops and is only useful after harvesting.

2.5.5 eChoupal

eChoupal is an initiative of ITC Limited (a large multi business conglomerate in India) to link directly with rural farmers for procurement of agricultural produce like soybeans, wheat, coffee, and prawns. eChoupal was conceived to tackle the challenges of Indian agriculture, characterized by fragmented farms, weak infrastructure, and the involvement of numerous intermediaries. The company has already established over 10,000 eChoupal village internet kiosks (sanchalaks), across several agricultural regions of the country each with a computer and Internet access where the farmers can directly negotiate the sale of their produce online with ITC Limited. These eChoupal centers also enable farmers to obtain online information and recommendations on good farming practices (EIAR, 2012). In addition, they can place orders for agricultural inputs like seeds and fertilizers. This helps farmers to improve the quality of their produce and realize better prices. Each ITC Limited kiosk is run by a villages, generally within about a 5 km radius. These farmers bear some operating cost but, in return, earn a service fee for each e-transaction done through their eChoupal. The eChoupal system is however limited to providing information on procurement of agricultural produce.

2.5.6 KACE MILS

The Kenyan Agricultural Commodity Exchange (KACE) collects, updates, analyses and provides reliable and timely marketing information and intelligence on a wide range of crop and livestock commodities, targeting actors in commodity value chains, with particular attention to smallholder farmers and small scale agribusinesses (KACE, 2011). The KACE marketing information and linkage system (MILS) involves harnessing the power and advantages of modern ICT for information collection, processing and delivery (KACE, 1997). The components of the KACE MILS are: Market Resource Centers (MRCs), Mobile Phone SMS, Interactive Voice Response (IVRS), Internet Database System (IDS), National Radio, Rural FM Radio and the KACE Headquarters Central Hub (KCH) in Nairobi.

MRCs are information kiosks located in rural markets and serve as sources of KACE market information for farmers and agribusinesses, as well as providing market linkage through matching commodity offers and bids. SMS service applies mobile telephone for

delivery of market information to users. The market information currently available through SMS includes daily wholesale buying prices for about 20 commodities, as well as offers to sell and bids to buy. IVRS uses voice mail for delivery of market price information. In this platform, a user dials a special phone number to access the information through simple menu steps, with a choice of language between the local Kiswahili and English. IDS is a system where updated market information is sent daily to subscribers in the database as email messages. The KCH in Nairobi receives processes, manages, updates, disseminates and coordinates market information services through the MILS (KACE, 2011). This system is however confined to providing marketing information specifically for rural markets.

2.5.7 Sokopepe

This is a pilot initiative of the Arid Lands Information Network (ALIN) in Kenya, aimed at enabling farmers to efficiently reach and exploit a fair market for their produce. *Sokopepe* is an integrated supply chain management solution that collects agricultural commodity information from the field, collates it into a regional and national perspective and disseminates packaged products to end users via various media, including SMS, WAP, Email and Web. In addition, it provides a payment mechanism whereby users pay for the information they receive and for services such as buyer/seller matching and posting of bids (www.sokopepe.co.ke).

Mugo (2012), the deputy director of ALIN, he highlighted some of the challenges they face as regards to the system such as literacy levels of farmers, establishing trust and accessibility of some areas.

Chapter 3. Methodology

This section describes the methodology that was used to conduct this project. The main areas covered include the system development methodology, the initial knowledge capture and creation and the research methodology for evaluation.

3.1 System Development Methodology

Structured Systems Analysis and Design Method (SSADM) software methodology was used. This is because of its well structured, robust, and descriptive way of system software development. It is used by many companies due to its disciplined engineering approach that eventually improves the quality of systems. The development process was divided into several manageable stages.

3.1.1 Planning and Selection

The need for a convenient knowledge management system was established by researching and critically looking at rising interest in agribusiness by peri-urban farmers.

3.1.2 Brief Systems Analysis

A thorough study of KMSs was conducted. Systems such as Cocoalink, SIMA,eChoupal among others were assessed to determine their merits, shortcomings and to know what concepts to borrow from each of them. Requirements were also determined by interviewing the various stakeholders.

The requirements gathered were then structured and DFDs of the system were drawn. Entity Relationship (ER) diagrams were made to show how the system data is organized. The ER diagrams were used to represent the entities, associations and data elements.

3.1.3 Brief Systems Design

This phase is in two parts:

3.1.3.1 Logical Design

The various forms and pages needed for the web client were designed. These forms and pages formatted and balanced to produce a desirable layout. The navigation

system for the pages was also designed. Appropriate tables and lists were made. Interfaces and dialogues were also made.

3.1.3.2 Physical Design

The logical designs were transformed into physical specifications. The storage format for each attribute from the logical database model was chosen. These attributes were then grouped into physical records. Data was represented as a set of related tables. The data structures were normalized to eliminate redundancy. The ER diagrams were transformed into a set of normalized relations.

3.1.4 Implementation and Operation

This was the most time consuming phase. The physical design specifications were turned into working computer code and the code tested to correct errors. This involved hardware and software installation, programming and documentation.

3.1.5 Features

- Log on and registration for farmers
- Rating of information
- knowledge repository for specific crops
- search for all information
- farmer's forum for other discussions

3.1.6 System Architecture

Figure 12 gives a conceptual view of the system's architecture. It is centered around the major knowledge management processes, that is, Knowledge Creation, Knowledge Storage and finally Knowledge Dissemination and Use.

As the figure shows, indigenous knowledge was gathered from other farmers using basic forms and video recordings. Scientific knowledge came from journals and publications of universities and research institutes. This knowledge was stored in a knowledge base which in this case was a database. The stored knowledge was disseminated to interested farmers through a web interface and some high end mobile phones and tables which could access the website.

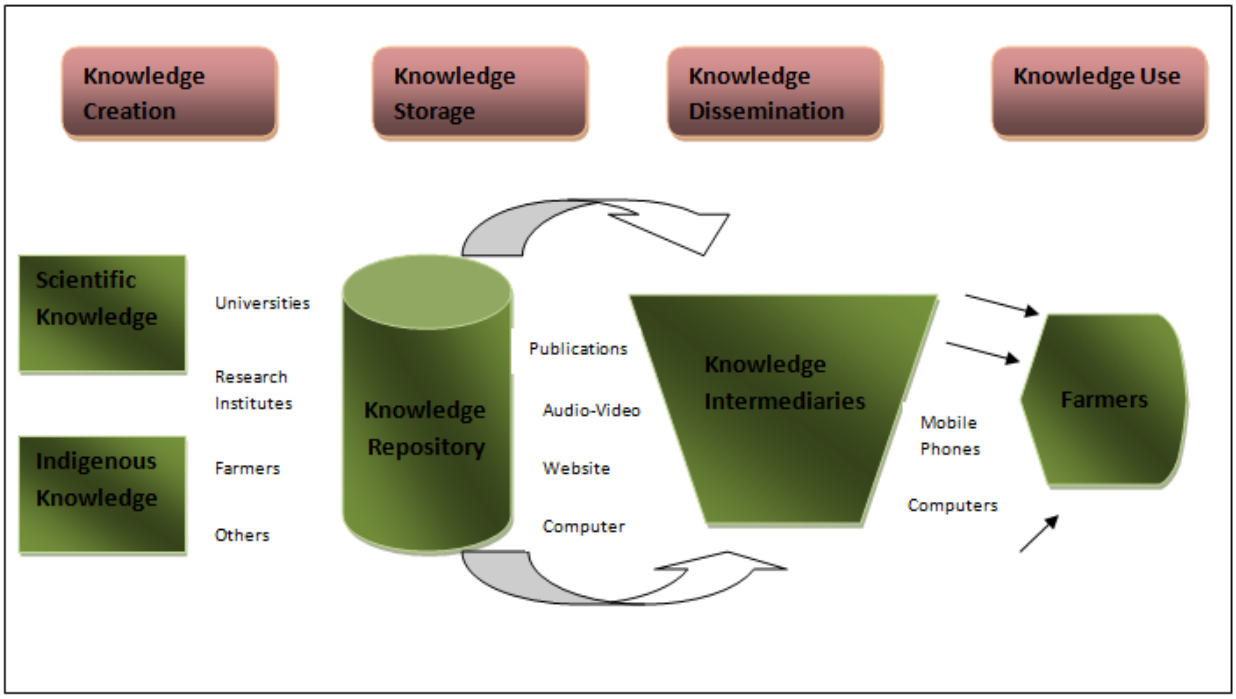

Figure 12: Proposed Knowledge Management Solution for Horticulture Farming

3.1.7 Detailed System Architecture

The detailed system architecture as depicted in Figure 13 is in three major phases:

- **Knowledge Capture/Creation**

  Modern scientific knowledge was obtained from research data and field stations such as KARI. Other scientific knowledge was obtained from numerous documents on the web. Indigenous knowledge was obtained from farmers and farm visits and the videos captured during this process.

- **Horticulture Repository**

  Knowledge from the step above was stored in a MySQL Database in various forms. There were images and videos accompanying most of the information categories especially pests and diseases information. The knowledge stored was structured around major processes in the value chain such as foliar feeding, harvesting and storage among others

- **Dissemination/Use**

  The knowledge stored was disseminated to farmers via a web interface. These are the urban and peri-urban farmers interested or practicing horticultural farming. Responses were obtained from them in form of questionnaires to gauge their attitude and confidence in using the system.

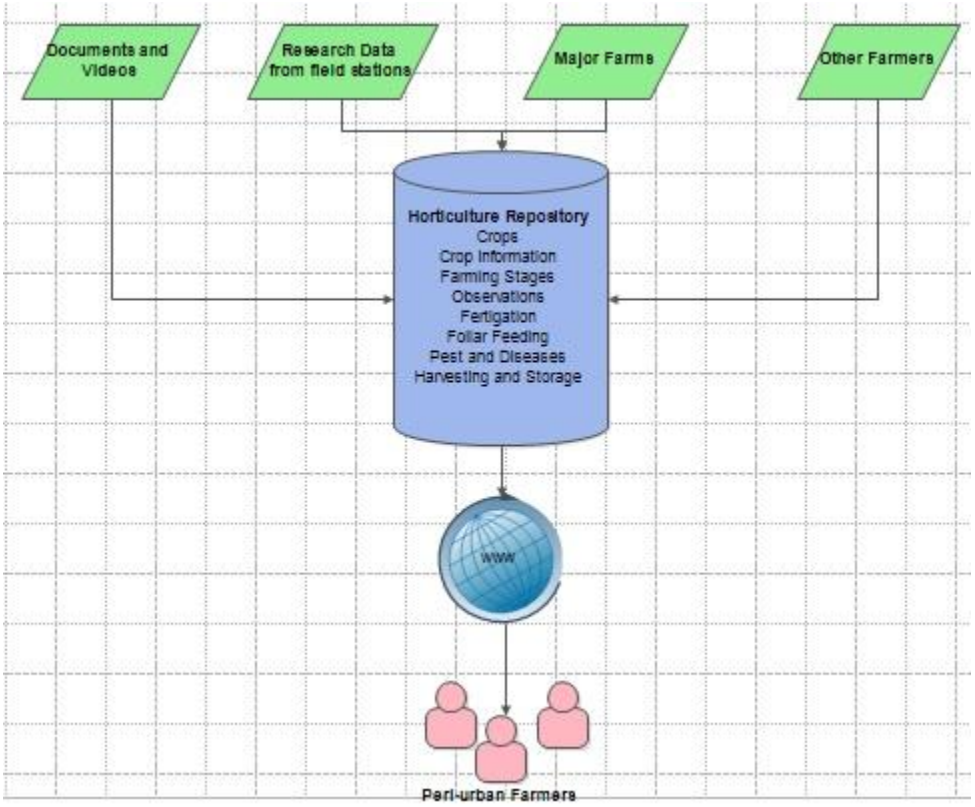

Figure 13: Detailed System Architecture

3.1.8 Database Design

The database tables, as shown by the figure in Appendix I, are modeled around the major farm processes such as planting and field preparation, wedding, pruning, harvesting, storage among others. This greatly enhances the scalability of the system since it gives room for any new emerging farm categories to be added. The major tables designed for this system include:

- Crops table
- Registered Farmers table

- Farmer's groups table
- Crop videos table
- Crop information categories table

3.1.9 User Interface Design

This involved designing the data capture forms and the data presentation forms for both the web interface and the mobile interface. These forms also clearly show the navigation sequence for the farmers.

Web Interface

The first form captures basic minimal information about an interested farmer. As shown in Figure 14 a farmer interested in using the system registers using his or her names, selects the crops they grow, how long they have been farming, in which area and a description of their success in farming.

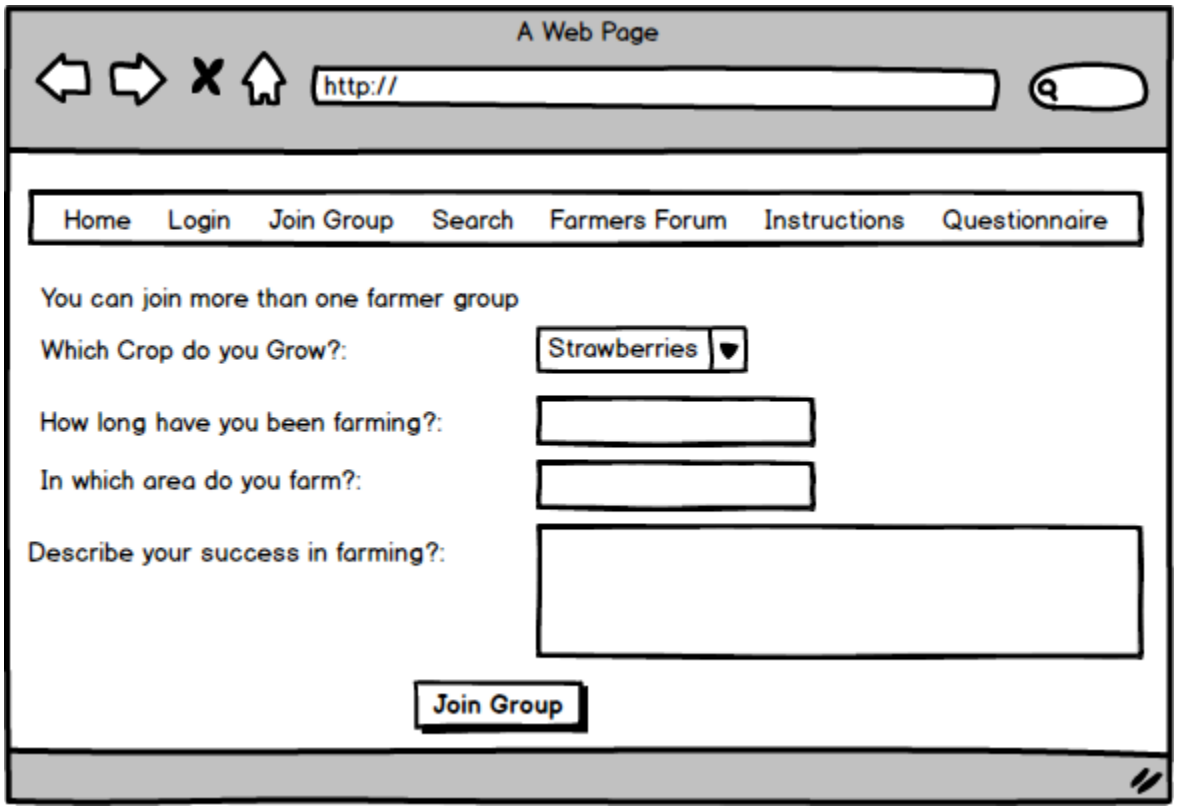

Figure 14: Farmer's Form for Submitting their information

Sample forms used for data capture will have a drop down menu for selecting a crop, an area for writing the description and a field for uploading an accompanying image as depicted in Figure 15

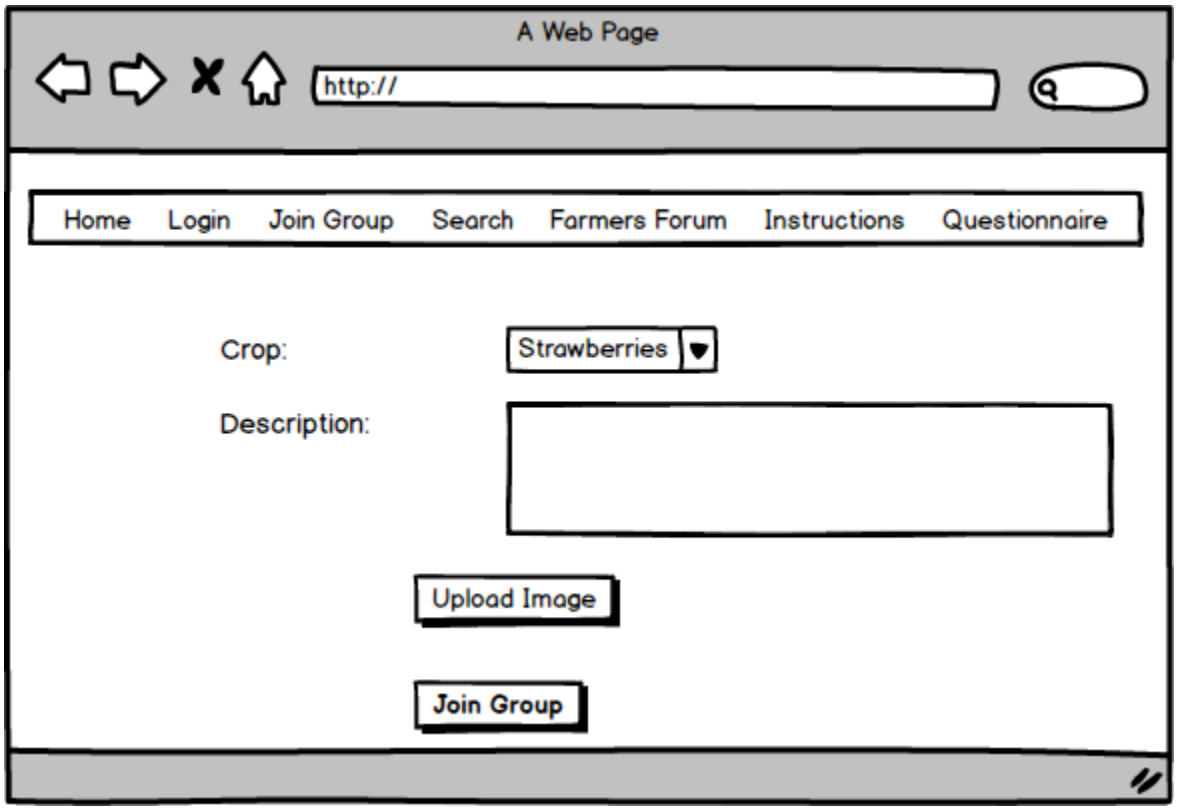

Figure 15: Designed Form for Data Capture

Mobile Web Interface

Simpler web forms were designed for the mobile interface. These enabled the mobile user to register, log in, join a crop group, view and search for information. The mockup screens are shown in Figure 16.

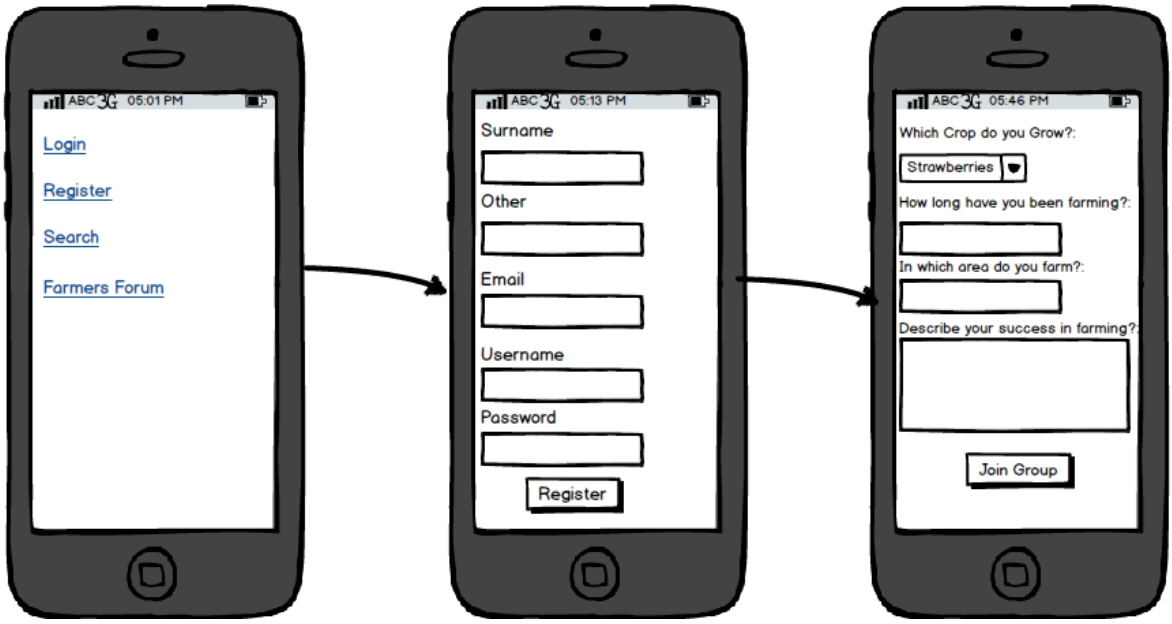

Figure 16: Screen mockups for the mobile web interface

3.1.10 Choice of Technologies

3.1.10.1 MySQL Database Server

MySQL is a relational database management system (RDBMS) that runs as a server providing multi-user access to a number of databases, and distributed under the open source and proprietary licenses.

The Mysql database holds information on the crops, crop videos, crop images, general information on crops, ecological requirements of crops, field preparation and planting, irrigation, weeding, harvesting and postharvest handling, storage, crop pests and diseases.

3.1.10.2 Netbeans IDE

Netbeans IDE is a free, open source tool used for developing desktop, mobile and web applications with Java, HTML5, PHP, C/C++. It is quick and easy to install, supports many platforms including Windows, Linux, Mac OS X and Solaris. I used it for developing the data capture forms.

3.1.10.3 Scripting

jQuery is a fast, lightweight JavaScript library. It makes things like HTML document traversal and manipulation, event handling, animation, and Ajax much simpler with an easy-to-use API that works across a multitude of browsers. It was used to present information to the web interface users. The users click on a hyperlink which displays the needed information right below the hyperlinks.

3.1.10.4 Drupal

Drupal is an open source content management platform used for a large number of websites and applications. This was used to develop the web interface for the system. I chose it due to its numerous plug in add-ons and highly dynamic features such as blogging with comments.

3.2 Initial Knowledge Capture and Creation

3.2.1 Overview

This is the conceptual structure within which the proposed project will be conducted. This was a mixed qualitative and quantitative research that involved collection of numerous forms of data and examining them from various angles to construct a rich and meaningful picture of complex, multifaceted situation. This project was conducted as a case study of how selected horticultural crops are grown.

3.2.1.1 Primary Focus

The sample of horticultural produce to be used for this project was determined. The horticultural crops to be used for the study include strawberries, mushrooms and watermelons. They were selected based on the following reasons:

- **Strawberries**

  Despite its high potential to alleviate poverty, earn substantial foreign exchange and suitability to grow in nearly every corner of Kenya on small parcels of land, the strawberry remains largely unexploited as the country spends millions of shillings importing the fruit whose flavor resonates with many tongues (Maina Wilson, October 2010).

  It is a favorite in jams, yoghurts, juices, cookies and milkshakes among other products. Strawberries are emerging as some of the sought after fruits in the Kenyan market prompting many farmers to venture into the business and establish strawberry farms in Kenya with the hopes of earning from it.

- **Mushrooms**

  Mushroom farming in Kenya is not common and this could be due to the fact that it is a delicate endeavor which requires a lot of attention especially when planting or spawning as it is referred (Ngotho Agatha, The star, March 26, 2013).

  Mushroom production is currently valued at KSh 340 million. Large scale producers account for over 95% all over Kenya most of which is button. Shitake,

though not common in Kenya, is globally rated second after button. Oyster mushroom production is readily picking up because it is easy to grow, has higher yields and has more nutritional value than button. Due to its lower cost of production and high yielding capacity it presents a good opportunity for small to middle scale farmers (National Farmers Information Service, 2013).

- **Watermelons**

  Watermelon is continually gaining popularity in Kenya's urban and rural areas alike. Watermelon is a good cash crop in Kenya with very good market opportunities, particularly in urban areas. Gross margin per ha for watermelon variety "Charleston Gray" in Embu area of Kenya is Kenya shillings 138,409 (AIRC, 2003).

3.2.1.2 Data Collection

Data collected from various sources provided in depth knowledge of how various rare horticultural crops are grown, right from land preparation to harvesting and subsequently marketing. I gathered data from the following sources:

3.2.1.2.1 Observations

Over a period of two months, I conducted observations through visits to farms of successful small scale farms. There were two farm visits of at least 6 hours each to the following farms:

- Shethia Greens Farm, in Thika, owned by Suraj Shah
- Rogita Farms, in Limuru, owned by Robert Gitau

The first farm visit was conducted at Shethia Greens farm on 4th of May, 2013. Quite a number of crops are grown at this farm. These include Tylka tomatoes, strawberries (chandler variety), capsicums, brinjals, african bird's eye chillies, herbenero chillies and purple passion fruit. The farmer and the farm manager were very detailed and well informed and they took us through the entire detailed processes of farming including irrigation and record keeping. They were able to demonstrate the important tips and

lessons they had learnt over the years through trial-and-error. I recorded most of the information as video and also took down important pointers in my notebook.

I conducted the second farm visit on the 18th of May, 2013 at Rogita Farms, Tigoni, Limuru. This is a demonstration farm that had tree tomato, apple tree, strawberry, wineberry, raspberries, various herbs and spices such as marjoram, thyme, sage, oregano, tropical mint, lemon grass and chives. I took some notes, pictures and recorded video demonstrations. One major challenge at this farm was language barrier. The farm manager conducted the demonstrations in a mixture of English, Kiswahili and vernacular.

3.2.1.2.2 Conversations and Interviews

I had conversations with other small scale farmers most of who were present during these farm visits. There was a lady from Eldoret who had tried growing strawberries but had incurred major losses. There were two farmers from Mombasa who had land for farming but had no farming experience and had no idea what crops to grow on their land. I picked out the important tips from these farmers and noted them down to be used as tips for the system.

I interviewed two people using informal semi-structured questions. I interviewed Michael Mbote from Smart Farmer magazine. Michael organizes monthly farm visits for interested upcoming farmers. I also interviewed Mr Mugo from ALIN who is involved in agricultural knowledge management for Arid Lands. Some of the questions I asked included:

1) What are some of the challenges that hamper sharing of knowledge among farmers?
2) What are the most common horticultural crops that people shy away from due to lack of information or technical know-how?
3) How receptive are farmers to technologies at the farm?
4) What is the state of agricultural knowledge management in Kenya?
5) How and where would farmers get knowledge on crops to grow and markets to sell?

I wrote down the informal conversations as soon as possible and later transferred the notes to my laptop in a legible and detailed manner.

3.2.1.2.3 Official Records and Documents

Official records and documents were another source of information. I will confirm the information collected with an officer at the Kenya Agricultural Research Institute, Kabete station. I will also counter check with information picked from agricultural journals such as the SmartFarmer magazine among other journals. Publications and information from web search tools will also be a good source of accurate information.

3.2.1.3 Coding and Analysis

As I collected and analyzed data from observations, I found issues that arose. Questions arose that created a need for further observing or interviewing. Using the constant comparative method of analysis (Glaser and Strauss, 1967), I collected data, looked for emerging trends, categorized them, and reevaluated my categories and trends. As I collected more data, I wrote analytic notes about my data, reevaluated my previous theories as I compared old data with new.

I identified text segments in the data I collected in as well as assigned categories. I did some ongoing revisions and collapsing of categories to my final analysis. I grouped the categories and coded them again, testing new coding categories and reexamining the data. Further hand coding yielded categories such as land preparation, foliar spraying, mulching, pest control, harvesting, storage and packaging.

3.2.1.4 Piloting/Pretesting

5 random successful farmers were picked to pretest the prototype. These farmers ranked the usefulness or accuracy of this information on a scale of 1 to 5 with 1 being poor and 5 being excellent.

3.3 Research Methodology for Prototype Evaluation

For this project, an online test was conducted with farmers provided by the Smart Farmer organization and a few other random farmers. They were expected to access the information on the web interface and rate it using a Likert scale presented in form of five stars. The users also filled an online questionnaire, shown in Appendix I, after the test run. The knowledge base and the interface were hosted on a computer with a public IP that was connected to the internet.

The objective was to:

- get the farmers' views of the web interface and functionality
- get the farmers' perception in terms of ease of navigation required to access information
- get the farmers' attitudes towards the system
- get the farmers' intention to interact with the system

3.3.1 Test Process

The link to the system was provided to the selected farmers. Instructions were also provided online. They were requested to fill in some basic information about themselves using an online form before embarking. They were then asked to select one of the test crops and to view content pertaining to that crop. Below the content was a rating scale shown in for them to rate the information they had viewed

Figure 17: Fivestar rating for the web content provided

When they were done, they filled in a questionnaire provided online and submitted it.

Chapter 4. Results and Findings

This section discusses the evaluation results obtained from an in-depth data analysis. Both qualitative and quantitative data was obtained from the survey questionnaire used to evaluate the system.

4.1 Qualitative Results

A number of open-ended questions were asked to obtain some common cross-cutting themes that would facilitate the improvement of the system. The following were key issues noted:

1) **Additional information needed**

   Farmers would like more information added in form of images for diseases and pests that attack crops so as to be able to identify them accurately when faced with such situations. They also expressed their interest in more information presented in form of demonstration videos.

2) **Geographic, climatic conditions and demographics**

   There were people who expressed interest in knowing complete information on what climatic conditions of areas in the country and specific crops that perform well in those areas.

3) **Need for more horticultural crops**

   There was a general consensus on the need for a wider range of crops such as capsicums, tomatoes, butternuts among others to be added to the system. This would greatly enrich the value of the system.

4) **Interaction with other farmers and stakeholders**

   Farmers expressed their genuine need to access information regarding experiences other small scale farmers had undergone in terms of the challenges they faced, lessons they have learned along the way and their success stories. Farmers also wish to contactor liaise with technical experts on the various farming practices.

5) **Access through mobile devices**

   Most of the responses gathered indicated that they would wish to access the same information on their mobile phones in mobile-friendly formats.

4.2 Quantitative Results

The final results were also analyzed using a webform tool provided by Drupal and using bar charts. The following analysis was arrived at using percentages:

Interest in the website

Table 2 shows the results obtained when 20 farmers were asked to rate their interest in the web interface presented. 80 percent responded positively, that is, their interest in the website was either excellent, very good or good. These results indicate that there is a great interest in horticulture in Kenya and people would like to get more information pertaining to this sub-sector.

	Frequency	Percent	Valid Percent	Cumulative Percent
Good, Very Good, Excellent	16	80	80	80
Poor, Fair	4	20	20	100
Total	20	100		

Table 2: Table showing results on the percentage of interest generated by the website

Figure 18: Graph showing results on the percentage of interest generated by the website

Usefulness of the content

Users were asked if they found the content presented on the three crops useful. As illustrated by the figures in Table 3 and Figure 19, 80 percent of the farmers who filled the

questionnaire found the content useful and relevant. This highlights the importance of proving up-to-date timely information relevant to the Kenyan context of horticultural farming.

	Frequency	Percent	Valid Percent	Cumulative Percent
Good, Very Good, Excellent	16	80	80	80
Poor, Fair	4	20	20	100
Total	20	100		

Table 3: Table showing results obtained when farmers were asked about usefulness of the content presented

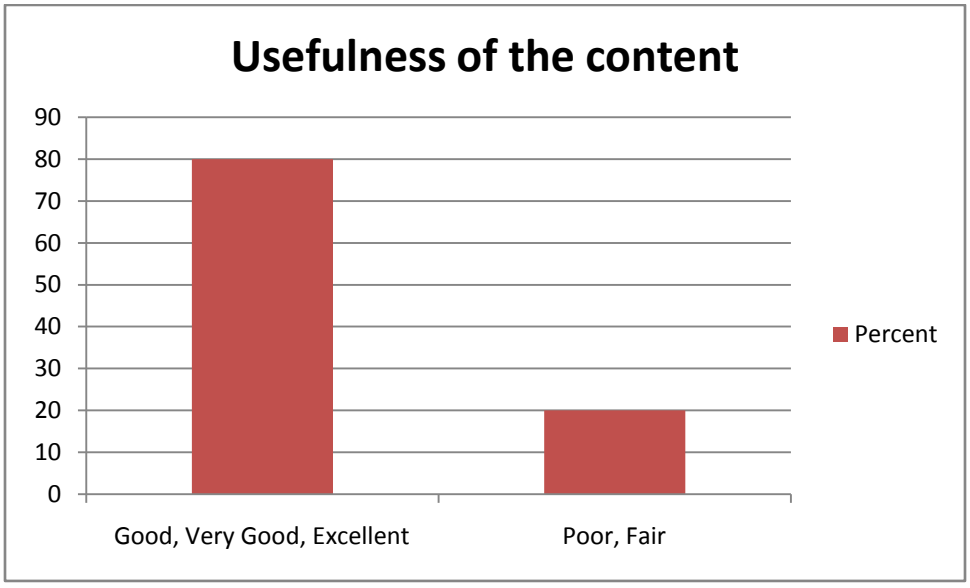

Figure 19: Graph showing survey results obtained regarding farmers' view on the usefulness of the content presented

Previous experience with horticulture

45 percent of the sample farmers responded that they have had a poor or fair experience with horticulture as shown in Table 4 and by Figure 20. To reduce this number, there exists a need to capture and disseminate agricultural knowledge to farmers especially small-scale farmers. This knowledge will enable farmers to have a better experience of farming various horticultural crops.

	Frequency	Percent	Valid	Cumulative

			Percent	Percent
Good, Very Good, Excellent	11	55	55	55
Poor, Fair	9	45	45	100
Total	20	100		

Table 4: Results on previous experience with horticulture

Figure 20: Graph showing percentages on previous experience with horticulture

Satisfaction with web-based format

Asked whether they were satisfied and comfortable using the web-base format provided, 85 percent responded positively as shown in Table 5 and Figure 21.This means that simple web interfaces and mobile web interfaces can serve as an excellent way of disseminating agricultural knowledge in various forms (videos, images, forums and web pages).

	Frequency	Percent	Valid Percent	Cumulative Percent
Good, Very Good, Excellent	17	85	85	85
Poor, Fair	3	15	15	100
Total	20	100		

Table 5: Table showing the percentage of the sample farmers satisfied with the web based format

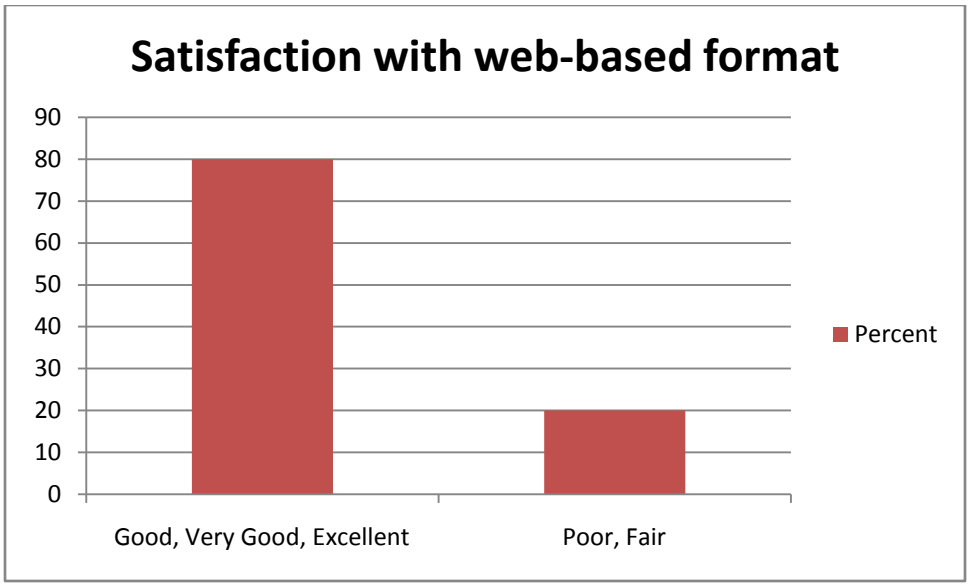

Figure 21: Graph showing the percentage of the sample farmers satisfied with the web based format

Video clips associated with the crops

There were video clips collected from the farm visits that were included in the information provided for the three crops presented. As shown in Table 6 and Figure 22, 85 percent of the farmers who filled in the survey responded positively when asked if they liked these video clips. This indicates that apart from reading and viewing images on the various farming aspects, farmers also want to watch how some things are done like spraying, weeding, mulching, pruning among others, without necessarily having to go physically to a farm.

	Frequency	Percent	Valid Percent	Cumulative Percent
Good, Very Good, Excellent	17	85	85	85
Poor, Fair	3	15	15	100
Total	20	100		

Table 6: Table showing the percentage of respondents who liked the video clips associated with the crops

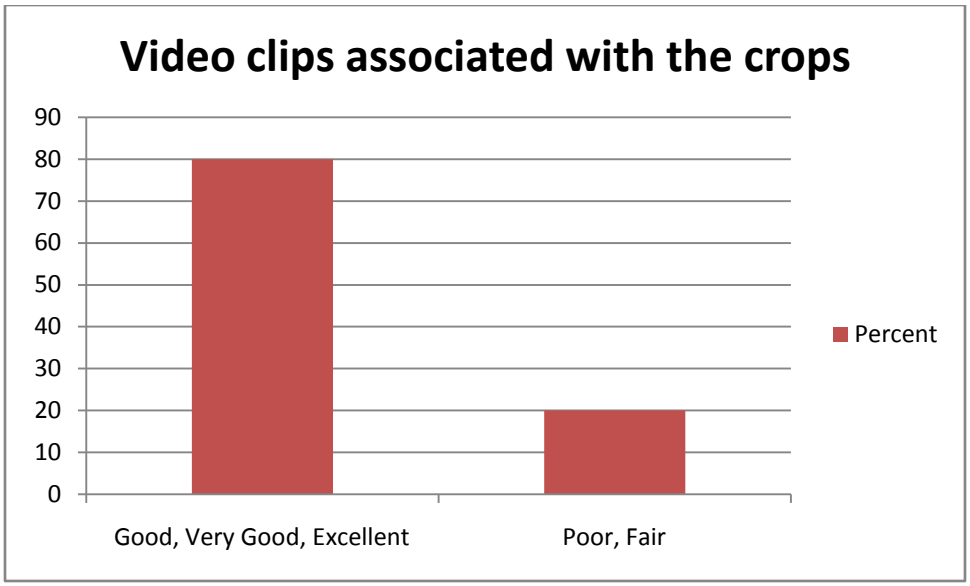

Figure 22: Graph showing the percentage of respondents who liked the video clips associated with the crops

The interactive format of this website aided learning

The website was presented in such a way that interested farmers could register as users, log in, join or leave crop groups, search for any information and post or reply to various forums. The results in Table 7 and Figure 23 show that 95 percent of the farmers appreciated this interactive format presented by the web interface and were able to learn more on the specific crops they chose. This clearly shows that in order to deliver information successfully to farmers, the delivery tool must be interactive and flexible enough to cater for both knowledge capturing and knowledge dissemination.

	Frequency	Percent	Valid Percent	Cumulative Percent
Good, Very Good, Excellent	19	95	95	95
Poor, Fair	1	5	5	100
Total	20	100		

Table 7: Table showing results of what the respondents thought of the interactive format of the website

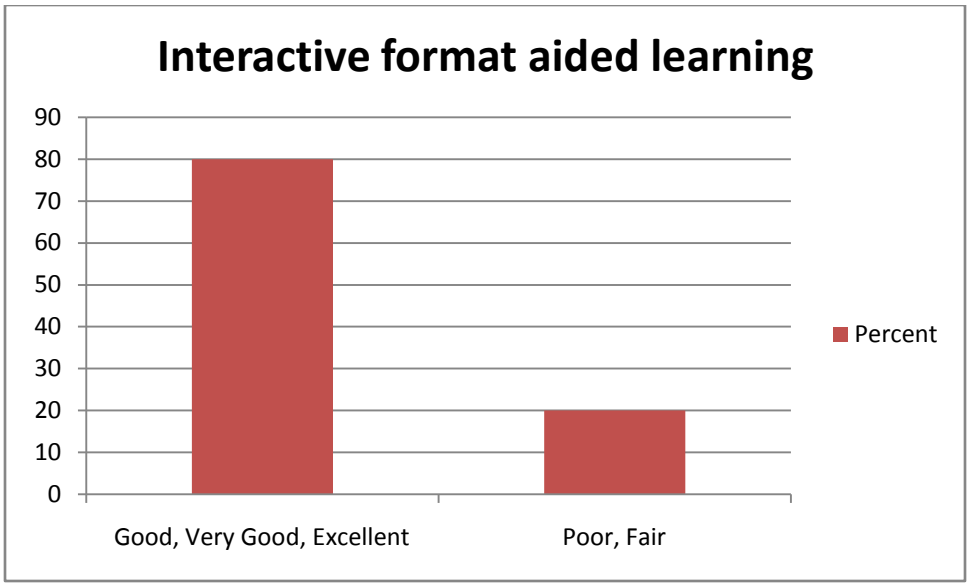

Figure 23: Graph showing results of what the respondents thought of the interactive format of the website

New level of understanding

The sample farmers were asked on what they thought was their new level of understanding of horticultural crop husbandry for their crop of interest. 80 percent of the farmers felt that their new level of understanding was much better than it was before interacting with the system. This is illustrated by Table 8 and Figure 1. This shows that the knowledge management system developed has the potential to improve farmers' understanding of horticultural crop husbandry.

	Frequency	Percent	Valid Percent	Cumulative Percent
Good, Very Good, Excellent	16	80	80	80
Poor, Fair	4	20	20	100
Total	20	100		

Table 8: Table showing what the respondents thought was their new level of understanding on horticultural crop husbandry

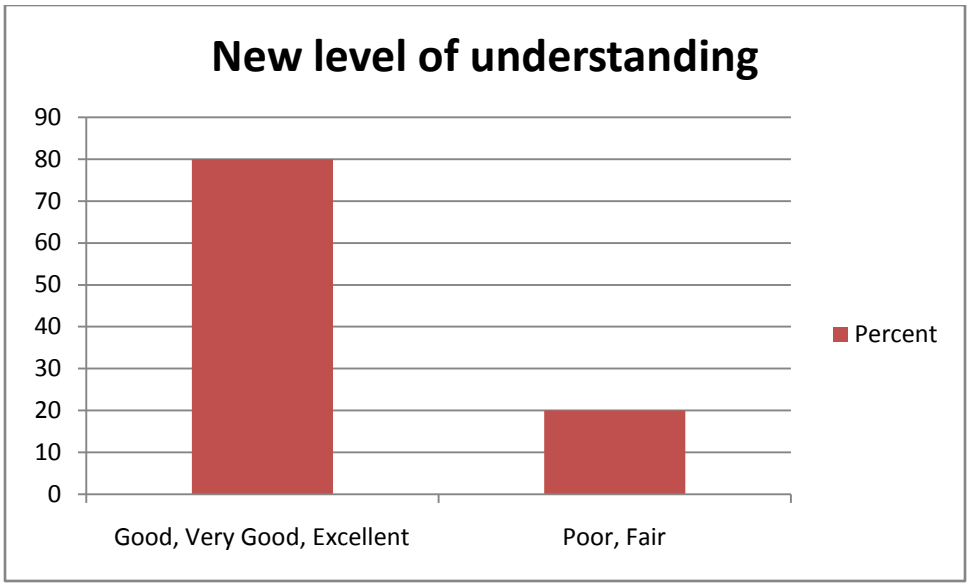

Figure 24: Graph showing what the respondents thought was their new level of understanding on horticultural crop husbandry

Chapter 5. Conclusion and Recommendations

This sections discusses the achievements made regarding the project, and highlights the limitations and challenges and suggestions for further work.

5.1 Achievements

The following were achieved as per the objectives stated in Chapter One.

Objective 1:To develop a knowledge management system for horticultural farmers in Kenya

A knowledge management system for horticultural farmers in Kenya was developed. Data capture mechanisms were developed, a knowledge repository in form of a database was also designed and developed and finally an interface for disseminating this stored information was also put in place.

Objective 2: To create a knowledge repository for rare horticultural crops such as strawberries, mushrooms and watermelons.

Data was collected pertaining to these three selected crops from farm observations and official documents. It was analyzed and categorized, it was also cleaned and modified appropriately. This data was then stored in a repository for further processing and retrieval.

Objective 3: To create a web interface that will enable farmers to access the system.

A simple, easy-to use interface in form of a content management system was developed and tested with real farmers for suitability. Any issues and suggestions raised were put under consideration. An application for capturing more information from farmers was also developed at the backend. From analysis, the solution would greatly enhance knowledge capture and dissemination to horticultural farmers. It would also enhance interactions among farmers. Farmers were able to view information on crops of interest, view images of pests, diseases among others and watch videos pertaining to crop husbandry. Sample pages of the web interface are shown in Appendix VI.

Objective 4: To create a mobile web interface that will give farmers the flexibility of accessing the system via their mobile devices.

Simple web forms were designed and developed for a mobile phone. Through their mobile phones, farmers were able to do the following:

- register as users and login
- join any of the three crop groups offered, that is, strawberries, mushrooms or watermelons group
- view information pertaining to their specific crop group in a mobile friendly way
- search for specific content using a simplified version of the web interface search form
- post and view content in the various farmers' forums

Screen shots of the mobile interface provided are shown in Appendix VII.

5.2 Limitations and Challenges

The biggest challenge was gathering the initial data to be used for the system. Identifying exactly who-knows-what in the horticultural sector and their willingness to share this information with others was a daunting task. Most of the small-scale farmers practicing horticultural farming work alone or rather individually as opposed to other major cash crops. It is only recently that farmers are moving away from traditional grown crops like maize and tea and hesitantly embracing horticultural farming.

The other challenge was organizing data gathered from the numerous sources into one resource. There were video recordings, photos taken during field work, various crop guides almost similar but generated from different institutions and reconciling any differences that I came across.

Another minor challenge was language barrier. At one of the field visits, the farmer conducting the demonstration did so in a mixture of English, Kiswahili and vernacular.

Also getting a large number of farmers to evaluate the web interface within a short time proved a challenge hence a sample of 20 farmers were used.

5.3 Conclusion

This project was able to identify a problem, analyze it, collect data and disseminate the collected data in a simple form to interested farmers. There is a great potential of use and adoption of a knowledge management system in the horticultural sub-sector. If adopted, it would facilitate capturing of undocumented data, especially in form of videos, and sharing of this data with other generations to come.

5.4 Suggested Further Research

Extensive use and tests could be conducted by more farmers. This will help in evaluating the application in terms of user experience, evolving user needs and user interface design.

Some of the farmers who tried the interface also expressed their interest with having it integrated to any system that would provide real time market data and cost estimates. Availability of market data can improve the distribution channels between farmers and consumers and also ensure they are not taken advantage of by middlemen or intermediaries.

Survey findings also shows some of the farmers requesting for other crops to be added to the system. This indicates a need for this system to be extended to other agricultural sub-sectors such as the tea and coffee subsector.

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Appendix I: Database Schema

Appendix II: Sample Questionnaire

Questionnaire

System Evaluation *

	Poor	Fair	Good	Very Good	Excellent
My interest in this website is	Poor	Fair	Good	Very Good	Excellent
The usefulness of the content is	Poor	Fair	Good	Very Good	Excellent
My previous experience with horticulture is	Poor	Fair	Good	Very Good	Excellent
I felt comfortable using this web-based format	Poor	Fair	Good	Very Good	Excellent
The organization of the material is	Poor	Fair	Good	Very Good	Excellent
The extent to which the content conforms to the current trends in horticultural farming is	Poor	Fair	Good	Very Good	Excellent
Readability of the content is	Poor	Fair	Good	Very Good	Excellent
The video clips associated with the crops are	Poor	Fair	Good	Very Good	Excellent
The amount of information presented for the crops is	Poor	Fair	Good	Very Good	Excellent
This website is an effective way to deliver information	Poor	Fair	Good	Very Good	Excellent
The interactive format of this website aided my learning	Poor	Fair	Good	Very Good	Excellent
The level of fun in using this website is	Poor	Fair	Good	Very Good	Excellent
Chances that I would like to use the website again are	Poor	Fair	Good	Very Good	Excellent
The completeness of the content (has all necessary information) is	Poor	Fair	Good	Very Good	Excellent
My new level of understanding of horticultural crop husbandry for the crop of my interest is	Poor	Fair	Good	Very Good	Excellent
The possibility to locate information I may need in the website is	Poor	Fair	Good	Very Good	Excellent
The ease of discovering how to navigate from one section to the other is	Poor	Fair	Good	Very Good	Excellent
The overall rating of this website is	Poor	Fair	Good	Very Good	Excellent

What information would you like to be added

What information would you like to be in video format

What information would you like to find out through interaction with other farmers using emails or social networking tools

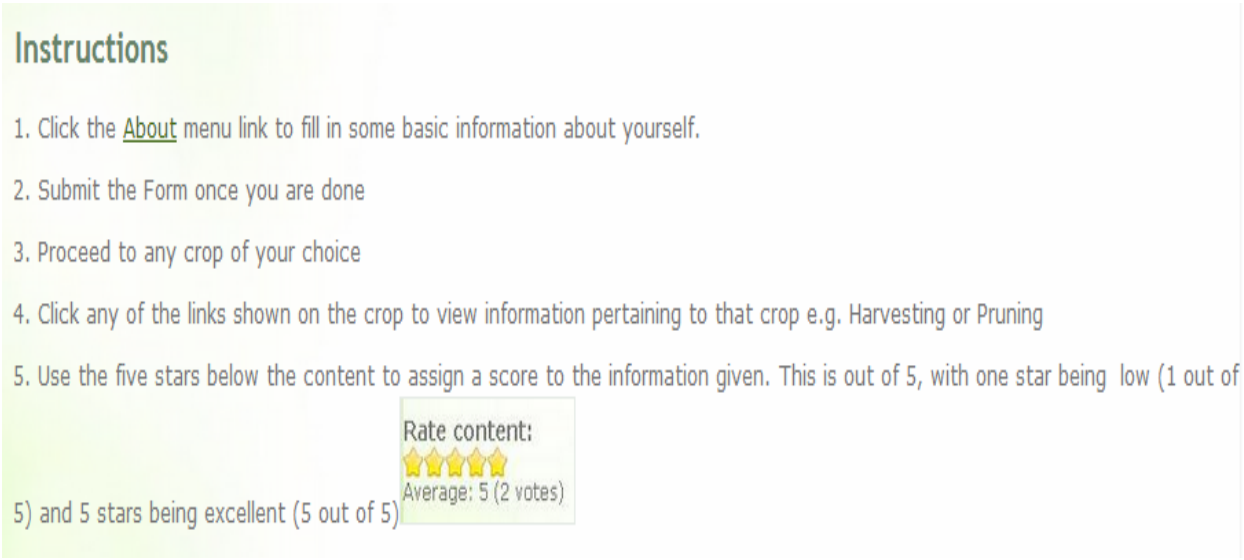
What information would you like to access through a mobile device such as a phone or tablet

Appendix III: Sample Raw Results

System Evaluation

	Poor	Fair	Good	Very Good	Excellent
My interest in this website is	0	4	8	5	4
The usefulness of the content is	0	5	6	6	4
My previous experience with horticulture is	4	6	5	4	2
I felt comfortable using this web-based format	1	2	4	6	8
The organization of the material is	0	3	6	8	4
The extent to which the content conforms to the current trends in horticultural farming is	0	3	8	7	3
Readability of the content is	0	4	5	7	5
The video clips associated with the crops are	0	4	7	8	2
The amount of information presented for the crops is	0	3	7	9	2
This website is an effective way to deliver information	0	2	8	5	6
The interactive format of this website aided my learning	0	2	6	9	4
The level of fun in using this website is	1	5	3	9	3
Chances that I would like to use the website again are	1	1	10	5	4
The completeness of the content (has all necessary information) is	0	4	12	3	2
My new level of understanding of horticultural crop husbandry for the crop of my interest is	1	3	9	5	3
The possibility to locate information I may need in the website is	0	4	6	8	3
The ease of discovering how to navigate from one section to the other is	1	2	5	9	4
The overall rating of this website is	0	1	8	8	4

Appendix IV: Web Interface Manual/Instructions



Appendix V: Sample Code

PHP script for adding information to the database

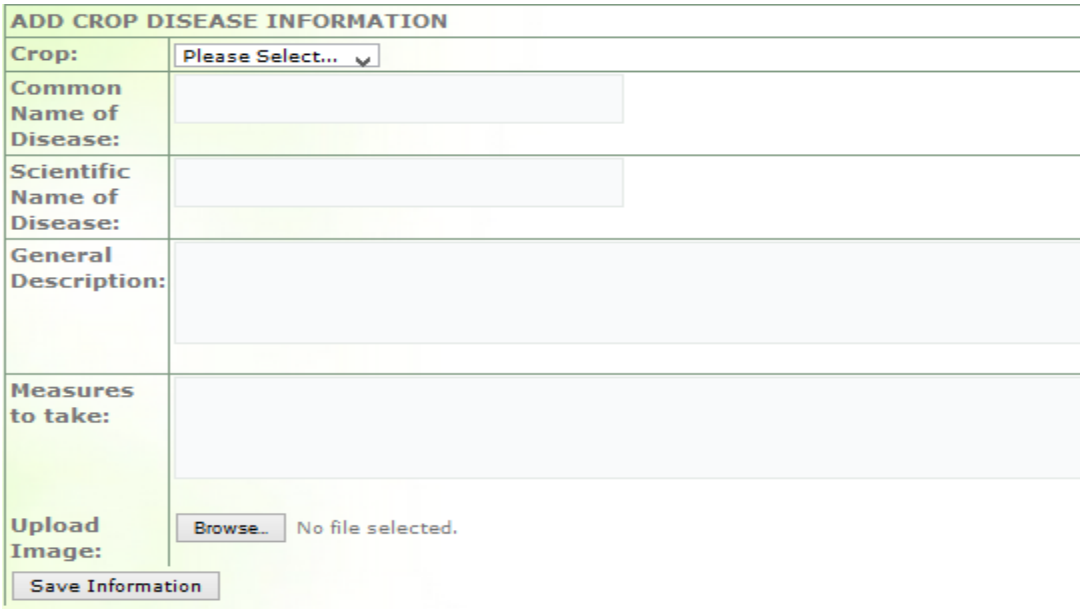
```php
function addDiseaseInfor() {
    global $cropaddinfor, $db;

    $vroll = "<table border=\"0\" align=\"center\" cellspacing=\"0\" cellpadding=\"0\" width=80%>";
    $vroll .= "<table border=\"1\" align=\"center\" cellspacing=\"0\" cellpadding=\"0\" width=60%>";
    $vroll .= "<FORM action=\"$cropaddinfor\" name=\"cropform\" id=\"cropform\" enctype=\"multipart/form-d
    $vroll .= " onSubmit=\"return validateinput()\" method=\"post\"> \n ";
    $vroll .= "<tr><td align=\"center\" colspan=\"2\"><b> ADD CROP DISEASE INFORMATION</b>";
    $vroll .= "</td></tr> \n";
    $vroll .= "<tr><td><label>Crop:</label></td><td><select name='crop'>\n";

    $sql = "SELECT
            crops.crop_id,
            crops.crop_common_name
            FROM
            crops
            WHERE crops.crop_id=4
            ORDER BY
            crops.crop_common_name ASC";
    $rs = $db->GetArray($sql);
    $vroll .="<option value=' '>Please Select...</option>\n";
    foreach ($rs as $key => $value) {
        $crop_common_name = $value['crop_common_name'];
        $crop_id = $value['crop_id'];

        $vroll .="<option value='$crop_id'>$crop_common_name</option>\n";
    }
    $vroll .= "</select></td></tr>\n";
    $vroll .= "<tr><td><LABEL for=\"common_name\">Common Name of Disease:</LABEL>";
    $vroll .= "</td>\n";
    $vroll .= "<td><INPUT type=\"text\" name=\"common_name\" id=\"common_name\" value=\"" . $common_name .
```

jquery code for dynamically displaying information

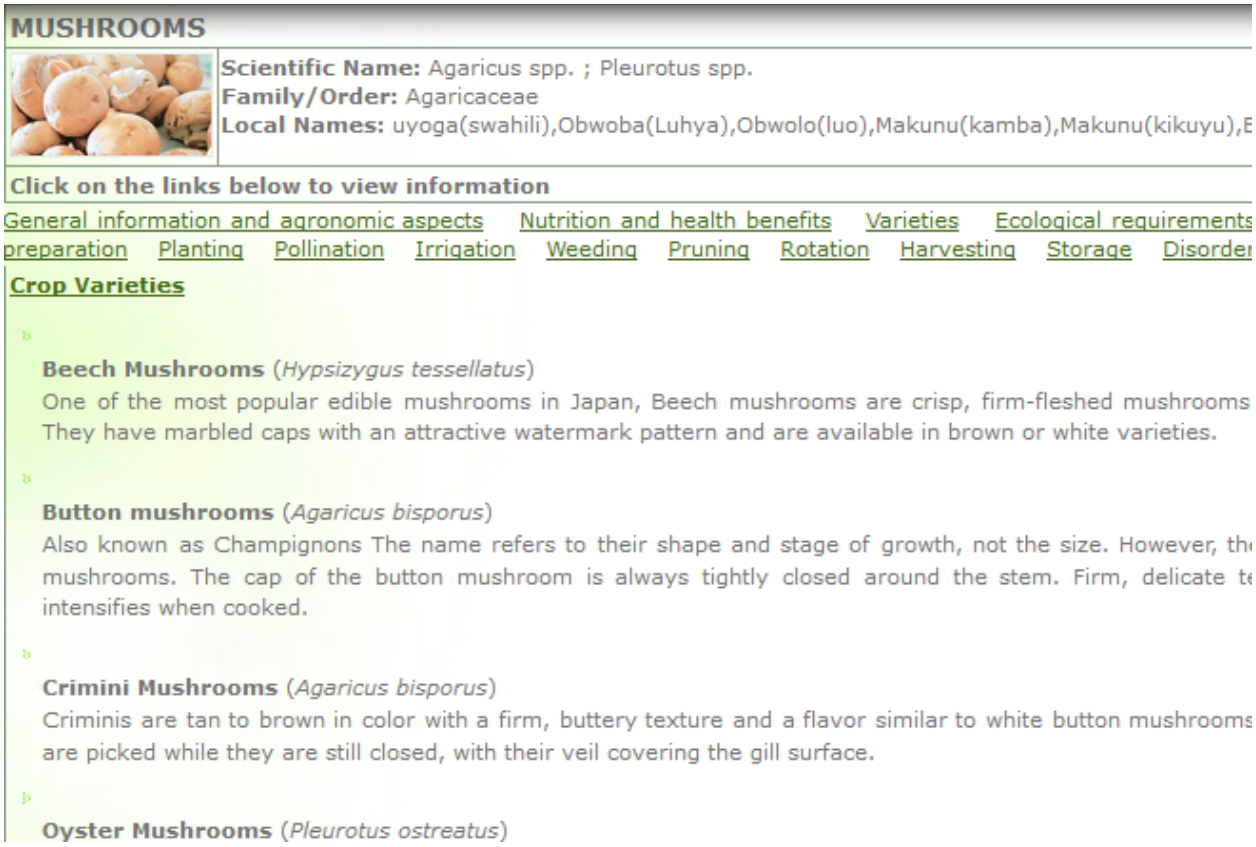
```javascript
<script type="text/javascript">
    jQuery(document).ready(function(){

        jQuery.get("/kmskenya/get_categories.php", function(json){

            var json = jQuery.parseJSON(json);

            jQuery.each(json, function(i,data){
                var crop_id = <?php echo $crop_id; ?>;
                var anchor = jQuery("<a></a>").attr('href',"/kmskenya/get_information.php?crop_id="+crop_
                    "&infor_category="+ data.information_category_id).html(data.information_category);
                anchor.click(function(e){
                    e.preventDefault();
                    jQuery.get(anchor.attr('href'), function(html){
                        jQuery("#information").html("");
                        jQuery("#information").append(html);
                    });
                });

                jQuery("#categories").append(anchor).append("    ");
            });
        }) ;
    });
</script>
```

Appendix VI: Sample Web Interface Output

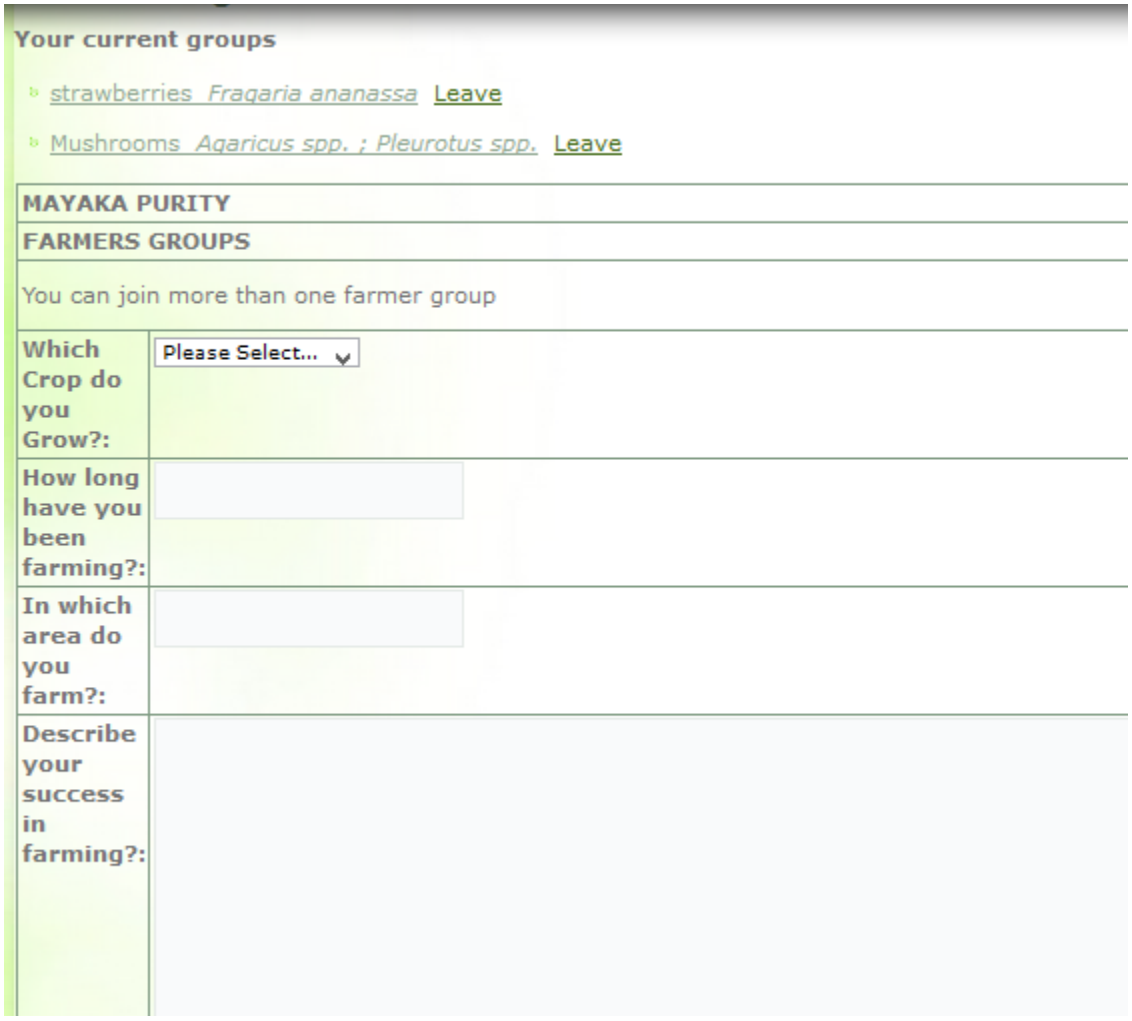
Sample Data Capture Form



Display Forms



Farmers' Crop Group Form



Appendix VII: Sample Mobile Interface Output